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Effective workplaces: contributions of spatial environments and job design - A study of demands and resources in contemporary Swiss offices

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I, Lukas Windlinger, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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Abstract

Offices environments are the stage of knowledge work. Together with job design and the social environment, physical office work environments are an important source of influence on well-being, health, and job performance. However, field research on the effects of office environments is scarce, fragmented and not related to job design.

Based on the Job Demands-Resources framework and action-regulation theory, effects of office design, job design, and the social environment are analysed in two field studies. The first study employs a longitudinal quasi-experimental research design with a control group. Data from 6 organisations and 568 (pre-change) and 682 (post-change) survey participants were analysed regarding the effects of changes in the office environments on office users' perceptions, attitudes, and behaviour while controlling for job characteristics and influences from the social environment. The results show that changes in the office environment do not affect job characteristics and social relations. Longitudinal regression analyses show that office noise and privacy affect job satisfaction; workplace appropriateness influences environmental satisfaction, and privacy and work and storage spaces have an impact on individual work performance. Additional cross-sectional regression analyses at both points in time benefit from larger sample size and complement the longitudinal findings on smaller sized effects.

In the second study the focus is extended and office building-level parameters' influences on office users are studied using multi-level models with data from 39 buildings and 1373 survey participants. The building-level parameters proved to be little informative and variance in the outcome is completely explained by employees' perceptions.

The two studies show that demands and resources associated with the office environment explain substantial amounts of variance in job satisfaction, health, and individual work performance in addition to job design effects and influences from the social environment.

Acknowledgements

Reading management literature and the literature on work and organizational design could raise the question of whether working occurs in a vacuum, so rarely the physical conditions are addressed.
It was a privilege to study the joint and unique effects of job and office design as a student at UCL and I owe my deepest gratitude to my supervisors Alexi Marmot, David Holman, Peter McLennan for their support, inspiration, and patience. I am especially grateful for the invitation of Alexi Marmot to pursue this project at The Bartlett.

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1. Introduction

1.1. General Introduction

Scientific analysis of work has focused on work design, technology, management, and leadership and their consequences for employees, teams, and organisations. The physical environment has not received much attention. The development of the service industry and the knowledge economy has changed workplaces. Today about 50 per cent of the European and North American labour forces work in offices. The research on the relationship between physical office environments and reactions on individual, group, and organisational level the literature remains fragmentary and ambiguous. Theoretical development of the interaction between office environments and employees, teams, and organisations is largely missing although the need to integrate the physical environment has been recognised in organization theory (Pfeffer, 1997) and work design (Davenport, 2008; Kompier, 2003; Oldham, 1996; Ornstein, 1990). Furthermore, results of scientific studies are poorly connected to the engineering and design disciplines that might make use of them (Veitch, Charles, Farley & Newsham, 2007). Many business managers continue to consider offices simply as space to house their employees, rather than a tool for work (Vischer, 1996) or an important component of the organisation as a system or organisational ecology (Steele, 1986; Becker, 2004).

The design of work has an enormous impact on individual well-being and organisational success (Morgeson & Campion, 2003). Work design is based on a history of more than 50 years of research and thousands of empirical studies. It focuses on the design of content and structures of jobs and tends to neglect the physical environment (Oldham, 1996; Morgeson & Campion, 2003). On the other hand, approaches to office design usually do not consider the nature of work, that can be described in terms of demands and resources associated with tasks and activities that employees complete in their daily work. Only few empirical studies of the physical work environment in offices have integrated measures of job characteristics (e.g. Fried, Melamed & Ben-David, 2002; Oldham & Rotchford, 1983) or socioeconomic position and psychosocial aspects of work (A. F. Marmot, Eley, Stafford, Stansfeld, Warwick & Marmot, 2006).

In combination with work design, reactions to the physical environment shape individual well-being, social interactions, and organisational effectiveness. Work environments should therefore be aligned with work tasks and organisational goals and strategies in order to produce the best accommodation for a certain work style. Office environments can support employees' work and well-being and should be contingent with general organisational conditions (Aronoff & Kaplan, 1995; Becker, 1990; Vischer, 1996). From this perspective, work environments can be considered as a resource that should not be designed primarily to reduce space (and cost) but to support the work style and business mission of the organisation (Vischer, 1996) and thus to contribute to organisational profitability. Office and work design are related to crucial outcomes that are related to productivity (e.g. individual performance) or relevant for performance (e.g. job satisfaction) (Heskett, Jones, Loveman, Sasser Jr., & Schlesinger, 1994).

The focus of this thesis is on the effects of job design and the design of physical work environments. At the core of activities in office buildings is work, a goal-directed human activity. Office design is therefore studied in relation to work tasks, their characteristics and outcomes.

In this thesis the effects of office and work design on employees is described in the Job Demands-Resources framework (Bakker & Demerouti, 2007). The framework used for two field studies classifies job relevant environmental factors into job demands and job resources on the basis of the action-regulation theory approach (Frese & Zapf, 1994). This approach describes work as a goal-directed activity and emphasizes its cognitive regulation. Thus, this approach integrates work load, resources, and subjective reactions and experiences. The Job Demands-Resources framework allows the integration of three major classes of work-related strain: task-related, environmental, and social sources of strain. A theoretical model of demands and resources incorporating these three classes is developed and analysed in this thesis.

1.2. Purpose of Research

The main goal of the research consists in the analysis of the extent to which the physical environment in offices has an influence on employees' well-being (satisfaction and health) and job performance. Effects of the office environment are analysed per se and in relation to influences of work design and the social environment.

More specifically, the aim of this thesis is to explore to which extent office work environments should be regarded as resources or demands in analysing and designing organisational work systems. Effects of the physical office work environment on office users are analysed in combination with job characteristics and aspects of the social environment in order to analyse relative contributions to selected outcomes of the three classes of components of work conditions. These effects are framed in the Job Demands-Resources model. The effects of physical environment facets on user experience are identified and analysed in direction and size. These effects are put into relation with job characteristics and characteristics of the social environment in order to examine their relative unique contributions and joint effects on outcomes. Outcomes studied are job and environmental satisfaction, organisational commitment, health, and individual performance. These analyses aim at assessing the suitability of facilities present in the work environment to the work tasks in relation to regulation processes of task-related work of office users. The relationship between physical office work environments, job design, social environment, and outcomes are analysed for traditional cellular offices and contemporary office concepts (such as multi-space offices[1]). Furthermore, these relationships are examined regarding their universality or building-specificity, respectively.

This thesis contributes to the further understanding of effects of work environments in offices. With longitudinal and cross-sectional field analyses in several organisations a broad empirical base is established that expands the knowledge from single case and laboratory studies that dominate empirical research on office environments. This allows more sophisticated statements about effects of office design on office users.
In practice there is a need for such analyses to support decisions in office planning, building, and change. The results from this research thus contribute to the development of evidence-based office design (Pullen & Bradley, 2004).

1.3. Scope

Different stakeholders are involved in planning, designing, managing, and using office work environments. Their aims and interests may be conflicting and they are subject to various sources of influence and power. Therefore, assessments of the built environment by different groups may diverge largely and in the end „office quality is in the eyes of the beholder"(Becker, 1990, p. 175). The focus of the research is on identifying and modelling influences of the work environment on the individual psychosocial level. The theoretical perspective of the Job Demands-Resources model stresses individual perceptions, experiences, and outcomes. Interpersonal and organisation level effects are considered as general conditions but not analysed in detail.
Office design change processes and change management procedures are not investigated. Instead the focus of the research is on the actual office work environments. The research focuses on offices in the German speaking part of Switzerland. The study objects therefore represent conditions that are different from US and UK offices for cultural, economic, and political reasons (Van Meel, 2000; Van Meel, de Jonge & Dewulf, 2006). Switzerland's building construction is characterised by high levels of technology and quality (Trost, 2007) and Swiss economy is characterised by high wages, a highly educated workforce, and high labour productivity (Strahm, 2008)

1.4. Overview and research goals

In this thesis the analysis of the influence of the physical environment in offices on employees' well-being (satisfaction and health) and job performance is

[1] Multi-space offices are extensions of open offices: normally users have an individual assigned workspace and the office environment offers different spaces and rooms for specific purposes (e.g. focus rooms, conference and meeting rooms, regeneration rooms, project rooms). Multi-space offices enable flexible use of different functional types of office spaces within the same building.

researched and put into relation with two other classes of influences (job design and social environment). The thesis builds on two empirical field studies.

The first study aims at the identification of effects of office environment on office users' perceptions and reactions. This study consists in investigations of effects of office design on office users in a longitudinal study design where office design changes occur while job design remains constant. The research goals of this study are the following:

- Identification of parameters of office users' perceptions and reactions that are changed as a consequence of change in office design from cell structures to multi-space offices.
- Identification of parameters of office and comfort assessment that are changed as a consequence of change in office design from cell structures to multi-space offices.
- Examination of effect sizes for the influences of office design changes on office users' experiences and reactions.
- Analysis of the relationships between perceived elements of office environments and employee's reactions.

The first study uses a longitudinal research design with 7 organisations including one that served as a control group and more than 550 respondents of a survey. Longitudinal analyses of change have the particular advantage that they are less susceptible to influences in participant background than cross-sectional studies. Findings from longitudinal study designs are therefore less threatened by confounding factors.

The second study extends the focus of the first one and more objective physical office environment parameters are included in a cross-sectional design including 39 office buildings and over 1350 participants in the employee survey. The research goals of the second study consist in

- Systematic analysis of the relationship between objective parameters of office design and office users' experience.
- Differentiation of within- and between-building effects on users' experience.
- Modelling effects of job design and design of physical office environment on users' experience and analysis of relative effects of the two classes of influences.

Regarding the available evidence on job design and design of physical office environments these research goals complement current research on effects of office design in various ways.
In this thesis, office design and job design are analysed jointly. This combination of perspectives addresses the problem of job-related office design. The basic assumption that offices should be considered as a tool for work (Vischer, 1996) makes it necessary to understand job-related requirements for office environments. This question has only been studied regarding social density

(Szilagyi & Holland, 1980). The open vs. closed offices debate has focused on office users' reactions to such office structures with disregard of the job-related necessities for communication or concentration and other factors of job design (Mylonas & Carstairs, 2007). However, the analysis of both, effects from job design and from physical environment design, contributes to variance explanation of general work organisation effects on job incumbents' perceptions and experiences (MacDonald, Karasek, Punnett & Scharf, 2001). Thus the multidimensional theory-based model of effects that is established and examined in this thesis leads to a broader understanding of impacts on employees' well-being (satisfaction and health) and job performance.
In the first study quasi-experimental longitudinal analyses in several organisations are carried out. The research design contains a control group which does not experience changes in office design. Longitudinal analyses of effects of office environments are largely missing (with notable exceptions: Brennan, Chugh & Kline, 2002; Oldham, 1988; Oldham & Brass, 1979; Zalesny & Farace, 1987; Sundstrom, Town, Rice, Osborn & Brill, 1994). The analysis of changes over time, however, is a strong means for identifying cause-effects-relationships and this research will contribute to a better and more thorough understanding of these relationships. Furthermore, building level effects of office design are analysed and put in relation to office interior effects. Thus, effects within and between office buildings (instead of focussing only on effects within buildings) are studied.
The research complements available knowledge by a geographical extension. Available results are mainly based on studies in North America. In this thesis these results will be verified in Swiss offices representing a different tradition and cultural context. Finally, contemporary office designs (including multi-space offices) are analysed.

The structure of the thesis is presented in Figure 1. The rationale for exploring the physical office environment as a source of influences on employee-related outcomes is presented in chapter 2. This chapter includes a discussion of the organisation – accommodation relationship (Vischer, 1996) from the perspective of socio-technical systems. The relationship between employees and their work environment is presented using the Job Demands-Resources framework (Bakker & Demerouti, 2007). This framework is presented and discussed in chapter 3. In order to more precisely identify job demands and job resources, a more fine-grained theory is required. Action regulation theory, the micro-theoretical approach complementing the Job Demands-Resources model, is presented in chapter 4. This theory of cognitive regulation of work-related action allows the classification of job demands and resources. The framework provided by this theory is extended for factors of office environments. Chapter 5 presents the outcomes of work and organisation research: satisfaction, organisational commitment, health, and work performance. Subsequently, the empirical literature on effects of office environments on these outcomes is reviewed (chapter 6). This chapter is followed by a review of effects of job design on the same outcomes. On the basis of these reviews and the theoretical frameworks, a working model is proposed in chapter 8. This working model is examined in the two empirical studies described in chapters 9-12.

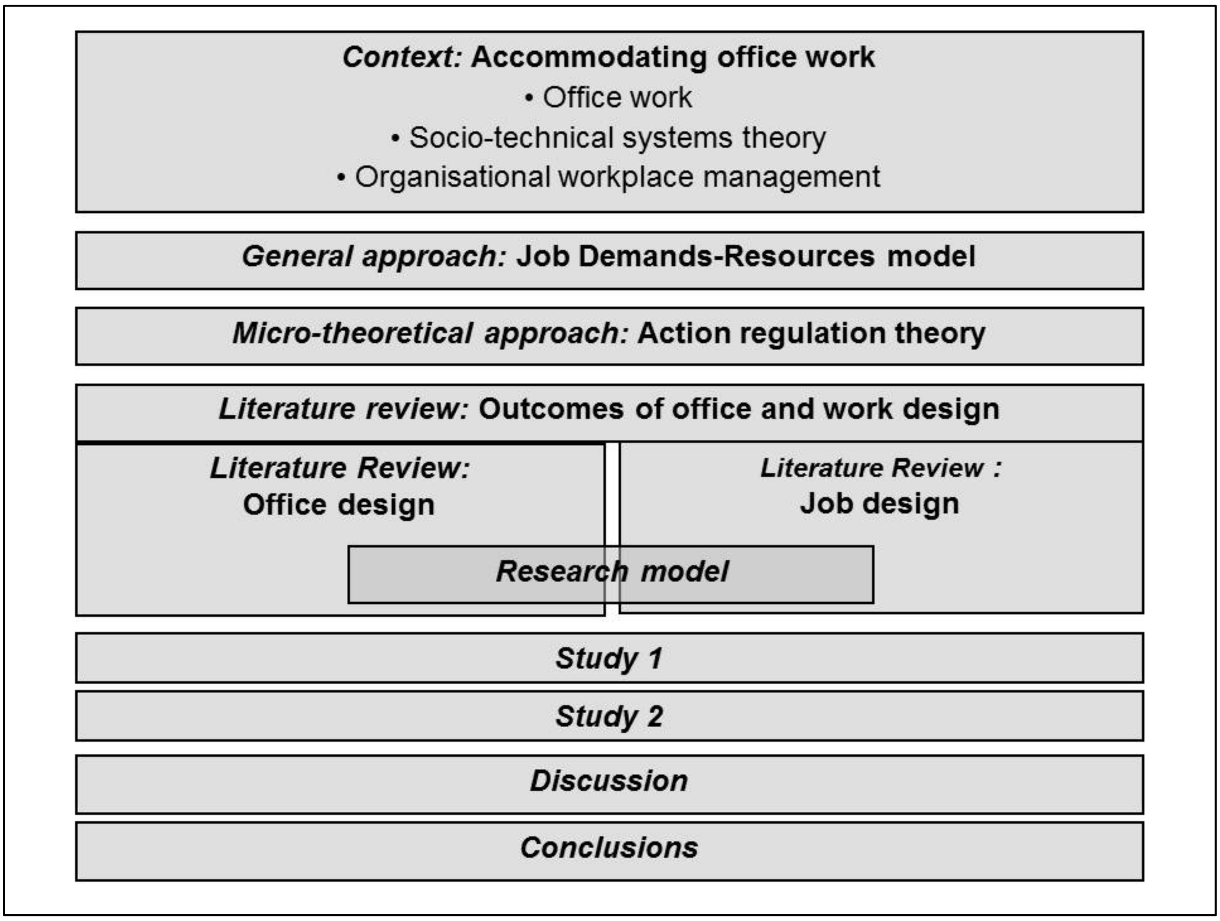


Figure 1. Overview over the structure of the thesis

2. Accommodating office work

2.1. Office Work

Since the 1980s the availability of computers has led to fundamental changes in office work (A. Kaplan & Aronoff, 1996). Information technology has contributed to the development of the service economy and has been used to support and strengthen knowledge intensive work. The term “knowledge work” (Drucker, 1958) describes a type of work that is mainly based on mental processes and not on physical labour. Knowledge work incorporates such tasks as planning, analysing, interpreting, and developing as well as the provision of information and knowledge based products and services. Knowledge work, however, does not include only demanding cognitive activities but also more mundane tasks such as storing and retrieving information, scheduling, making phone calls, writing and answering E-mails (Suchman, 2000). Such little demanding tasks use considerable amounts of work time of office workers (Brill, Weidemann & the BOSTI Associates, 2001; Reder & Schwab, 1990) (see Figure 2).

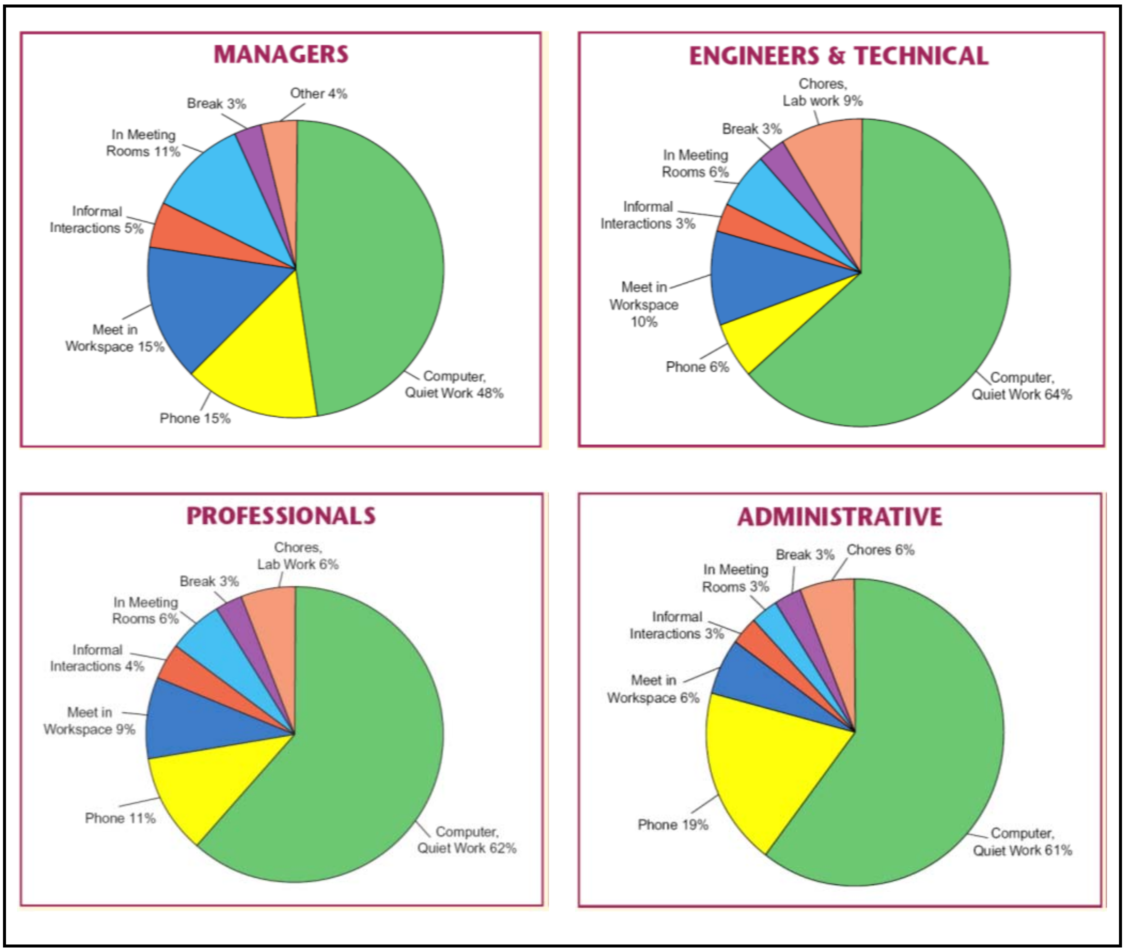


Figure 2. Time-at-task for four functional job types (Brill et al., 2001, pp. 22f)

An important component of knowledge work is social interaction: concepts, outlines, and draft papers are produced individually and subsequently collaboratively reworked in project teams or with colleagues or superiors. Thus the material must be made available to others, a process that implies communication. In everyday working life such communicative transfer and exchange processes occur in formal as well as in informal settings (Allen, 1977; J. S. Brown & Duguid, 2000). Peripheral participation in communication (Lave & Wenger, 1991) or overseeing and overhearing are essential mechanisms in learning and knowledge exchange (Bjerrum & Bødker, 2003). An additional mechanism of knowledge exchange is the shared access to resources such as information, materials, and artefacts. Thus, the enhancement of knowledge exchange, communication, and collaboration is often an important goal in office design (Myerson & Ross, 1999; Raymond & Cunliffe, 1997). Office spaces are thus considered not only as a cost factor but as a means to establish and modify workers' behaviours and corporate culture (Becker & Steele, 1995).

The provision of effective space for knowledge work or office work in general presupposes knowledge about actual office work activities (Gjersvik & Blakstad, 2004). However, knowledge work is harder to describe than physical work because cognitive work cannot be observed directly. Descriptions of office work activities therefore are rather unspecific and abstract (Heerwagen, Kampschroer, Powell & Loftness, 2004):

- Office work typically consists in preparing texts and correspondence by computer, keeping track of schedules, events and records, filing and retrieving of materials, and communicating (formally or informally) with others by phone or face to face (Kroemer & Kroemer, 2001).
- Typically, a little more than half of the total working time is spent with desk work. Large-scale survey studies by Brill et al. (2001) show that professionals, engineers, and administrative personnel spend 61-64% of their time working quietly at their desks (Figure 2). Managers spend 48% of their time with individual quiet desk work. 16-30% of the total working time is used for communicative activities at the individual workspace (phone calls and meetings). These results are reported to be consistent across industries and across both public and private sectors. Similar results are reported by Vos & van der Voordt (2001) for office workers in the Netherlands. In their study 53% of work time is spend with desk work.
- Several studies describe interruptions in office work. Uninterrupted work periods last between 10 and about 30 minutes in software engineering (Perlow, 1999; Reder & Schwab, 1990) or managerial work (Mintzberg, 1990), for example. Gonzalez & Mark (2004) report an average duration of 12 minutes of working on a task before switching to another task. Switching between tasks may be caused by frequent interruptions (Perlow, 1999).
- Interruptions and task switching impede the completion of tasks. Therefore only portions of tasks are worked on at a given time and other portions of the same task and different tasks are held at a state of suspension. Interruptions

lead to decrements in performance and have a negative impact on well-being (Zijlstra, Roe, Leonora & Krediet, 1999).

- Social interaction is mostly face-to-face communication (Brill et al., 2001; Perlow, 1999; Reder & Schwab, 1990) although there are substantial differences between job categories. In Reder and Schwab's (1990) study, managers spent about 60% of their work time in face-to-face interactions. Professionals spent 25-30% of their work time in such interactions.

In summary, these results indicate that office work is a complex, opportunistic and reactive activity that can be described as situated action with constant adaptations of plans, tasks, and work activities (Suchman, 1987).

In order to establish a viable understanding of the environment for office work, it is necessary to understand the organisation - work environment relationship (organisation – accommodation relationship, Vischer, 1996) and the person – work environment relationship. In order to provide a conceptual link between physical environmental attributes and various levels of worker responses to those attributes, a theoretical framework composed of the socio-technical systems approach and action regulation theory is therefore presented in the following chapters.

2.2. Socio-technical systems perspective

In order to understand the accommodation of office work from an organisational perspective and to position office design activities in the organisational context, a socio-technical systems (STS) approach is proposed. STS theory provides a frame of reference for the analysis of organisations. It invokes a body of concepts to describe and explain the behaviour of organisations and their members. There is, however, no single body of concepts. Rather, the STS perspective directs attention to system component parts that contribute to the performance of organisations and their interrelation (Emery, 1993).
The STS framework has proved its applicability to workplaces in several studies (Duffy, 1997; O'Neill, 1998; Sundstrom, 1986). It forms the basis of the "organisational ecology" (Becker, 1990, 2007; Steele, 1986) approach that describes the workplace as a system composed of physical design, work processes, organisational culture, workforce, and technology. Becker (1990, 2007) uses the term „organisational ecology" in order to capture the fact that all organisations are characterised by the interdependence of social and physical systems. Organisational performance can only be understood within this framework of interdependencies and not by examining any single facet or component of the overall system.

The STS approach was developed by the Tavistock Institute in London in the late 1940s and early 1950s. The starting point was a study of coal-mining techniques (Trist & Bamforth, 1951). The researchers were mandated to investigate why productivity and staffing problems persisted despite an extensive programme of mechanisation in the coal pits. The researchers found that the introduction of new technology was paralleled by changes in the social organization of work. In particular, with the introduction of a new system of labour division the autonomy of the working groups and thus their self-regulation abilities had been limited. Trist and Bamforth (1951) demonstrated that the adverse consequences were not due to the introduction of technology but to the intervention in the social system. These results and further investigations (see van Eijnatten, 1993 for an overview) led to the conceptual development of the socio-technical systems approach. This approach regards the technical and the social subsystems within an organisation or a primary work system as separate but interdependent subsystems. The technical subsystem consists of the technical equipment, production materials, the technical conditions of the transformation process and the spatial conditions and structures. The social subsystem consists of all organizational members with their individual and group-specific abilities and needs, including their interaction relationships (Emery, 1993).

The raison d'être for a socio-technical system consists in the organisational aim or primary task. The primary task parallels the system's function in a larger context (i.e. the economic environment) and consists of the tasks that the system is designed for. It can be described as the transformation process of input into output. The concept of the primary task integrates the technological, economic, and socio-psychological aspects of a production system.
According to the STS approach organisations or organisational units as systems of production of goods and services are considered as primary work systems (Figure 3). They are composed of two parts: a technical and a social subsystem. Like any other system an operating unit does not work on the basis of the existence of its parts or elements but because of the relationships between them. The interplay between the technical and the social subsystem is characterised by the following two propositions (Frei, Hugentobler, Schurman, Duell & Alioth, 1993):

1. The technical and social subsystems do not function in the same way but according to different rules and laws. The technical system is governed by the laws of natural and engineering science, while the social system is characterised by the complexity of human behaviour.
2. The whole system cannot be optimised through the optimisation of each subsystem. Rather a joint optimisation is needed, i.e. technical planning and programming with the consideration of social criteria on the one hand and organisational development incorporating technical possibilities on the other hand.

In addition to the primary process, secondary processes support the primary task. The secondary tasks of a primary work system include all the additional tasks that are necessary in order to perform the primary task. Such secondary tasks relate to both the upkeep (e.g. maintenance, training) as well as the regulation (control of inputs, internal coordination) of the system. Organisations can be divided into several, more or less independent work systems. The tasks of these subsystems are either directly or indirectly productive primary tasks or support or secondary tasks (e.g. facilities management, human resources). A specific feature of work systems with secondary tasks as their main tasks is that their main objective is oriented at the secondary processes of productive organisational units in that they take over parts thereof. The tasks of productive and support units are therefore entwined and decoupling is possible only to a limited degree. For that reason secondary systems are difficult to differentiate from primary systems and influence on both the technical and the social subsystem. While support tasks may be called secondary from a business operations perspective, they are crucially important for an organisation's overall functioning.

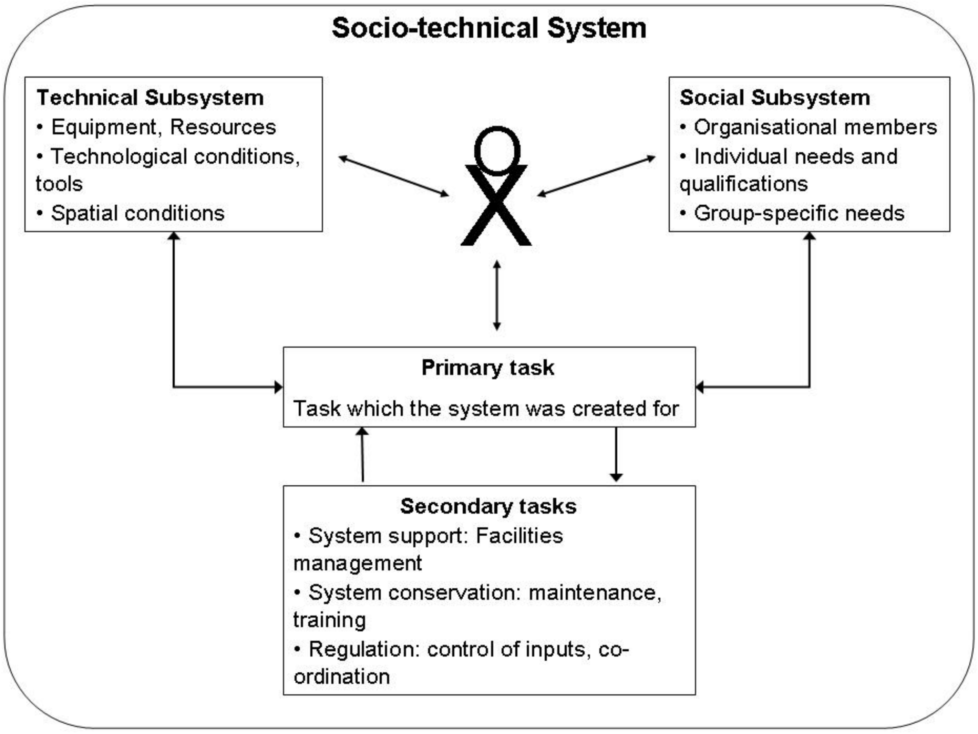


Figure 3. Socio-technical system (Ulich, 2001, modified)

In business organisations the integration of the technical and social subsystem are supported by various secondary functions and corresponding supportive and maintenance organisational units. Facilities management is one of these subsystems. It is usually described as the management of the non-core or secondary business functions. The differentiation between core and non-core functions, however, is difficult and can obscure the understanding of an organisation's functionality. In reality many functions of a business are part core and part non-core and therefore services – such as office-related FM services – are more than pure support services. They contain an enlarged potential for optimisation of the overall system (Barrett & Baldry, 2003).

The STS perspective stresses the interdependence of the social and the technical subsystem. It acknowledges, however, that the social and the technical subsystems are subject to different laws. Therefore and because of their

interdependence, the design of organisations for achievement of their primary tasks should focus the joint optimisation of the technical and the social subsystem (Clegg, 2000). The STS approach assumes that there are alternatives for organisational design that require deliberate choices (Trist, Higgin, Murray & Pollock, 1963). Thus STS argues against technological or environmental determinism. In connection with the requirement for joint optimisation, the socio-technical approach is characterised by a postulation for a work organisation that is oriented at workers' autonomy and responsibility. This requirement is justified with a higher overall system efficiency. Sustainable economic benefits can only be achieved through ensuring of workers' motivation, low absenteeism and low staff turnover. These goals can be reached by allocation of autonomy to the workers. The STS approach thus combines a capital- and labour-oriented assessment of work systems by theoretically justifying the compatibility of the two perspectives. Empirical results seem to confirm this compatibility (S. Parker & Wall, 1998).
The practical implications of a STS approach are twofold: first, it implies that the design of work environments has to consider not only design elements or single workstations but the whole work system. This implies that the design of the physical environment should be considered as one element of work system design. In the tradition of job and work design, this element, however, has not received much attention (S. Parker & Wall, 1998). The space, in which the social and the technical subsystems operate, influences the degree of effective integration of the two subsystems.
Second, it shows that humane work system design not only serves the benefit of employees but also the operational goals of improved organisational efficiency and productivity.

From an organisation-theoretic perspective the STS approach argues for a joint optimisation of the social and the technical subsystem regarding the primary tasks of an organisation. Facilities management adopts the secondary task of providing and managing space and services for the integration of technical and social aspects of organisational functions.
The contributions of FM for the optimisation of STS can be regarded from a strategic and an operational perspective. For workplace management, a strategic perspective means to raise the awareness for the relationship between an organisation and its physical environment and to use the built environment as a tool for better efficiency and effectiveness (Vischer, 1996). Such an approach deals with facilities and workspaces not only from a cost perspective but considers the systemic interrelations between technology, tasks, and social factors. The dimensions addressed by strategic workplace management are e.g. location, cost, functional quality, communication, symbolic meaning (corporate image and organisational identity) (Hatch & Cunliffe, 2006, chapter 7). Strategic workspace decisions are based on accommodation and occupancy intelligence (Vischer, 1996) and therefore are rooted in operational workspace management. Thus information on the design of physical workspaces that simultaneously support work processes, organisational members' preferences and needs, and organisational

objectives and aims have to be collected and exploited (Chan, Beckman & Lawrence, 2007).

Depending on the general strategic approach towards workspaces, Vischer (1996) distinguishes between a cost and an investment model of workspace strategies. The cost model considers space as a liability. By contrast, the investment model regards space as an asset and as a central factor influencing the work style and business mission of the organisation. The latter model acknowledges that operation costs (mainly staff costs) outnumber construction and maintenance costs by several orders of magnitude over the lifecycle of an office building[2]. Workspace planning according to the investment approach is understood as part of the strategic planning process and carries the expectation that the work environment will support the work processes and, in turn, the creation of value to the organisation. Office spaces are seen not only as expenses but as a means to establish and manage organisational behaviours and creating organisational culture (Becker, 1990; Vischer, 1996).
Following this approach, indirect effects of design contribute to the assessment of work environments as well as do costs. Indirect costs and benefits influenced by workspace design are mediated by factors such as health, well-being, social climate, satisfaction, and performance (Heskett et al., 1994). These costs have not been analysed in their influence on organisational profitability. In organisational reality, behaviour and experience of employees exposed to specific work environments can quickly become cost relevant, e.g. through sick leave or absenteeism, inefficiencies due to lack of information or reduced performance caused by low satisfaction with the work environment. Accordingly, the benefits associated with the investment model are indirect and complex in nature.

2.3. *Organisational workplace management*

In the tradition of the socio-technical systems approach the physical work environments have not received much attention. Emery (1993) acknowledges the influence of physical layouts on co-ordination, social support among the workforce and interpersonal contacts. The role of the physical work environment, however, has not been further clarified within the STS perspective.
From the macro perspective of organisational theory, however, other approaches recognise the significance of the physical work environment. Horgen and colleagues (1999) consider “workplace making” as an element of strategic organisational development. According to these authors, workplace making extends beyond the design of physical spaces and includes the analysis of underlying conditions and objectives. In their framework, organisational design and development is understood as an interaction between four interdependent dimensions of the workplace: Space, organisation, technology, and finance. More

[2] R. Evans, Haryott, Haste & Jones (2004) estimate a ratio of 1 (construction costs): 5 (maintenance costs): 200 (costs of the operation being carried out in the building, including staff costs). A more thorough empirically based estimation by Ive (2006) results in a ratio of 1 : 1.5 : 15 for Central London office buildings.

generally, organisational theorists consider design and management of space a key element of the organisational environment and as such an important dimension of planned organisational change and organisational development[3] (Porras & Robertson, 1992; Porras & Silvers, 1991).

The significance of the built environment for the effective operation of an organisation is rooted in the fact that buildings and spaces are constructed for particular purposes or functions. Functional and programmatic aspects are translated into spatial forms. Thus, offices can be regarded as production factors. This translation process is dependent on international cultural differences and organisational peculiarities. Although the most general functional requirements for office buildings should be the same in different parts of the world, international differences can be observed (Van Meel, 2000; Van Meel, de Jonge & Dewulf, 2006): Form does not follow function the same way everywhere. The reasons for that are the interpretation of functional requirements, the assessment of the relative importance of the requirements and their translation into design solutions. Furthermore market, regulatory requirements concerning health and safety, and the power of trade-unions may play a role (Van Meel, 2000).

The contribution of physical work environment design to organisational operations is threefold:
First, topography and layout determine and direct behaviour or possibilities for behaviour respectively: People cannot go through floors and see through walls. Thus, the physical environment poses natural constraints on human action (Norman, 1988). The boundaries that divide the built environment and the connections between elements of the built environment organise the way in which people act, come together, and remain apart (Peponis & Wineman, 2002). Space syntax (Hillier & Hanson, 1984; Peponis, Bafna, Bajaj, Bromberg, Congdon, Rashid, Warmels, Zhang & Zimring, 2007; Rashid, Kampschroer, Wineman & Zimring, under review) is a theory of architecture and space based on the idea that configuration (i.e. the way in which spatial parts are put together) is a key and necessary resource for social organisation and influences social interaction.

Second, the physical (material and ambient) work environment is not only context and condition for individual actions but also for individual reactions in terms of well-being, health, satisfaction, motivation, and productivity (Rashid & Zimring, 2008). These factors are discussed in more detail in chapter 5 and 6.

Third, the design of the physical environment reflects and reinforces organisational culture. According to Schein (2004) „meaning and use of space [are] among the most subtle aspects of organizational culture because assumptions about space, like those about time, operate outside of awareness and are taken for granted“ (S. 163). These assumptions become visible when the corresponding rules are broken. The emotional reactions provoked in doing so are

[3] The other dimensions mentioned by Porras & Robertson (1992) are technology, social factors, and administrative arrangements.

rooted in the symbolic functions of space: status, social distance, and membership. Status inconsistency, for example, leads to dissatisfaction and reduced performance (J. R. Carlopio & Gardner, 1992; Greenberg, 1988; Zalesny & Farace, 1987).

The individual level of analysis is considered as fundamental, because of its importance in the service economy where perceptions of service encounters are crucially important (Bitner, Booms, & Tetreault, 1990) and because of its influences the group and organisational level (Cairns, 2008; Vischer, 2007a). Adopting an individual-centred perspective means that the office user's experience and assessment of the built environment is central. The study of user experience promises a better understanding of the influences of the environment (Vischer, 2008). The Hawthorne studies (Roethlisberger & Dickson, 1939)[4] disproved the deterministic-mechanistic approach of environmental influences and pointed out the perceived qualities of the environment. Thus, for the behavioural relevance of a given environmental exposure not the physically measurable quality is crucial but its function for a person and his/her actions. This approach does not require an abstraction of physical parameters but an extension of such measures with subject- and action-related terms (Schultz-Gambard & Hommel, 1987).

The theoretical approach for subject-related data chosen for this research is the Job Demands-Resources model (Demerouti, Bakker, Nachreiner & Schaufeli, 2001). This model categorizes work conditions into demands and resources that relate in different ways to positive and negative outcomes. The Job Demands-Resources model is a theoretical framework that integrates two approaches to work design: the stress research and the motivation research tradition. Although some questions related to the processes postulated in the model remain open, it is a popular model in burnout and work engagement research (Bakker & Demerouti, 2007).

[4] Although the scientific value of the Hawthorne studies is disputed (e.g. Carey, 1967; Parsons, 1974) and they have never been published in scientific journals, they are noteworthy because they stand for a paradigm shift in the history of social science.

3. The Job Demands-Resources model

Occupational stress research over the past six decades has resulted in different theories and models that describe the antecedents and processes of stress in organisations and the individual and organisational outcomes (see Cooper, 1998 and Sonnentag & Frese, 2003 for an overview). Theories focusing stress reactions that are still common in application today include e.g. the Job Demands-Control model (Karasek, 1979), the Person-Environment Fit model (French, Caplan & Harrison, 1982; Edwards, Caplan & Harrison, 1998), the Effort-Reward Imbalance model (Siegrist, 1996, 2002), and the Vitamin model (Warr, 1999).

The Job Demands-Control model identifies two critical job aspects related to job strain: job demands and job control (Karasek, 1979). While job demands refer to sources of stress (stressors) such as work load demands, job control refers to decision latitude, i.e. the worker’s potential control over his tasks and his conduct during a workday (Karasek, 1979). The Job Demands-Control model focuses on the interaction between these two core job aspects and postulates that a combination of high demands and low control causes job strain.

The Person-Environment Fit model assumes that stress arises from misfit between the person and the (job) environment (French, Caplan & Harrison, 1982; Edwards, Caplan & Harrison, 1998). Person-Environment Fit models have been described in different versions: Person-environment fit focuses on the fit between employee’s needs and environmental supplies and/or on the fit between environmental demands and individual skills and abilities (Edwards, Caplan & Harrison, 1998).

The Effort-Reward Imbalance model is based on the concept of reciprocity. Its basic assumption is that effort at work is spent as part of a social exchange process in which this effort is compensated by occupational rewards such as money, esteem, and career opportunities (Siegrist, 2002). The central hypothesis of the model postulates that the lack of reciprocity between costs (intrinsically and extrinsically motivated efforts) and rewards leads to a state of emotional distress and associated strain reactions (Siegrist, 1996).

The Vitamin model relates job characteristics and employee well-being. Warr (1990) distinguishes three principal axes of employee well-being: (1) from displeasure to pleasure (e.g. job satisfaction), (2) from anxiety to comfort, and (2) from depression to enthusiasm. Warr (1999) acknowledges that the three dimensions are intercorrelated, but have partly different causes and outcomes. The Vitamin model received its name because the influences of job characteristics on employees are proposed to be non-linear, analogous to the impact of vitamins on physical health (Warr, 2009). Some job characteristics are thought to affect well-being in a curvilinear way, similar to the effect of vitamins A or D on health. Other job characteristics are assumed to follow a linear pattern, similar to effects of vitamins C or E on health.

While these theoretical models have received empirical support (see Van der Doef & Maes, 1999 for the Job Demands-Control model; Edwards et al., 1998 for the Person-Environment Fit model; Siegrist, 2009 for the Effort-Reward Imbalance model, and Warr, 2009 for the Vitamin model), they have been criticized for their limitation to given and limited sets of predictor variables that may not be relevant for all job positions. Furthermore, the static character of the models is a related point of critique (Bakker & Demerouti, 2007). Finally, due to the neglect of resources, models of stress have focused on the relationship between stressors and strains from a limited perspective of negative effects.

In an attempt to overcome these limitations, a group of German and Dutch psychologists have developed the Job Demands-Resources (JDR) model of occupational stress (Bakker & Demerouti, 2007; Demerouti et al., 2001). This model integrates a focus on negative job characteristics (reducing job demands) with a focus on positive aspects of the work environment (increasing job resources) with regard to employee well-being. Studies support the proposition that job resources can increase levels of work engagement in periods of high job demands (e.g. Hakanen, Schaufeli & Ahola, 2008) and the Job Demands-Resources model was a stronger predictor of job satisfaction and emotional exhaustion than either the Job Demands-Control model or the Effort-Reward Imbalance model (e.g. Lewig & Dollard, 2003). The Job Demands-Resources model has proven its robustness across different occupations and nationalities (Llorens, Bakker, Schaufeli & Salanova, 2006).

The Job Demands-Resources model (Bakker & Demerouti, 2007; Demerouti et al., 2001) is based on the assumption that all work activities are associated with specific risk factors of job stress. However, it posits that job relevant environmental factors can be classified into general categories of job demands and job resources. Whereas occupations have their own specific risk factors associated with negative outcomes such as ill health, dissatisfaction, or performance, these factors can be classified into job demands and job resources. Thus, this model can be applied to different occupational settings.
Job demands refer „to those physical, social, or organizational aspects of the job that require sustained physical or mental effort and are therefore associated with certain physiological and psychological costs (e.g., exhaustion)“ (Demerouti et al., 2001, p. 501). Job demands are not essentially negative. They turn into stressors when they require extra effort and are therefore associated with high costs (Schaufeli & Bakker, 2004). These costs may elicit negative responses such as reduced well-being or ill health. When faced with stressors, workers use strategies to protect their performance (Hockey, 1997) and resources (Hobfoll, 1989) (see chapter 4.2). Examples of job demands are work pressure, unfavourable physical environments, or emotionally demanding interactions (Bakker & Demerouti, 2007).
Job resources refer to „those physical, psychological, social, or organizational aspects of the job that are either/or:

- Functional in achieving work goals.

- Reduce job demands and the associated physiological and psychological costs.
- Stimulate personal growth, learning, and development“ (Bakker & Demerouti, 2007, p. 312).

Resources are thus not only important for dealing with job demands, but they are also important in their own right because they are means to protect other valued resources (Bakker & Demerouti, 2007, Hobfoll, 2002). Resources can be found at organisational level (e.g. pay, career opportunities, job security), the interpersonal level of social relations (e.g. social support, team climate), at the level of the organisation of work (e.g. role clarity, participation), and at the level of tasks (e.g. skill variety, holistic task, scope of action) (Bakker & Demerouti, 2007).

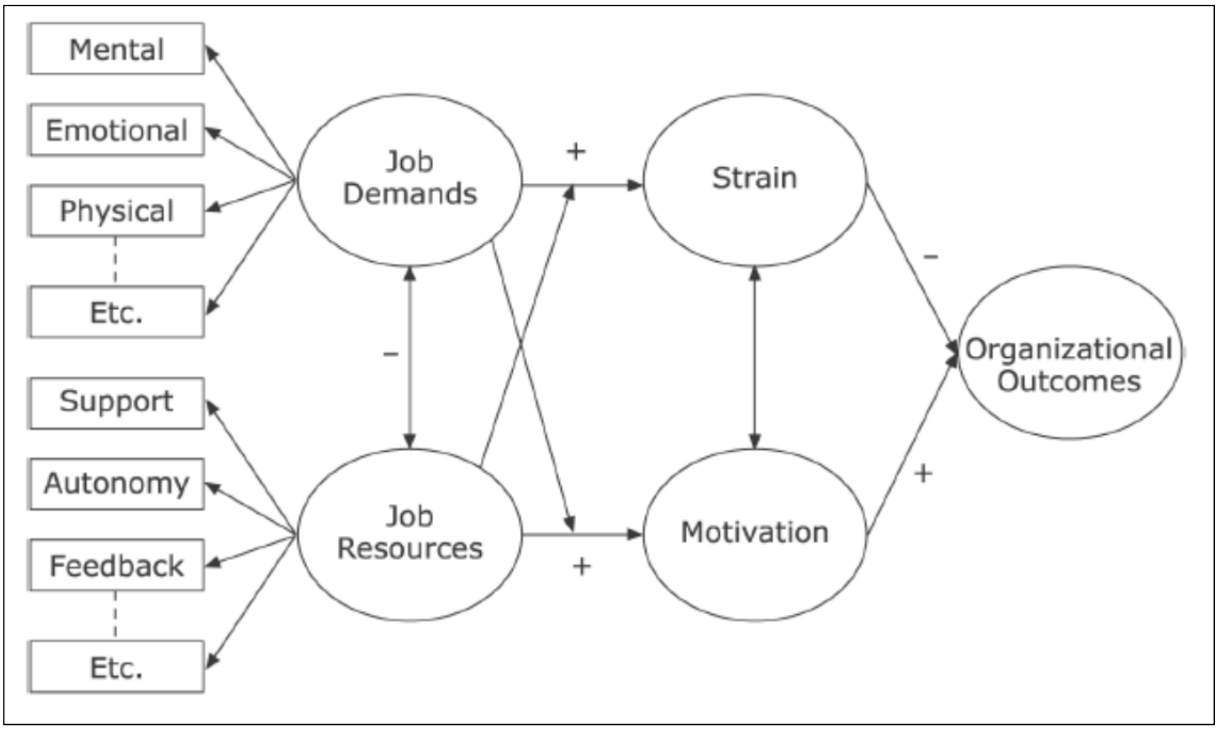


Figure 4. The Job Demands-Resources model (Bakker & Demerouti, 2007, p. 313)

According to the Job Demands-Resources model two different processes in the development of job strain and motivation should be considered (Figure 4): (1.) the health impairment process states that poorly designed jobs or chronic job demands (stressors) exhaust employees’ mental and physical resources. Job demands lead to the depletion of energy (e.g. burnout, Demerouti et al., 2001) and to health problems. The process that leads to these negative outcomes is based on the performance protection strategies that individuals use under the influence of environmental demands (Hockey, 1997). Performance protection consists of greater activation and/or effort and thus increases the physiological costs for the individual. (2.) The motivational process postulates that job resources have motivational potential and lead to high work engagement and performance. According to the definition of resources they may play either an intrinsically motivating role because they foster employees’ growth, learning, and

development, or they can play an extrinsic motivational role because they are instrumental in achieving work goals.
The current version of the Job Demands-Resources model proposes that the interaction between job demands and job resources is important in addition to the main effects of job demands and job resources (Bakker & Demerouti, 2007).

With the two processes by which the stressor-strain relationship occurs described above and their interaction, the Job Demands-Resources model integrates and expands previous models of stress and well-being and thus provides a new perspective on work and work environments. The JDR model overcomes several limitations of previous approaches: (1.) In contrast to the Job Demands-Control model it considers the main additive effects of demands and resources instead of focusing on the interaction of these factors. Furthermore, the JDR model suggests that different outcomes are associated with demands and resources (Demerouti et al., 2001). (2.) The JDR model considers both, motivational and energy-related processes, while previous models focus on a combination of demands and the lack of resources that is perceived as stressful leading to exhaustion and ill health. (3.) The JDR model is more versatile because it is not limited to a specified set of predictors, i.e. specific demands and (lacking) resources for all occupations, jobs, and employees. Bakker & Demerouti (2007) refer to evidence showing that research has revealed more variables influencing health, well-being, and performance than is captured by approaches such as the Job Demands-Control model or the Effort-Reward Imbalance model, e.g. physical or emotional demands. These extensions of previous perspectives and the robustness of the JDR model across different occupations make it appear suitable for the study of work environment as composed of physical surroundings, job design, and social aspects.
One of the strengths of the JDR model, namely its versatility may, however, also be a weakness because it may give way to arbitrariness in variables considered. The JDR approach is therefore needs to be considered as a framework rather than a theoretical model and the content of the JDR models need to be defined for specific studies. Demands and resources in the Job Demands-Resources model are defined in function but not in content because they differ between different occupations. For the analysis of office work and physical work environments, the elements of the environment must be classified as demands/stressors or resources on theoretical and/or empirical grounds.
In order to develop contents of demands and resources on theoretical grounds, action-regulation theory and an action-regulation approach to stress and strain are introduced in the following chapter. Action-regulation theory provides a theoretical basis for the identification and specification of job demands and resources.

4. Action theory

The Hawthorne experiments (Roethlisberger & Dickson, 1939) are a milestone social science[5]. The investigators set out to understand the effects of illumination on workers' performance. A group of selected employees moved to a specially prepared space and worked under varying lighting conditions. The results were surprising: regardless of the direction and magnitude of change in lighting, the work output of the employees increased. These results led to a seminal series of studies concerning the relationships between employers and employees. The investigators realised that the special experimental setup and effects of the social situation, such as informal relationships between employees and investigators, were crucial for the understanding of the results. The focus of the investigations thus was shifted from the work environment to the social relations. It was concluded, that the physical environment at work was relatively unimportant regarding workers' performance.
This conclusion, however, is based on the oversimplified assumption that there is a direct cause-and-effect relationship between physical conditions and human behaviour. Because workers' output was not improved by changes in lighting levels but by social relations, the investigators assumed that light levels were irrelevant to performance. Psychologists now know that there are complex cognitive processes that mediate the effects of physical conditions on human behaviour (Frese & Zapf, 1994; McGrath, 1976; Miller, Galanter & Pribram, 1960).

These cognitive processes can be analysed as information processing (Anderson, 1995) or as a component of human action (Nitsch, 1985, Roe, 1999). Thus, a simple behaviouristic stimulus-response approach is too limited to explain human activities and their components and actions that are motivated by higher-order goals.
Action theory is concerned with the processes that intervene between environmental input and behaviour: the regulatory functions of cognition (Frese & Zapf, 1994). Human action is regarded as regulated by goals in a cybernetic control loop (Miller et al., 1960). A general model of human action can be described as an action cycle that consists of the following steps (Frese & Zapf, 1994; Norman, 1988):

- perception of the environment,
- interpretation,
- appraisal and goal development,
- plan generation,
- decision, and
- execution and monitoring of the plan.

The action process is thus followed by perceptions and processing of feedback leading to a new cycle of orientation and goal development.

[5] See footnote 4.

In its more general formulation this approach assumes causal relations between the environment and individual reactions (Figure 5). It assumes that individuals react to features of the environment perceptually, affectively, and behaviourally. The three components of this model form the basis of much applied research in industrial and organisational psychology (e.g. Spector, 1992) and environmental psychology (e.g. Bell, Greene, Fisher & Baum, 2001). Outcomes in this model may consist of behaviour (e.g. performance), attitudes (e.g. satisfaction), cognitive results (e.g. learning), or emotional reactions (e.g. mood).

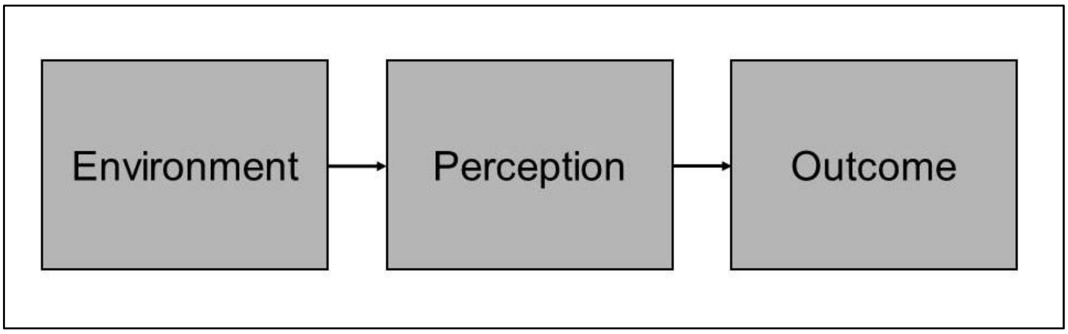


Figure 5. Traditional model of individual responses to organisational conditions (Morgeson & Campion, 2003; Spector, 1992)

There is considerable evidence for this general causal chain (Spector, 1992). However, the influences of the social environment and person-related variables such as personality, mood, and dispositions on attitudes and outcomes should not be neglected when the main aim of research consists in explaining certain behaviour. In this research the focus is on the influences of environmental aspects of office design. Social and person-related influences are addressed to a lesser degree. Generally, it is assumed that social influences will be balanced over the sample of organisations analysed and that person-related effects will be balanced in the sample of participants and its subgroups[6].

The regulatory character of cognitions is described in the action-theoretic framework by McGrath (1976) (Figure 6). He distinguishes four stages in human action: The four-stage closed-loop cycle begins with a situation that can be described as a set of circumstances in the socio-physical environment. This situation is perceived and assessed by the focal person. Based on the subjectively perceived and assessed situation a response alternative is chosen and executed with the intention of changing the relation to the situation in a favourable direction. That response leads to consequences for the focal person and the situation.
The four stages are connected by four linking processes which provide the substance for explaining human behaviour. The appraisal process describes the perception of a situation in relation to expectations and results in the experience

[6] In statistical terms this assumption is known as the Central Limit Theorem. It states that with sufficiently large samples sizes, sampling distributions of means are normally distributed (Tabachnick & Fidell, 2007).

of a situation. The process link between the perceived situation and response selection is a decision making process. It consists in relating the situation to available alternatives and choosing a response or a set of responses in order to deal with the undesirable features of the situation. The third process link is the performance process which results in a set of behaviours. The performance process depends on ability, task difficulty, motivation, and standards used to assess performance. The fourth process links the behaviour with its consequences. In contrast to McGrath (1976) not only the consequences for the situation (outcome, effect, change) are considered, but also the consequences for the focal person are considered. These consequences concern evaluation of own performance, learning, and affective reactions.

According to this framework the human-environment relationship is considered as an interaction. The actions of a person are not determined by his/her environment but the person conceives options and alternatives regarding the perceived situation and the possible course of action. Accordingly, cognitions are both cause and effect of actions.
From a point of view of action-theory, the main content of these cognitions is goal development, since action is defined as goal-directed behaviour. Action is considered the smallest behavioural unit that is related to a conscious goal. The notion of goal integrates motivational and cognitive aspects (Locke & Latham, 2002): Goals serve a directive function because they direct attention toward goal-relevant activities and away from irrelevant activities. Goals have an energizing function and high goals have been shown to lead to greater effort than low goals. Finally, goals affect action indirectly by leading to activation, discovery, and/or use of task-relevant knowledge.

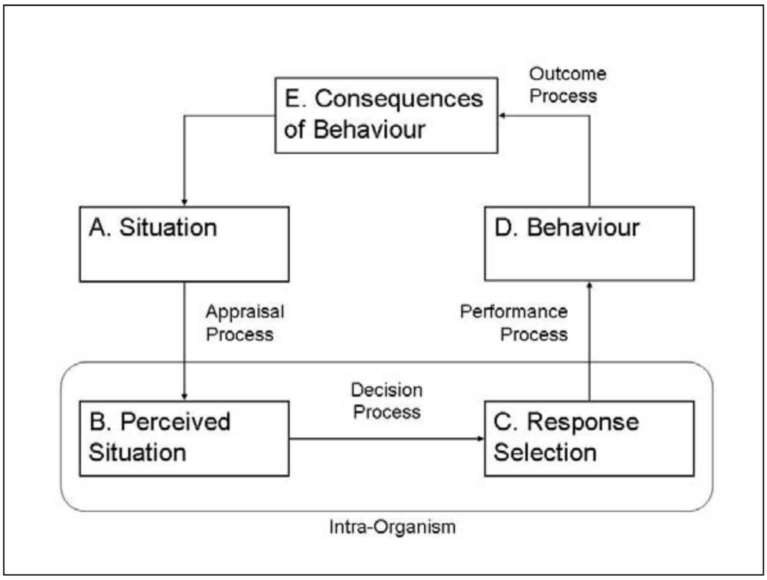


Figure 6. Framework of human action (McGrath, 1976, modified)

Like any theory about human thinking, action, and learning, the action theoretical approach is rooted in a specific idea of man. The acting man is regarded as an active, goal-oriented being that consciously deals with its environment. In this human-environment interaction the environment is altered and at the same time the actor is influenced by the environment.

Environment behaviour interactions therefore also have to be analysed from a long-term perspective, including e.g. the formation of attitudes and their role for behaviour. Further long-term effects concern health, well-being, and social behaviour. Thus, an extension of the traditional model (Figure 5) for office work environments is adopted for this research. This model is based on Marans and Spreckelmeyer's (1981) work (Figure 7).

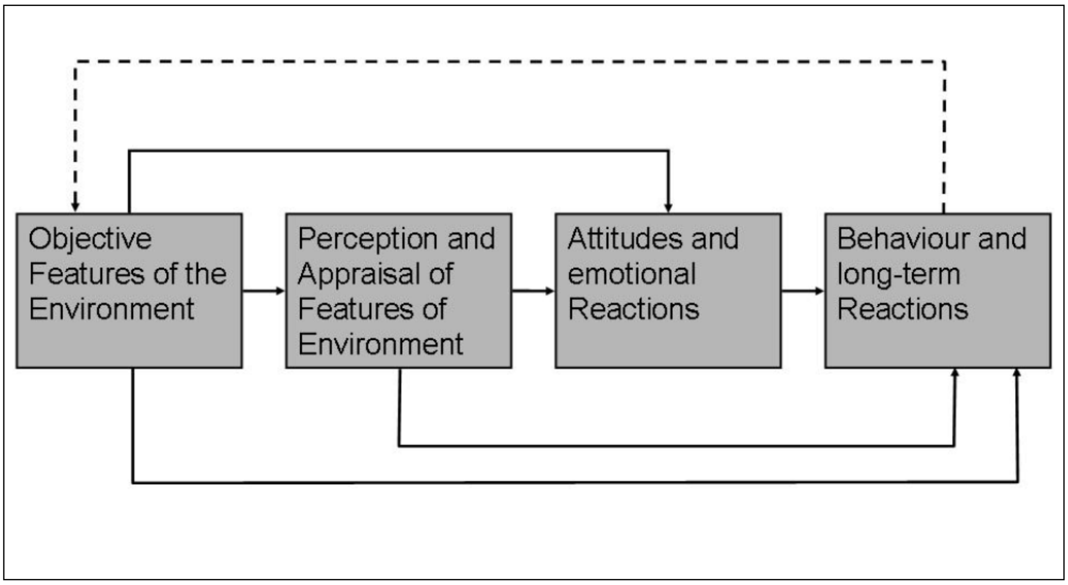


Figure 7. Conceptual model of environment-behaviour relationship (Marans & Spreckelmeyer, 1981, p. 22, modified)

Perception and appraisal are combined because they occur in the same phase of the process but also because they are active constructions. According to Neisser (1976) perception is best understood as a schema-based cyclical process. The active schema directs exploratory perceptual action in the environment. The information picked up during the exploration results in modifications of the schema. The altered schema eventually facilitates the acquisition of more information and so on.

Repeated action processes in the same environment leads to the development of attitudes towards environmental objects (Bargh, 2001; Eagly & Chaiken, 1993). The development of attitudes (e.g. satisfaction) and emotional reactions is influenced by processes of perception and appraisal. Attitudes and emotional reactions in turn influence decision making and behaviour in the environment or setting and long-term reactions (e.g. health). Thus the results in terms of productivity and effectiveness of people working in offices are partly dependent on the design of the office environment.

A more detailed account of the effects of the work environment on work activities and worker's experience based on the action cycle (as described above) is provided by the action regulation theory.

4.1. Action regulation theory

Action regulation theory has a long history in German work and organisational psychology (Hacker, 1998; Volpert, 1982, 2003). The basic tenet of this theoretical approach is that work is goal directed. Action regulation theory emphasizes the cognitive regulation of actions. It "relates remarkably well to current cognitive models of human activity" (Roe, 1999, p. 238) and integrates several theoretical approaches.

Action regulation theory allows the independent definition of resources (regulation demands), work load factors (regulation problems), and health (Ducki, 2000). Furthermore, action regulation theory focuses the interplay between the objective world and subjective reactions and experience.

For these reasons, action regulation theory is considered as particularly well suited for joint analysis of work content factors and physical work environment.

4.1.1. The hierarchical-sequential model of action regulation

Miller et al. (1960) introduced the concept of cybernetic regulation in action psychology and developed a model that forms the basis of current action regulation theories, such as the German action regulation theory (Frese & Zapf, 1994). According to Miller et al. (1960), an actor compares situations or stimuli with expectation parameters or plans. In the case of incongruence he tries to reach congruence through action. He then compares the new situation with his plans and decides whether new action is needed in order to produce congruence. Such comparison processes are modelled as cybernetic TOTE (Test-Operate-Test-Exit) units (Figure 8) that can be in nested hierarchically (Figure 9). The cybernetic theory of action regulation models the translation of goals into plans, the execution of plans through action and feedback. The theory of Miller and colleagues (1960), however, does not specify the action *process*. It is therefore not able to explain the influences of an environment that may change goals or plans. Furthermore, this model is not able to capture multiple simultaneous goals of an actor (that may be achieved by one or multiple actions).

On the basis of the cybernetic theory of action regulation the hierarchical-sequential model of action regulation was proposed by German work psychologists (Frese & Zapf, 1994; Hacker, 1998; Volpert, 1982). It is based on the assumption that human activity can be characterised as goal-oriented and conscious. Action is oriented towards a mentally anticipated result and deliberately regulated towards this goal.

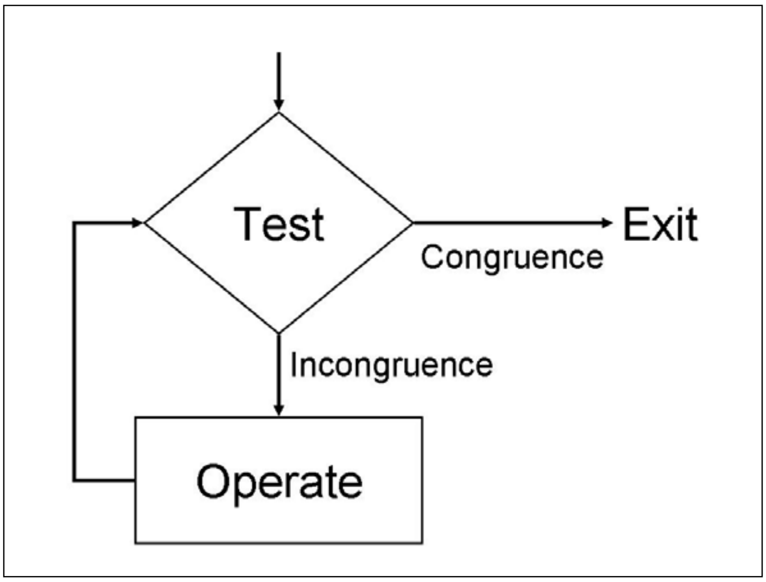


Figure 8. Test-Operate-Test-Exit (TOTE) Unit (Miller et al., 1960)

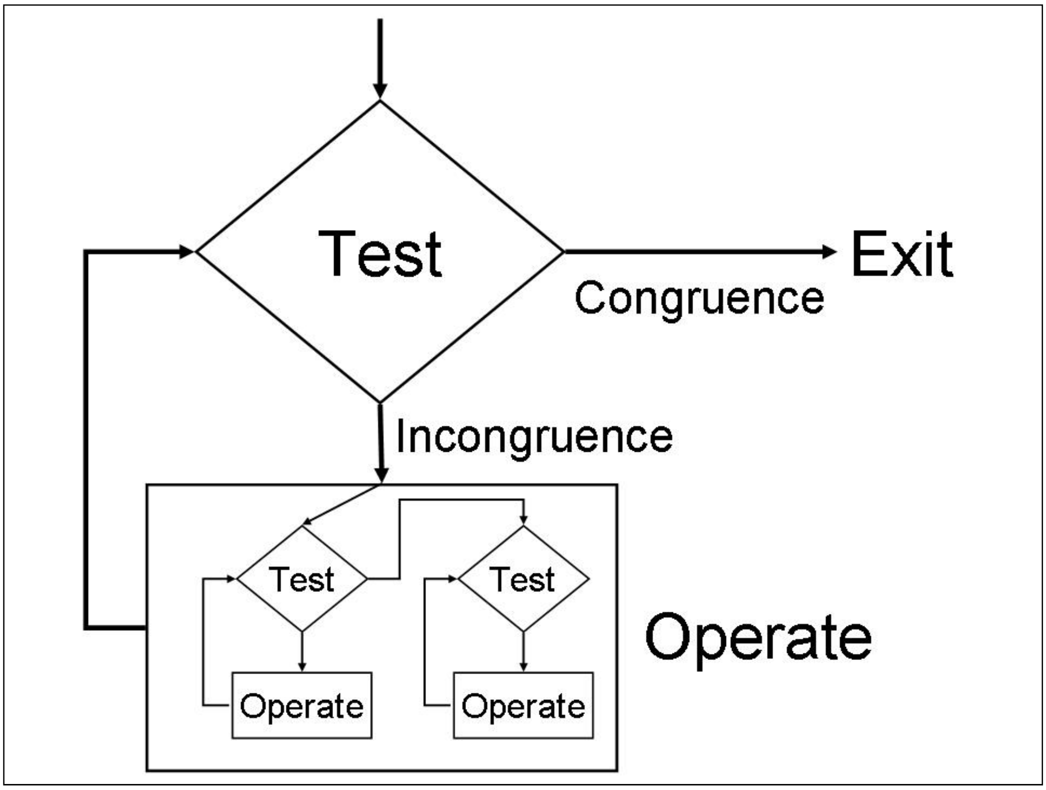


Figure 9. The hierarchical structure of TOTE units (Miller et al., 1960)

Additionally, human activity is considered as integrated in physical environments and societal contexts. Despite this consideration of context, physical environments and conditions of action are hardly addressed from the perspective of action regulation theory. As an explanatory framework it is useful, because action regulation theory addresses principally all forms of environmental demands.

Research and application related to this theory, however, have mainly focussed the design of work tasks and learning (Hacker, 2003).

The hierarchical-sequential model of action regulation describes action from a process and a structural point of view. The process component focuses on the sequential aspects of action and the structural component refers to its hierarchical organisation.

The core unit of action regulation is a cyclical unit comparable to the TOTE-Units developed by Miller et al. (1960): As a function of goal-setting, series of transformations of the environment are produced. In work contexts goals are in essence defined by work tasks (as they are understood and interpreted by the worker). The sequence of transformations is defined through a preliminary run before performance (i.e. the execution of a series of transformations) begins; the transformations are queued to be worked through (Volpert, 1982). Then feedback takes place and the degree of goal-attainment is examined. If differences remain, transformations are repeated, adapted, or the goal is modified.
Figure 10 shows Volpert's model of the cyclical unit. The descending arrow and the straight arrows from left to right show the generating process of transformations (based on goal G transformations T1 to T4 are generated). These transformations are sequentially worked through when the generating process is finished (curved arrows). After the last transformation is performed, feedback about goal-attainment follows (ascending arrow). If the achieved state corresponds to the goal the cyclical unit is completed.

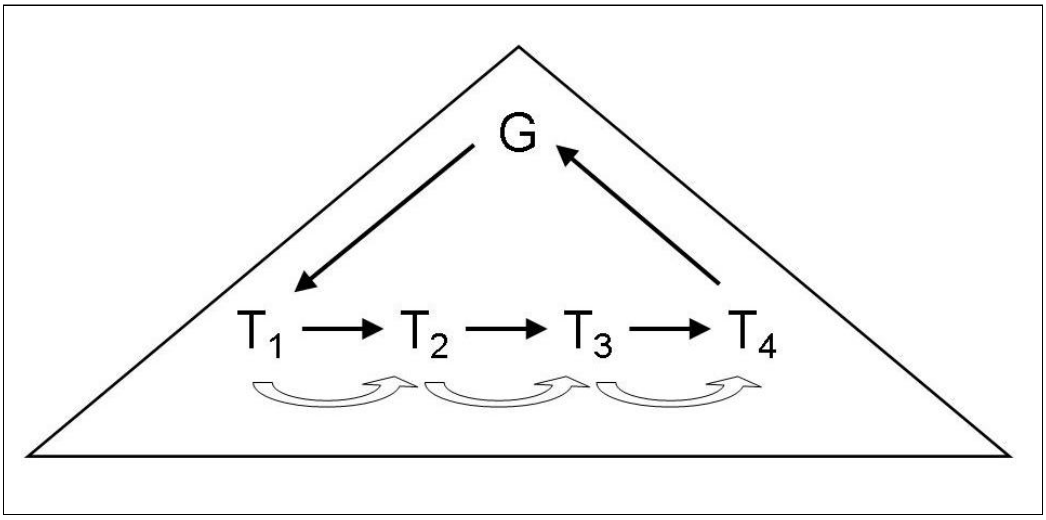


Figure 10. The cyclical unit (Volpert, 1982)

Every cyclical unit is part of a system that is composed of multiple interlaced cyclical units. Complex action structures emerge when multiple cyclical units are connected in a hierarchical order (Figure 11). On the lowest level base-units represent directly performable operations and on the highest level a peak-unit represents a hypothetical general goal. In principle the number of levels and the number of transformations is arbitrary but there are psychologically substantiated reasons to assume only three levels (Frese & Zapf, 1994; Hacker, 1998). In the hierarchical-sequential model of action regulation the following three levels of regulation are distinguished: The sensorimotor level is the lowest level of regulation. It contains stereotyped and automated movement sequences which are executed without conscious attention (as long as they remain undisturbed by external circumstances). From a point of view of action regulation, sensorimotor regulation is the interface between the acting person and his/her physical environment. Conscious regulation occurs on the next level, called perceptive-conceptual level. This is the level of flexible action patterns where execution happens by means of operation sequences learned before, guided by perception of signals that have been learned before. These action patterns can be adjusted to the situation and are accessible to consciousness. Regulation on this level is not necessarily conscious, though. The highest level of regulation is the intellectual level. On this level situations are analysed and action sequences planned. Actions concerned with problem solving are regulated on this level in form of analysis of goals and environmental conditions, decision making and planning. Regulation on this level is laborious and resource-limited. It works in a serial mode and feedback is interpreted step by step (Frese & Zapf, 1994). Regulation on the intellectual level is necessarily conscious.

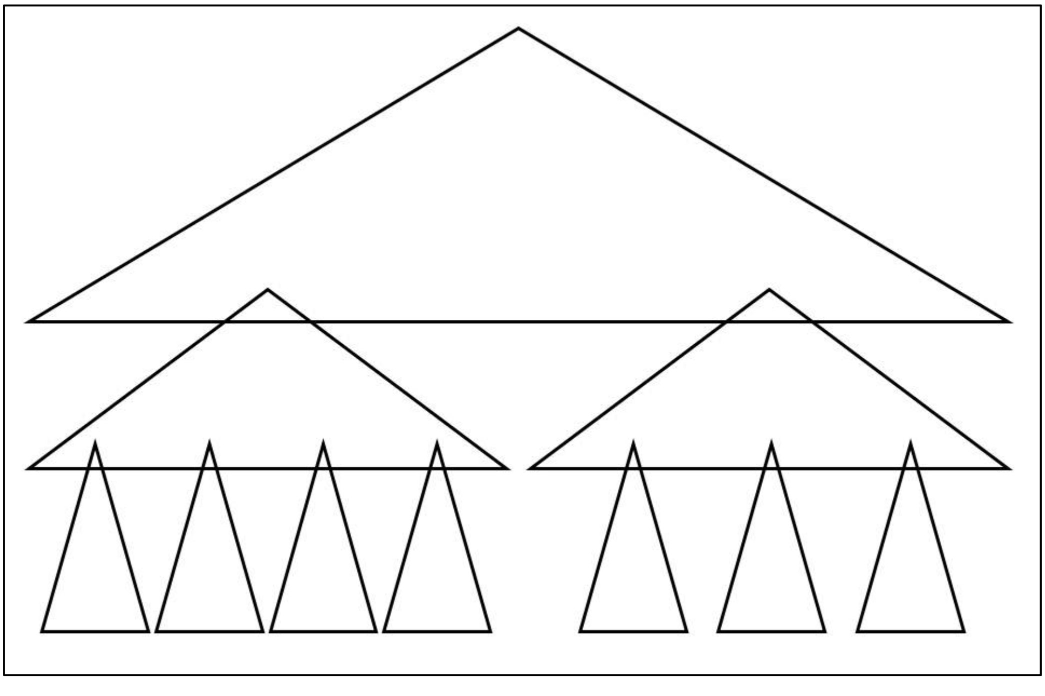


Figure 11. The hierarchical order of cyclical units (Volpert, 1982)

The hierarchical-sequential model of action regulation can be described as a model of interlaced cyclical units: a cyclical unit can be the transformation part of a higher unit. Reversely, the transformation parts of a cyclical unit can be described in its structure as a cyclical unit. In a context of occupational activities, the starting point for actions is the work task (Hackman, 1969). With complex actions higher order goals are formed and partial goals and subgoals are derived. Thus, a hierarchical action plan in form of goals and transformations develops. The execution of actions occurs sequentially in the form of operations that change the environment. Goal-attainment is fed back to the next higher level. The subgoals are worked through in a sequential order (Figure 12).

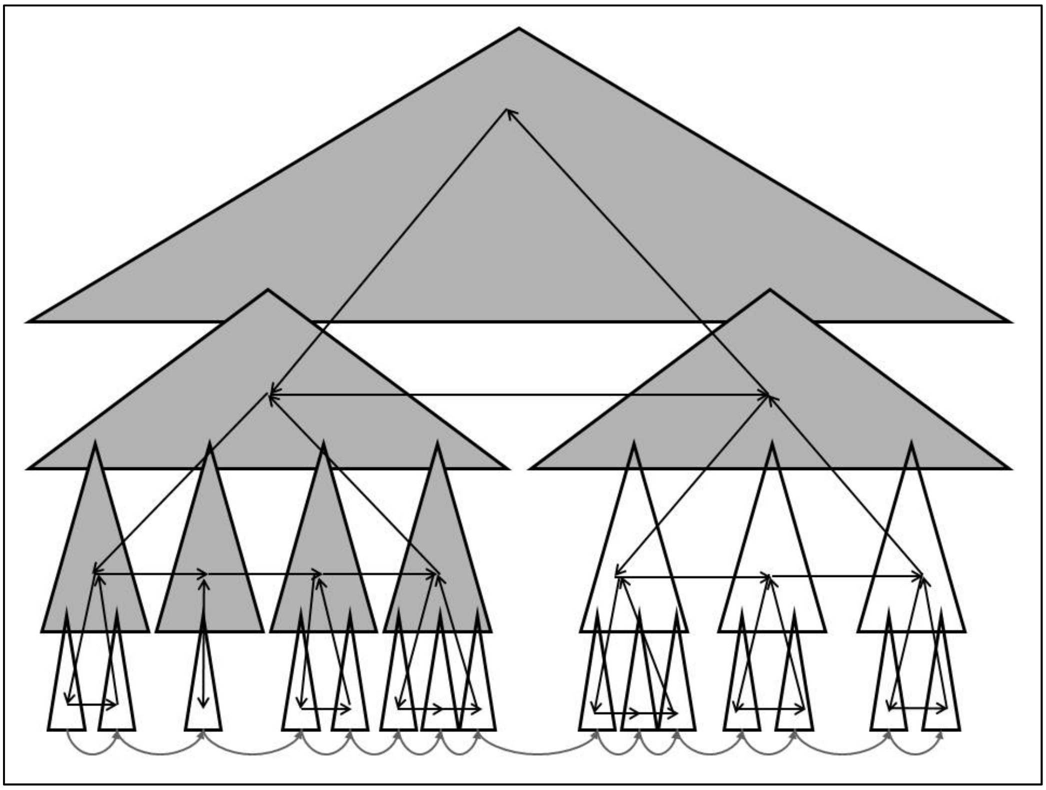


Figure 12. The hierarchical-sequential organization of action (Volpert, 1982)

For the generation of complex action systems the human ability to anticipate goals is crucial because it permits the ordering of transformation. In order to plan actions, mental “rehearsals of actions” are performed (Volpert, 1982, p. 43). This anticipation (or “tentative action”, Volpert, 1982, p. 43) takes place without feedback from the actual environment and therefore requires a mental representation of the environment and the possibilities for actions within. This representation, however, does not have to be complete. Only those issues that are important for the tasks are needed.
In the action process initially only a rough planning of partial goals takes place (Frese & Zapf, 1994). The generation of more detailed sub-units occurs successively. This implies that disturbances can be corrected on the level where they occur and thus do not necessarily negatively impact higher order goals. Therefore, unexpected environmental changes or errors in planning or execution of transformations do not lead to disruptions of the pursuit of a higher level goal but to modifications or repetitions of lower-level cyclical units. Thus the model of hierarchical-sequential organisation regulation allows the explanation of stable long-term goal-oriented and at the same time flexible actions.

4.1.2. Regulation requirements

Dealing with simultaneous multifactorial requirements in work contexts, workers must decide how they want and can deal with these requirements in order to work effectively and efficiently. The regulation requirements are related to properties of the hierarchical-sequential organization of action (Frese & Zapf, 1994). The main regulation requirement is complexity. Complexity describes a set of decision necessities. Tasks and goals with a high complexity require a high degree of regulation. Complexity is understood as an interactive term and refers to a person's skills in relation to the necessities of the situation (Frese & Zapf, 1994). Decision necessities are based the number of different goals, plans, and feedbacks that have to be regulated and organised in time and the nature and number of relationships within and between goals, plans, and feedback (Dörner & Schaub, 1994).

In contrast to industrial regulation, in human actors often multiple goals are active simultaneously (Hockey, 2000). Switching between goals during a workday is thus a characteristic feature of human action. However, in order to attain important goals, this flexibility has to be regulated by maintaining goals as anticipated future states in the feedback process and to adapt behaviour according to the differences of the feedback process.
Goal-oriented behaviour always implies the overcoming of the natural tendency to switch to other goals (Hockey, 2000). This process implies regulation costs (i.e. regulation efforts). The maintenance of performance under unfavourable conditions is connected with extra regulation because the effort to reduce differences of the feedback process increases (greater difference or more difference) and the distraction through multiple goals has to be tackled. A constant effectiveness of action can be accompanied by reduced cognitive and emotional efficiency. Unfavourable conditions do not normally influence the effectiveness of actions but efficiency deteriorates because unfavourable conditions require compensatory control (Hockey, 1997). Compensatory control is a performance protection strategy – an adaptive regulation process that supports goals with high priority at the expense of goals with lower priorities. Compensatory control is a response to external threats (e.g. stressors) by increasing effort and concentrating more on goals considered important. The cost of this regulation may be decrements in non-focal aspects of tasks and a neglect of personal needs and other goals.

Variety of job content is an additional indicator of regulation requirements related to job content (Hackman & Oldham, 1975). From the point of view of action theory, variety describes the amount of different actions required by the task. Variety is independent of complexity. Having many different tasks in a given job implies variety. Therefore the amount of regulation hierarchies needed to do the job constitutes variety (Frese & Zapf, 1994).

A third indicator of regulation requirements is the completeness of action. It refers to the completeness of the action process in terms of steps (goal setting, plan development, plan decision making, monitoring, and feedback) and in terms of completeness of the hierarchy of action regulation. Actions are considered complete in the latter sense when a person uses all levels of regulation for his/her actions (Frese & Zapf, 1994; Hacker, 1998).
There is hardly any evidence for the effects of completeness of action on satisfaction or performance. In most empirical studies, only the sequential aspect of completeness is measured and it is understood in the sense of task identity (Hackman & Oldham, 1975), a concept that rather focuses doing a job from the beginning to a visible outcome than on action regulation.

4.1.3. Regulation possibilities

Control describes the possibilities available for an actor to have an impact on the conditions and on his/her own activities in relation to the goals (Ganster & Fusilier, 1989). In contrast to complexity as a set of decision necessities, control describes a set of decision possibilities (i.e. a resource).
Both, complexity and control can be distinguished as subjective and objective. One of the key assumptions of action regulation theory is that people do not perform work tasks as they are given, but tasks as they are understood and redefined (Hackman, 1969). The objective task is translated into a subjective task. This translation process involves accepting the task and a redefinition according to perceived situational constraints and opportunities and personal wishes. This translation process results in a process of goal development. Accordingly, subjective control is the perceived control in a situation. The perception of control is dependent on knowledge and skills that determine whether objective decision possibilities are perceived and whether perceived decision parameters can be realised (Frese & Zapf, 1994).

In German action regulation theory the crucial concept of control is termed “Handlungsspielraum” (Frese, 1989) (literally translated: “scope of action”). It describes the amount of regulation possibilities. Within the hierarchical-sequential model a large scope of action can include own goal-setting and work task definition. A very low scope of action can mean that only decisions about execution of a task on sensorimotor level are possible. A number of studies show that job control is related to psychological well-being (Frese, 1989; Van der Doef & Maes, 1999). This is especially the case in working conditions of high demands and low control (Karasek, 1979).

4.1.4. Regulation problems

Classes of regulation problems can be distinguished which act as stressors because they disturb the regulation of action (Frese & Zapf, 1994; B. Greiner & Leitner, 1989) (Figure 13). Regulation problems can be task specific (task design), or task un-specific (job and work design) (Ducki, 2000). They can be subdivided into regulation obstacles, regulation uncertainty, and overtaxing regulation (Frese & Zapf, 1994). Regulation obstacles or barriers directly influence action regulation and require short-term reactions. Regulation overtaxing in contrast is related to continuous conditions that reduce mental and physical performance over longer periods (e.g. the workday) (B. Greiner & Leitner, 1989).

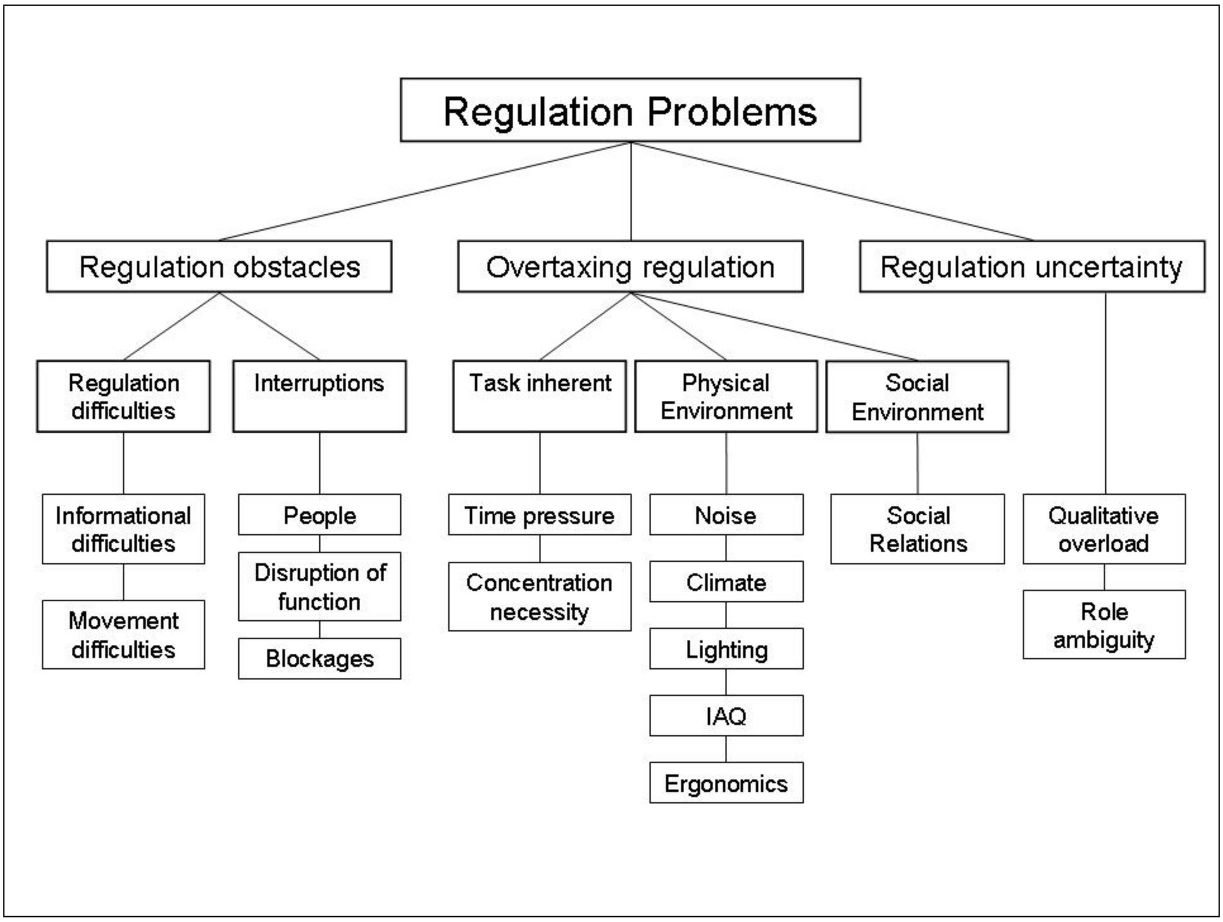


Figure 13. Classification of regulation problems (based on Frese & Zapf, 1994; B. Greiner & Leitner, 1989; Leitner, 1999)

Regulation obstacles are conditions that hinder the accomplishment of work results because they make it harder or impossible to pursue a goal and to regulate an action. Regulation obstacles are stressors because they require additional effort for task completion. They necessitate repetition of the action, the making of detours, and/or use up regulation capacity that is then subtracted from the main task.

Regulation obstacles can be subdivided in interruptions and regulation difficulties (Figure 13). Interruptions are unpredictable outside events (such as a computer breakdowns or phone calls) that disrupt an on-going activity. Interruptions are regulation obstacles because they force the actor to restart a task or because due to interruptions parts of the task already completed may be lost. Regulation difficulties are conditions that impede efficient execution of tasks. They appear

when access to task-relevant information is unnecessarily difficult or when movements need extra effort, for example due to inadequate tools. Regulation obstacles may have their roots in organisational problems (e.g. lack of supplies) or the social environment.
Regulation uncertainty describes a state in which the actor is confused about how to achieve a goal because he's unable to determine which kinds of plans are useful or what feedback can be trusted (Semmer, 1984). In this case not a lack of information is the cause, but rather the inconsistency or ambiguity of information.

Overtaxing regulation describes a state of overload due to overstimulation related to required speed and intensity of regulation. Time pressure or quantitative overload of the working memory or concentration, for example, is a typical stressor. In order to complete a task, more processing resources have to be allocated to regulation and thus more effort is expended. For this class of regulation problems, permanent conditions of time pressure or bound attention are characteristic as well as environmental conditions that do not constrain working activities (like regulation obstacles do) but exceed human performance capacities. Social stressors such as hostile colleagues, conflicts with colleagues or supervisors, unfair treatment by colleagues or supervisors, and a negative group climate can be considered as overtaxing regulation because they divert attention from the main tasks to thoughts and worries about social relations. Thus social stressors consume regulation capacity (Dunckel, 1991).

Action regulation theory assumes that human beings actively deal with their environment. Regulation requirements (complexity) and corresponding regulation possibilities (control) lead to positive effects (i.e. satisfaction) because they address human needs such as a feeling of competence or pride over achievement (Zapf, 2002). On the other hand, regulation problems do not address needs and impede goal directed acting. Regulation problems thus act as stressors.

4.2. Action Regulation and Stress

Stress is a concept that is discussed from various perspectives. Accordingly, there are various definitions of stress. At least three different meanings of the term can be distinguished (R. L. Kahn & Byosiere, 1992):

- Stress as a stimulus or environmental condition. This perspective focuses the conditions that elicit stress, e.g. job content (Karasek & Theorell, 1990) or physical work environment (G. W. Evans, 2001; Sutton & Rafaeli, 1987).
- Stress as a response. From this perspective, stress is viewed as a psychological and/or physiological response to some kind of threat (Selye, 1976).
- Stress as a mediational process. This approach focuses on cognitive, motivational, and evaluative processes that intervene between the stimulus and the response. According to this approach, stress reactions result from interactions between person and environment (Lazarus & Folkman, 1984).

After years of debate, there is a factual consensus about content and processes of stress models today (Beehr, 1998; Greif, 1991; Greif, Bamberg & Semmer, 1991). The basis of this consensus is the cognitive, transactional stress concept of Lazarus (1966).
The transactional view of stress denotes the general process linking stressors, strain and coping and thus has more explanatory power: Stress arises from environmental demands that exceed a person's perceived resources and capacity, when the outcomes are important for the person. The critical variable in the stress process is the cognitive appraisal of the situation (Lazarus & Folkman, 1984). Potentially stressful stimuli lead to different stress reactions in different persons, depending on their cognitive evaluation (appraisal) of the situation and the perceived resources they have at their disposal to cope with the stressful situation. The different reactions of different people to the same or similar situation are a strong argument for a mediational or transactional view of (psychological) stress (Warr, 2005).
Two types of appraisal occur in the stress process: Primary appraisal refers to the evaluation of an environmental demand or event regarding a focal person's well-being. Secondary appraisal is an evaluation of internal and external resources for coping with the environmental demand or event. Primary and secondary appraisals do not necessarily occur serially. On the contrary, it can be assumed that the two evaluations strongly influence each other. Following these evaluations coping behaviour starts. The coping behaviour refers to two things. First it refers to the stress-generating problem, e.g. the handling of an additional task. Second, it refers to dealing with the emotions activated in this process. Coping with stressful demands or events thus leads to additional demands that can aggravate the situation in the case of inappropriate assessment of the problem situation or ineffective coping attempts (Schönpflug, 1983). Thus, coping takes effort and thereby produces fatigue and consumes resources. According to Hockey (1997) compensatory control model, individuals use performance-protection strategies when dealing with environmental stressors. Performance protection is realised through increased subjective effort (psychological process) and/or sympathetic activation (physiological process). The greater the activation, the greater the costs for the individual. Short-term effects of compensatory control in the regulation of performance under stress consist in inefficient strategies. Long-term effects may be a draining of energy and a state of exhaustion.

According to the transactional view, stress is seen as a product of the complex and dynamic transaction between the person and the environment, rather than a product of one of these components on its own.
It can be assumed that individuals possess different coping strategies and competences and that they evaluate situations differently (Semmer, 2003). Thus not only the transactions, but also the demands and consequences in stress situations vary strongly. These qualitative diverse combinations and effects of transactions between actor and environment increase the complexity and dynamics of Lazarus' transactional stress model to a degree that make the empirical

examination methodologically nearly impossible (Greif, 1991). In order to comprehensively test the model, it would for each hypothetical stressor be necessary to specify all theoretically thinkable individually moderating coping strategies or competences, and evaluations. Such a procedure would include so many dimensions and interactions that almost arbitrary causal hypotheses could be derived.
The solution to this problem lies in a more detailed specification of the causal hypotheses in the transactional model. This seems to be possible for the application domain “workplace”. The simple hypothesis that objective work stressors correlate with subjective disorders is empirically well confirmed in cross-sectional and longitudinal analyses as well as when moderators (such as control) are taken into consideration (Greif et al., 1991; Sonnentag & Frese, 2003). Thus, a reduction of the transactional model is near at hand for this domain.

The core of the reduced transactional model for the workplace-domain is the concept of stressors. Stressors are job or work features that increase the probability of stress reactions and stress-related outcomes (R. L. Kahn & Byosiere, 1992, Semmer, McGrath & Beehr, 2005). Stressors are not defined on the individual level but on the level of populations. Each individual perceives the same objective environment somewhat differently and stressors do not lead to stress reactions in every individual. Like some people are more resistant to infections than others, some people are more resistant to certain stressors than others. Stressors therefore are considered as risk factors and not as determinants of stress reactions and outcomes. Stress reactions are indicated in one or more of the following signs: verbal reports of being stressed or overtaxed or the like; observable behaviour, and physiological signs (Semmer et al., 2005).
Stress-related outcomes can be identified at various levels (Semmer et al., 2005): on the psychological level, different outcomes have been discussed, including depression, psychosomatic complaints, exhaustion, and disengagement. On the physiological level, work related stress has been shown to act as a cofactor in the increase of risk for cardiovascular diseases, ulcer, musculoskeletal pain, and general morbidity. On the social level, diminished social resources and conflict are related to stress. On the behavioural level, health-relevant behaviours such as physical activity, substance abuse, and nutrition have been related to stress. Furthermore, job performance is reduced under conditions of chronic stress, mainly due to reduced contextual performance. This facet of individual work performance refers to the willingness to engage in activities going beyond immediate job duties such as helping co-workers and supporting their well-being, investing time beyond formal requirements, following organisational rules and procedures, and the like (Borman & Motowidlo, 1997).
Stressors may lead to outcomes on any one or more of these levels and it is difficult to know a priori which stressor is likely to have specific effects. There is, however, theoretical and empirical evidence for the general proposition that chronic exposure to psychosocial stressors can create significant health problems (Ganster & Murphy, 2000).

The stressor-as-job features approach of stress has a good empirical basis: Summarizing several studies, Frese and Zapf (1999) state that correlations between objective work situations and ill-health are well established. Furthermore, there is evidence that stress perceptions act as mediators rather than moderators (Frese & Zapf, 1999).

The job features approach of stress (as described above) accepts that measures of job stressors and other work conditions are all biased because they are affected by personal factors (Spector, 1992). However, if self-report measures of stress are considered to reflect individual perceptions of the environment, personal factors are real causes of the underlying construct of interest, viz. perceptions. Personal factors thus are considered as an element of the stress episode or stress reactions that cannot be eliminated from measurements (Spector, Zapf, Chen & Frese, 2000). Attempts to identify individual-level variables and their influences and interactions with external factors in stress episodes are only in an early stage of theory and research and results are inconclusive (Semmer, 2003). Job oriented analyses generally seem to result in more consistent findings than person oriented analyses. Farrell and Stamm (1988) for example conducted a meta-analysis that shows that job oriented theories are empirically better based in explaining absenteeism than person oriented factors such as age, sex, or job satisfaction.

Thus, while in cognitive theories of stress (e.g. Lazarus & Folkman, 1984) the concept of appraisal is central for the examination of the relationship between the person and their work environment, the tradition of work and job design emphasizes objective[7] characteristics of jobs. The reasons for this emphasis on objectivity are twofold: first, it is rooted in the theoretical tradition of action regulation theory that aims at contributing to job design. Second, there is empirical evidence of correlations between objective work characteristics and individual health and well-being. From a practical point of view, the reason for emphasizing the objective nature of work and work environments is that work and environmental design is usually accomplished without taking individual factors into consideration (Zapf, 1993). While individual appraisal is obviously unique, it is not idiosyncratic (Semmer et al., 2005). It is therefore possible to identify patterns in the way people appraise specific work conditions. This is particularly so with patterns that relate to the way in that the workplace is seen to threaten a person's health and well-being.

In terms of action regulation theory stressors are equalised with regulation problems (Frese & Zapf, 1994; B. Greiner & Leitner, 1989). Regulation problems act as stressors and impair work performance because they require extra regulation efforts. This additional regulation effort in turn can lead to overtaxing of regulation and lead to stress reactions and stress-related outcomes.

[7] Objective characteristics of jobs are not necessarily physical characteristics. Rather, objective characteristics are conceived as independent of a specific person's cognitive and emotional processing and are inter-individually agreed physical or social facts (Frese & Zapf, 1988).

This approach allows for a conceptualization of stressors that is not dependent on worker appraisal but does not omit mental processes in general. Stressors are conditions that interfere or are incompatible with mental regulation processes such as information processing, planning, and movement execution.
Approaches to work and job analysis and design focus on work tasks and organisational conditions. The physical environment has received considerably less attention in this tradition (Oldham, 1996; S. Parker & Wall, 1998).

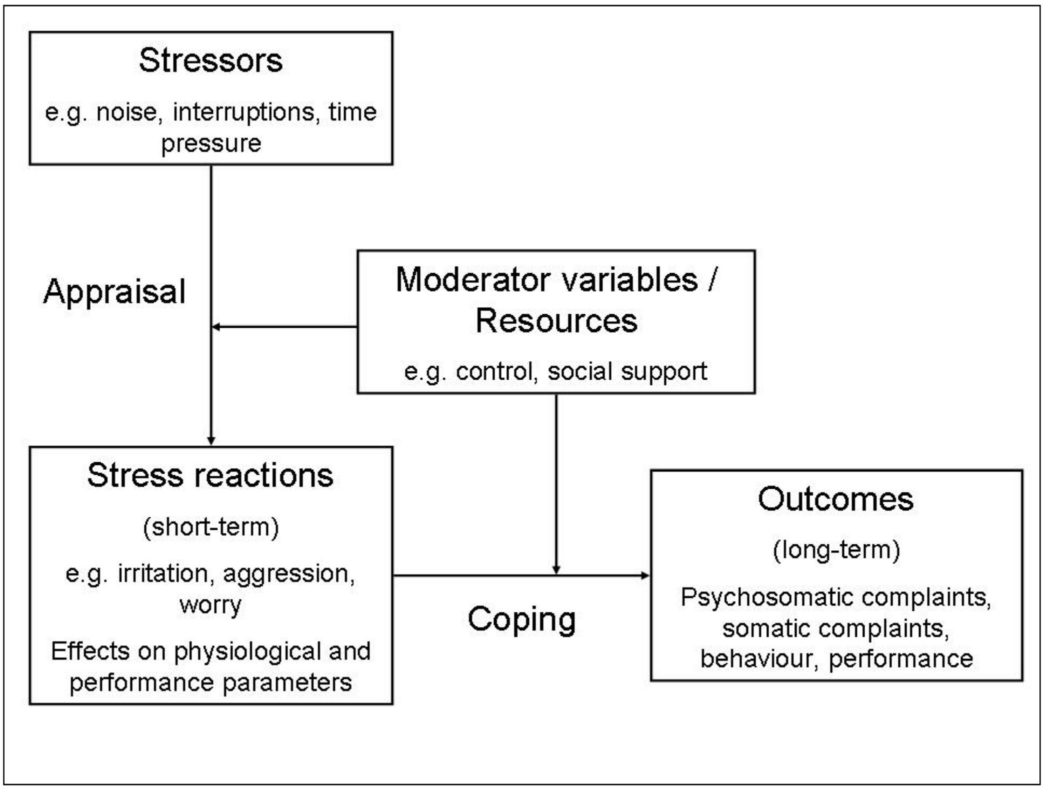


Figure 14. Stress model (based on Greif, 1991, Oesterreich, 1999, Frese, 1989)

The concept of psychological stress allows for an extension of the job and work design literature towards the analysis and design of the physical environment. It encompasses not only short-term stress episodes but emphasizes long-term impacts on health and well-being. Furthermore, it acknowledges the possible influence of moderating variables such as control (e.g. job decision latitude or environmental control) or social support (Figure 14). In stress research, the moderating effects of control and social support are empirically well confirmed; research on other moderator variables is inconclusive (Semmer et al., 2005).

4.3. Environmental stress and comfort

Research on workplace stress has focused on psychosocial, organisational, and job design aspects but largely ignored the potential effects of the physical environment (Vischer, 2007b). Environmental stressors can be classified into

environmental conditions and person-based environmental variables (Baron, 1994; Haynes, 2007; Sutton & Rafaeli, 1987). These stressors are discussed in more detail in chapter 6.
Poor environmental quality can have direct and indirect consequences for individuals' health (Cox & Cox, 1993). Direct physical consequences are produced by toxins and other hazards. Indirect consequences are psycho-physiologically mediated, i.e. a poor fit between the physical environment and the individual can lead to stress because additional effort to make accommodation is needed. Environmental stressors interfere with mental regulation processes and/or consume resources that otherwise would be used for task related activities. In terms of the action-regulation theory described above, environmental stressors act as regulation problems because they impede goal-directed regulation. Therefore, environmental stress leads to frustration and dissatisfaction. Endangering the fulfilment of accepted tasks has been found to be experienced as stressful and tends to correlate with psychosomatic symptoms (B. A. Greiner, Ragland, Krause, Syme & Fisher, 1997; Leitner & Resch, 2005; Semmer, Zapf & Greif, 1996). Evidence of the (small) negative effects of situational constraints (i.e. regulation problems) on performance and satisfaction is reported by (O'Connor, Peters, Pooyan, Weekley, Frank & Erenkrantz, 1984).

Action-regulation theory has mainly been applied in order to study negative aspects of work, specifically stress. Action-regulation theory, however, does also consider positive aspects such as learning and individual development through acting (and therefore values complexity of work tasks high). The two foci on stress and learning do not allow the assessment of positive effects of the physical work environment. The theoretical framework therefore has to be completed with an approach that permits the study of environmental impacts that lead to higher well-being, better health, or higher performance. The absence of regulation problems or stressors does not fulfil human needs. Workers need not only freedom from regulation problems but want environmental support for the activities they perform. The concept that captures these aspects is environmental comfort (Vischer, 2005, 2007b). Environmental comfort contains the satisfaction with the relationship between individual goals and physical, functional, and psychological aspects of the physical work environment. It links the assessments of office environments by their users to outcomes such as performance and well-being.
The experience of comfort is understood as guided by similar regulatory mechanisms as stress. Comfort is thus not a physiology-oriented concept of neutral sensation (sensu Fanger, 1970) but of neutral regulatory demands from the physical environment. Comfort is thus conceived as a psychological concept. The measurement of comfort should focus on satisfaction with comfort because the concept of satisfaction should relate to longer periods of time than sensation. Thus, while sensation may be an adequate measure in laboratory studies, satisfaction is considered more appropriate in field studies. Satisfaction with aspects of environmental comfort includes the possibility of individual adaptation to environmental conditions in order to achieve comfortable levels (Nicol & Humphreys, 2002). Furthermore, conceptualizing comfort as satisfaction

acknowledges the multidimensional nature of comfort. In an empirical study of seating comfort, for example, (Zhang, 1996) seating comfort was found to be based on a sense of well-being, relief, and relaxation, as well as on the appearance of the chair.

4.4. Theoretical implications and research model

The Job Demands-Resources model (Bakker & Demerouti, 2007; Demerouti et al., 2001) postulates that job relevant environmental factors can be classified into general categories: job demands and job resources.
Job demands refer to aspects of the job that require physical or mental effort. Job demands are therefore associated with physiological and psychological costs. Job resources on the other hand refer to aspects of the job that are functional in achieving work goals, reduce demands and the associated costs, and stimulate personal development.

From the theoretical perspective of action-regulation, stressors are defined as regulation problems. In the Job Demands-Resources model, job demands are defined as those physical, social, or organisational aspects of a job that require physical or mental effort. The greater the effort needed, the greater the physiological and psychological costs for the individual (Demerouti et al., 2001). Poorly designed jobs, work environments, or chronic job demands exhaust employees' resources and lead to exhaustion, health problems, and discomfort. The characteristics of demands leading to these problems are described as stressors.
The general taxonomy of regulation problems (Figure 13) can be translated into a taxonomy of regulation problems for office work that is related to the physical office environment (Figure 15).
Regulation obstacles are conditions that make it harder or impossible to pursue a goal or to regulate an action. They are directly related to the task. Regulation obstacles have a negative influence on otherwise intact action (Zapf, 1993). The subcategory of regulation difficulties refers to conditions that impede efficient task execution. In office work such conditions are noise (Leitner, Lüders, Greiner, Ducki, Niedermeier & Volpert, 1993), ineffective design of workspaces, and crowding (Schultz-Gambard, Feierabend & Hommel, 1988). Noise requires higher concentration, e.g. for an individual's own telephone calls. Ineffective workspace may impede task execution on the level of movements (spatial barriers, dysfunctional arrangements). Crowding is associated with excessive stimulation, scarce resources, and behavioural constraints and aggravated action regulation. The second subcategory of regulation obstacles refers to interruptions. In office settings, the main source of interruptions and distractions are other people (Jett & George, 2003).

Overtaxing regulation refers to speed and intensity of regulation and the risk of physiological and psychological overload. Conditions belonging in this category are time pressure and concentration necessity (Zapf, 1993) as task inherent factors. Furthermore environmental factors such as noise, climate, lighting, indoor air quality, and ergonomics are task unspecific risk factors for overload or overstimulation (e.g. Sundstrom, 1986). In relation to the social environment, problematic social relations due to conflicts may overtax regulation. Thoughts and worries about social relations divert attentional resources from work tasks. It is, however, questionable, whether social relations should be considered as a regulation problem or as an outcome of job design or both (Clegg & Spencer, 2007). Social density is a second factor of the social environment that is relevant for overtaxing regulation. Social density is associated with overstimulation and impairs focusing and concentrating abilities (Oldham & Rotchford, 1983).

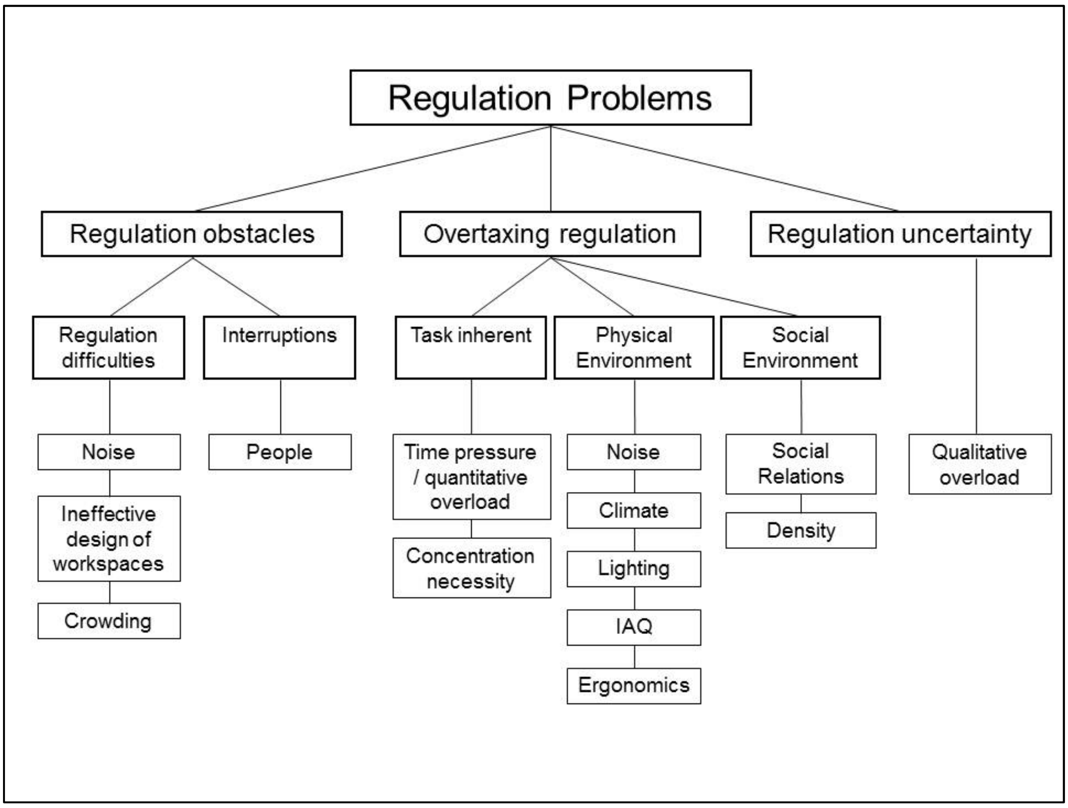


Figure 15. Regulation problems in office work

Noise appears as a stressor in two different ways. First, noise acts as a regulation difficulty for specific tasks requiring extra effort. Second, noise may overtax regulation as a task unspecific stressor that leads to cognitive overstimulation. Task unspecific stressors do not require extra regulation effort but have to be borne by the job incumbents.

Regulation uncertainty describes a state in which an actor is confuse about how to achieve a goal because he’s unable to determine which kinds of plans are useful or what feedback can be trusted (Semmer, 1984). This concept is strongly associated with qualitative overload, a state that is characterised by excessive requirements on working memory as much as too many pieces of information must be kept in memory simultaneously and for too long periods of time.

The Job Demands-Resources model assumes that resources have motivational potential. Resources are important for dealing with job demands, but they are also important in their own right because they are means to protect other valued resources. Thus, resources have an instrumental and an intrinsic value.
From the perspective of action-regulation theory, the far most important resource is control. Control – or scope of action for the action-regulation theory term – describes the amount of regulation possibilities an individual worker has. A second resource is social support, a concept that has been shown to buffer negative effects of work stressors in many studies (R. L. Kahn & Byosiere, 1992; Van der Doef & Maes, 1999). Although social support is not derived from action-regulation theory (which has an individualistic cognitive focus) it is usually considered in action-regulation based research on work stress, well-being, and health (Frese, 1995).Taking into account the physical environment, further resources can be identified. Privacy and control over the own physical environment are two facets of autonomy that are likely to act as instrumental resources (De Croon, Sluiter, Kuijer & Frings-Dresen, 2005). Furthermore, comfort may play a role as an intrinsically valued resource.

The Job Demands-Resources model assumes that both job demands and resources effectuate main effects. Additionally, the model proposes an interaction between job demands and job resources. This interaction is relevant for the postulated outcomes, job strain and motivation. The interaction between job demands and resources consists in a buffering role of resources for job demands (Bakker & Demerouti, 2007).
In order to identify the contents of the Job Demands-Resources model in relation to the physical work environment on the basis of the theoretical considerations presented above, the literature on office and work design is reviewed in chapters 5 to 7.

5. Outcomes of office and work design

Work systems are composed of work tasks, structures, processes, workplaces and work environments. From the perspective of organisational development, the design of physical work environments and the relationship between interior design and the other elements of work systems are acknowledged (Becker & Steele, 1995; Porras & Robertson, 1992) but not integrated in theory and research.
From a socio-technical systems perspective, work and organisational design should aim for both, economic and employee-related goals. Thus, productivity and quality of work life are considered simultaneously. Organisations have control over elements that have impacts on both satisfaction and performance. Therefore interventions in organisational design and development can result in both a more satisfied workforce and increased productivity. Economic and employee-related goals are usually operationalized as performance, satisfaction, social behaviour, health, and comfort (Sundstrom, 1986). These dimensions link employee-related goals with economic goals: only healthy employees are capable of efficient performance; satisfaction and comfort are linked with performance (Judge, Thoresen, Bono & Patton, 2001; Vischer, 2007b); social behaviours such as social interaction are crucial for coordination and the development of trust and social relations (Gabarro, 1987; Tsai & Ghoshal, 1998) and social support may be a buffer of stressors.

In this chapter, outcome dimensions of the design of work environments studied in this research are described. These outcomes are satisfaction, organisational commitment, health, and individual work performance. The focus of this research is on individual perceptions and behaviour in office environments. Therefore, social behaviour is not included in this review but will be dealt with in the empirical research in an explorative way (see chapter 8).

5.1. Job satisfaction

Satisfaction is a major dependent variable in many domains of psychological and organisational research (Judge & Church, 2000). Notably job satisfaction has received much interest in industrial and organisational psychology and may be the most widely studied topic in this discipline (Judge & Church, 2000; Locke, 1976). Since field studies in the 1980s revealed that open plan office users were mostly dissatisfied, occupant satisfaction has become the standard measure also in workplace research (Vischer, 2007a).
Efforts in studying satisfaction are often based on the assumption that job satisfaction and individual performance are closely related (Judge et al., 2001). Job satisfaction has important effects on the organisational level of analysis: it is related to organisational commitment (Gaertner, 1999), turnover intentions (Lambert, Hogan & Barton, 2001; Spector & Jex, 1991), customer satisfaction

(Harter, Schmidt & Hayes, 2002), and employee absence (Farrell & Stamm, 1988; Warr, 1999).

The correlation between an individual's job satisfaction and his job performance is subject to debate. Meta-analyses identify low to moderate correlations between satisfaction and performance (Iaffaldano & Muchinsky, 1985; Judge et al., 2001): mean correlations according to these analyses range between 0.17 and 0.30. With complex work tasks the correlations rise up to 0.52 (Judge et al., 2001). Thus the correlation between satisfaction and performance is more substantial with complex jobs.

These low to moderate correlations can partly be explained by narrow performance measures, i.e. the sole measurement of output. Contemporary views on work performance include not only tasks assigned to certain persons (task performance) but also contextual aspects that relate individual behaviour to the organisational, social, and psychological environment (contextual performance) (Borman & Motowidlo, 1993). This contextual aspect of work performance is usually not specified in task descriptions but is considered indispensable for the optimal performance of work groups and organisations (Organ & Paine, 1999). Recent research finds work engagement a better predictor of job performance than job satisfaction (Demerouti & Cropanzano, 2010; see chapter 5.5).

At present, there is no agreement about the psychological nature of job satisfaction and therefore causes and consequences of job satisfaction and their measurement are much debated (Judge & Klinger, 2008; Warr, 2002; Weiss, 2002).

Current approaches to job satisfaction can be characterised as follows:

- Satisfaction as an affective reaction, e.g. Locke's (1976) popular definition of job satisfaction as "a pleasurable or positive emotional state resulting from appraisal of one's job or job experience" (p. 1300).
- Satisfaction as a cognitive comparison process or evaluation (Adams, 1965; Herzberg, Mausner & Snyderman, 1959; Marans & Spreckelmeyer, 1981).
- Satisfaction as an attitude (Weiss, 2002), i.e. an evaluative tendency (Warr, 2002), and
- Satisfaction as a personal disposition (Judge & Larsen, 2001).

In a critical review of standard treatments of job satisfaction Weiss (2002) deconstructs job satisfaction and separates evaluations, beliefs and affective experiences. He notes that job satisfaction often is not clearly and explicitly defined and is therefore treated simultaneously as an affective response and an attitude. This, according to Weiss (2002) obscures important differences between affective and attitudinal constructs, the main difference being the temporal stability. Affective states, whether they are considered as moods or as discrete emotions, are considered as being more dynamic than attitudes. Affective states have behavioural consequences at the time when they occur but may also have longer-term effects on evaluative judgements of the objects in question. Attitudes are evaluations or evaluative judgements regarding an attitudinal object. More

precisely, “an attitude represents an evaluative integration of cognitions and affects experienced in relation to an object. Attitudes are the evaluative judgments that integrate and summarize these cognitive/affective reactions” (Crano & Prislin, 2006, p. 347). Thus, evaluation is not synonymous with affect. Rather, affective reactions may form one basic element of an evaluative judgement of an attitude object.
Attitudes and affective reactions have different causes and consequences. While affective responses have a directional (i.e. positive or negative) character, they also have experiential (often physiological) components that go beyond evaluation (Weiss, 2002). Theoretical as well as empirical understanding of causes and consequences of affect in the workplace is only at a beginning stage. This is especially true for influences of the physical environment on moods and emotions (Brief & Weiss, 2002). Only the influence of personality (mainly researched as negative affectivity) as a determinant of workplace mood (but not workplace emotions) is relatively well established (Brief & Weiss, 2002). There is evidence suggesting that personality factors influence individual job satisfaction (Judge & Larsen, 2001).

Holding evaluations about attitude objects serves different functions (Pratkanis & Turner, 1994). According to Pratkanis and Turner, attitudes have the main function of assigning objects to a favourable or unfavourable class. This classification in turn serves several heuristic functions which influence judgements and interactions with the object. Thus, expectations about an object are influenced by evaluations; explanations and interpretations of ambiguous events involving the object are guided; recall of information and events involving the object are influenced, and there are influences of evaluations on approach and avoidance behaviour in relation to the object.

5.2. Environmental satisfaction

Satisfaction is among the predominating outcome measures in workplace research. Previous research has analysed effects of office environments on health, satisfaction and performance. Results show that about fifteen per cent of variance in individual performance can be explained by satisfaction with the office environment and its facets, respectively (Clements-Croome & Kaluarachchi, 2000; Vischer, 1989). However, little effort has been expended to understand what exactly users are reporting when they rate themselves satisfied with the working environment they occupy (Vischer, 2008). Tautological definitions of satisfaction prevail in workplace research, for example according to Oldham (1988, p. 255) “Office satisfaction refers to the degree to which the employee is satisfied with the office setting itself”.

According to the description of satisfaction as an attitude, environmental satisfaction can be defined as the evaluative judgements regarding aspects of the office environment[8]. These evaluations are empirically defined as an assessment of a person's satisfaction with a specific environmental condition, feature or object. The conditions or objects that build the content of environmental satisfaction are usually based on the experience of the researchers and existing instruments (J. R. Carlopio, 1996; Stokols & Scharf, 1990; Veitch, Farley & Newsham, 2002), based on interviews (Zagreus, Huizenga, Arens & Lehrer, 2004) or derived empirically using factor analytical techniques. In the latter case, questionnaire items are considered to reflect a smaller number of underlying latent variables which are determined using factor analyses (Jim Carlopio, 1986; J. Carlopio, 1990). Common conditions that affect environmental satisfaction include satisfaction with office layout, furnishings, indoor air quality, lighting, acoustics, and thermal comfort.

The relation of environmental satisfaction to job satisfaction in office environments has been studied by a group of researchers of the Institute for Research in Construction (National Research Council of Canada, Ottawa) (Charles, Danforth, Veitch, Zwierzchowski, Johnson & Pero, 2004; Marquardt, Veitch & Charles, 2002; Newsham, Brand, Donnelly, Veitch, Aries & Charles, 2009; Veitch et al., 2007; Veitch, Charles, Newsham, Marquardt & Geerts, 2003; Veitch et al., 2002). Their results show a significant effect of overall environmental satisfaction on job satisfaction (Veitch et al., 2007). The model this group of researchers derived from their data using structural equation modelling is presented in Figure 16.

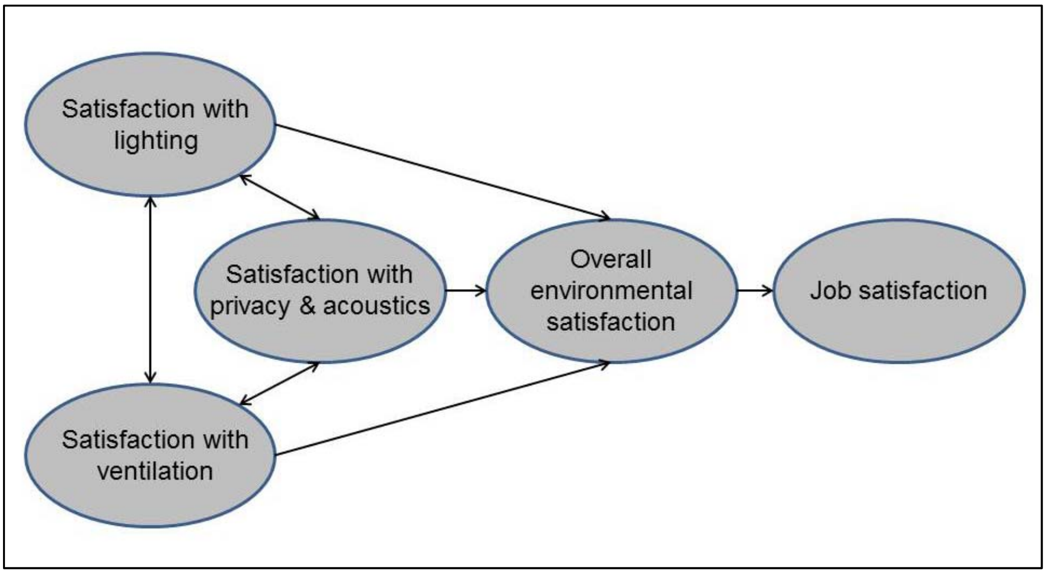


Figure 16. Components of environmental satisfaction and their relation to job satisfaction (Charles, Veitch, Farley & Newsham, 2003)

[8] The theoretical distinction between evaluative and affective content of satisfaction, however, is not mirrored in empirical studies. In a study of the relationship between environmental satisfaction and work outcomes Lee (2006) compared an evaluative and an affective approach to satisfaction with the workplace. The results did not indicate a difference between the two satisfaction measures and their linkage to work outcomes.

In a study with Chinese white-collar and blue-collar workers, Donald & Siu (2001) obtained similar results. Their results show that satisfaction with environmental conditions (space, ventilation, lighting, temperature, noise, air quality) is related to job satisfaction and to physical and mental well-being. Other research identified environmental satisfaction as a mediator between office use practices such as the ability to personalise one's work area and job satisfaction and employee well-being (Wells, 2000). Taken together, these findings refer to the mediating role of environmental satisfaction in office workplace research. Environmental satisfaction mediates the effect of environmental conditions (e.g. lighting, privacy, ventilation, and personalisation) and outcome variables such as well-being and job satisfaction.

5.3. Organisational commitment

Organisational commitment is an essential variable in organisational studies. It has a high explanatory power for turnover intentions. For example in a study of employees in industrial companies, 80 per cent of the variance in turnover intentions could be explained by organisational commitment (J. R. Carlopio, 1996). In an attempt to identify the "core essence" of the commitment construct in work organisations, Meyer & Herscovitch (2001, p. 301) define commitment as "a force that binds an individual to a course of action that is of relevance to a particular target." Definitions differ in form (e.g. affective, normative, and continuance commitment, Meyer & Allen, 1991) and focus (e.g. organisation, job, goal, team) of commitment. In this research organisational commitment is examined in relation to workplace design.
Different forms of commitment relate to three topical areas: affective commitment describes the emotional attachment to an organisation along with identification with the organisation and involvement in the organisation. Normative commitment describes feelings of obligation to continue an employment and continuance commitment describes the awareness of the costs linked with leaving the organisation (Meyer & Allen, 1991).

Different definitions and conceptualisations of organisational commitment share the basic assumption that commitment binds individuals to the organisation and thereby reduces the likelihood for turnover (Meyer & Herscovitch, 2001). Research comparing the implications for behaviour of the three forms of commitment shows that affective commitment has the strongest correlation with job performance, organisational citizenship behaviour[9], and attendance. The other two forms of commitment – normative commitment and continuance commitment – are less strongly related to these outcomes.
Affective commitment is composed of three components (Buchanan, 1974; J. Cook & Wall, 1980): (1) identification represents pride in the organisation and

[9] Organisational citizenship behaviour describes employees' behaviours that go beyond formal job duties and core task requirements. They are considered to actively promote and strengthen an organisation's effectiveness (Organ, 1988, 1997) and regarded as the core of contextual performance (see chapter 5.5).

internalisation of organisational goals and values, (2) involvement refers to the willingness to invest personal effort in the work itself because it is seen as an important contribution to the organisation as a whole, and (3) loyalty describes affection for and attachment to the organisation and a sense of belongingness that translates into a wish to stay in the organisation.

Research in organisational commitment has tended to examine correlations between potential antecedent variables and commitment. Mathieu and Zajac (1990) list personal and organisational characteristics, job characteristics, social relations, and role states as antecedents of organisational commitment. Consideration of the reasons why these variables should relate to commitment has rarely been a topic in research on organisational commitment (Meyer & Herscovitch, 2001).
On the basis of a literature review Meyer & Herscovitch (2001) argue that mechanisms such as involvement, shared values, and identification are involved in the generation of affective commitment. These mechanisms can be seen as elements of social exchange (Morris, Lydka & Fenton O'Creevy, 1993). Workspaces are important contents in the social exchange between employees and organisations. In addition to salary, employees expect other returns from their employers, e.g. recognition and appreciation. The space that is assigned to employees and the fact that they occupy it in order to perform their work tasks symbolizes implicit terms of a socio-spatial contract (Vischer, 2005). This type of social exchange affects the basis of the normative facet of commitment which is rooted in reciprocity (Meyer & Herscovitch, 2001).
Organisational commitment is co-determined by territorial behaviours (G. Brown, Lawrence & Robinson, 2005): identity oriented marking (personalisation) increases the identification with the marked organisational objects and the attachment to these objects because a feeling of ownership is connected with marking (affective component of commitment). Marking and defending individual or group workspace territories are personal investments of time and energy and thus increase continuation commitment. Both forms of commitment are affected by the perceived possibilities to exert influence over the personal physical work environment and thus to have some degree of control over it. Possibilities for individual control reflect organisational practices based on organisational culture (normative component of organisational commitment).

Empirical evidence for the relationship of organisational commitment and the physical work environment is scarce. Leather, Beale & Sullivan (2002) studied the effects of psychosocial stress, noise, and their interaction on job satisfaction, organisational commitment and well-being. The results indicated that there was no main effect of noise on commitment and other work related indicators. The findings, however, point to an interaction effect of noise and psychosocial stress on commitment: noise intensifies the negative effects of psychosocial stress or low ambient noise buffers negative effects of psychosocial stress on organisational commitment. A similar interaction effect was found in a study by Fried, Slowik, Ben-David & Tiegs (2001). These authors found that organisational commitment was more completely explained when not only main effects of workspace density, job complexity, and tenure were considered. The addition of the cross product of workspace density and organisational tenure significantly contributed to the explained variance of organisational commitment. The same was true with the three-way interaction of workspace density, job complexity, and organisational tenure. Thus, the findings of this research suggest that the effects of workspace density on organisational commitment cannot be fully understood if organisational variables such as job characteristics and tenure are not taken into consideration. Negative effects of workspace density on organisational commitment can mainly be found for people with highly complex jobs and high organisational tenure.

Donald & Siu (2001) studied the role of organisational commitment as a moderator of the relationship between environmental conditions (including ventilation, lighting, temperature, and noise) and job satisfaction and well-being. The results of this study regarding organisational commitment as a moderator are inconclusive. There are main effects of environmental conditions and organisational commitment on job satisfaction and physical and mental health. The interactions between environmental conditions and commitment, however, do not contribute to more explained variance. Organisational commitment therefore does not seem to moderate the relationship between environmental conditions and job satisfaction and well-being.
Implicit to this research is the assumption that organisational commitment acts as a determinant of job satisfaction. While there is a significant correlation between these two measurements (J. R. Carlopio, 1996; Ostroff, 1992; C. P. Parker, Baltes, Young, Huff, Altmann, Lacost & Roberts, 2003), the causal direction remains undetermined. In a comparison of several structural equation models, J. R. Carlopio (1996) concluded that data on the relationship between job satisfaction, organisational commitment and turnover intentions could be explained equally well by two models that differed in the direction of effects between commitment and job satisfaction.

5.4. Health

According to World Health Organization (2006, p.1) “health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity.”
Healthy working environments may thus be defined as environments that do not contain any risk of disease and that ensure comfort and well-being for all occupants. In contrast to a traditional idea of health, this approach recognizes that physical, mental, and social well-being are prerequisites for performance of knowledge workers.
On the basis of the action-regulation framework described above, well-being is reduced when the capacity to act is restrained (Ducki, 2000). The capacity to act is determined by a dynamic process of balance between the individual and his/her

resources and the environment (physical, biological, and social demands) and can be described as the ability

- to pursue (longer-term) goals,
- to deal adequately with environmental conditions and demands, and
- to integrate physical processes and symptoms on the one hand side and actions on the other hand side (i.e. actions are partially reactions to physical symptoms).

This capacity can be understood as a positive indicator of health and is measurable as satisfaction (Warr, 2005). Positive indicators of health are usually complemented by indicators of health impairment and psychological strain (negative indicators).

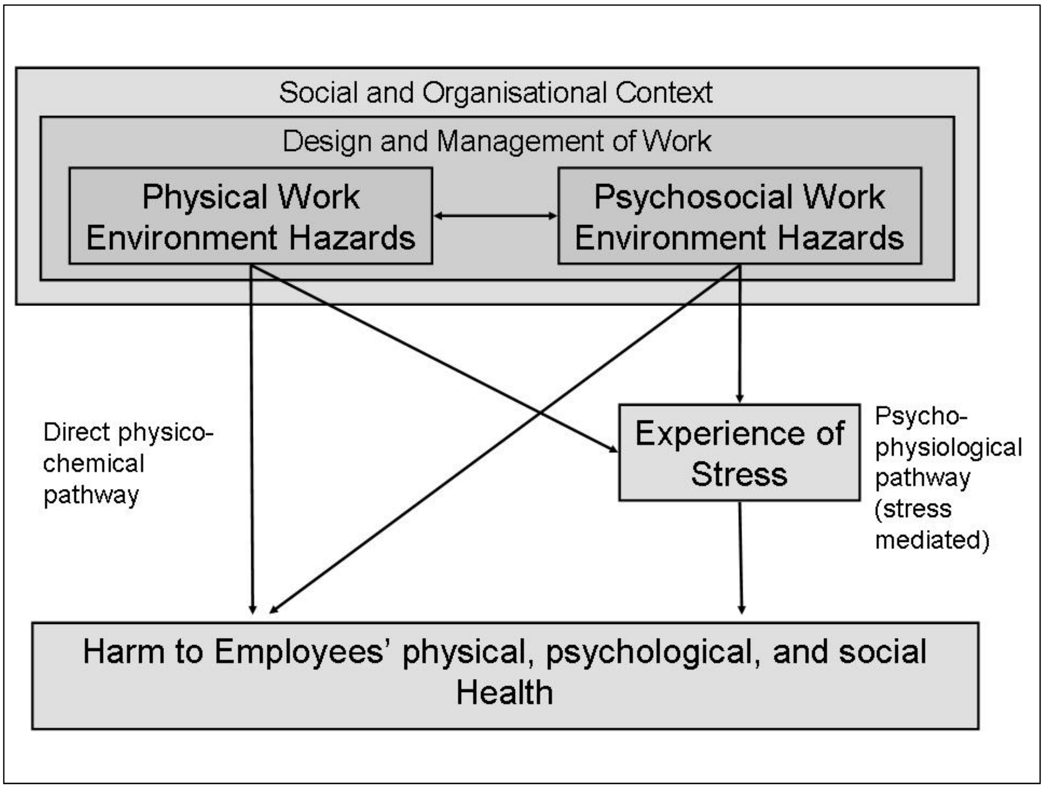


Figure 17. Pathways from hazard to harm (after Cox & Cox, 1993; Cox et al., 2000, modified)

In work environments, two pathways from work settings to employees' health and well-being can be distinguished (Cox & Cox, 1993; Cox, Griffith & Rial-González, 2000; Taylor, Repetti & Seeman, 1997) (Figure 17): (1.) via the physico-chemical pathway the work environment may directly affect illness precursors or illness by exposing employees to physical, chemical, or biological hazards. (2.) A second possible pathway regards stress experience as a mediator between work environment and health. This pathway is called psycho-physiological by Cox and Cox (1993) and is described as indirect because the health effects of the work environment are mediated by cognitive appraisal. These two pathways are not

considered as alternative explanations of effects of the work environment but are always present simultaneously and interact with each other.
Research on work stress has tended to neglect physical, chemical, and biological work hazards (Cox et al., 2000). This category of hazards not only influences bodily functions directly but may also alter employees' awareness, suspicion or fear of being exposed to harm. This suspicion or fear in turn can lead to the experience of stress. Cox et al. (2000) argue that there are also psychosocial hazards that directly affect workers without mediation by the experience of stress. These hazards include aspects of work design and the organisation and management of work as well as their social and environmental contexts. For example, a job that does not utilise available competences or that includes ergonomically inappropriate tasks does not necessarily cause stress but causes harm to the worker's health. Such a job becomes stressful when attempts to improve or ergonomically correct tasks are impossible due to job design and organisation.

In the following two chapters the two pathways are discussed in more detail and with respect to office environments.

5.4.1. Physico-chemical pathway from hazard to harm

Environmental conditions can be harmful because they overtax the responsive capacity of the nervous system (e.g. in the case of lighting and noise) or the adaptive capacity of bodily functions (e.g. temperature). Furthermore, contaminated air can irritate the respiratory system, be poisonous or potentially carcinogen (Hedge, 2000).
There is some evidence for the physico-chemical pathway from hazard to harm in office settings. The findings, however, are equivocal (Brauer, 2005; Seppanen & Fisk, 2006). The symptoms directly linked to environmental conditions include headaches, eyestrain, elevated stress hormone levels, and mucous membrane irritation. Some authors (e.g. Bourbeau, Brisson & Allaire, 1997; Fisk, Mirer & Mendell, 2009; Hedge, Erickson & Rubin, 1995; Seppänen & Fisk, 2004) use the label "sick building syndrome symptoms" for a cluster of such symptoms (see chapter 5.4.5).
The main research strategy in studies of physico-chemical influences has been to study physical work environment hazards separately and in laboratory research. Only recently researchers have begun to combine different dimensions (e.g. Witterseh, Wyon & Clausen, 2004, studied the combined effects of temperature and noise). Research on conditions hazardous to health in office environments has focused lighting, noise, and indoor air quality (Rashid & Zimring, 2008). Results of this research are reviewed in Chapter 6.

Environmental conditions in this body of research are usually measured objectively and in some cases complemented by study participants' perceptions. Correlations of subjective and objective measures tend to be weak. A review of ten studies (Wyon, 2004) shows that perceived indoor air quality is related to experimental manipulation of objective conditions only in some of the studies discussed. This finding points out the multidimensional nature of perceived indoor air quality that may be the cause of insensitivity to changes on single dimensions (cf. Fanger, 2006). Furthermore data on health symptoms are usually based on self-assessments and many studies use comfort assessments as outcome measures. Wyon's (2004) review also shows that changes in performance and symptoms in some cases occur without changes in perceived air quality and in other cases parallel to changes in perceived indoor air quality. Thus, there is limited support for direct effects from hazards to harm in office settings. Perceived quality of the office environment seems to have greater explanatory power than the objective measurements of environmental facets. Because of the multi-factorial influences in real work settings, dose-response relations are not available (Fanger, 2006).

5.4.2. Psycho-physiological (stress) pathway from hazard to harm

While there is some evidence for harmful consequences of objectively measurable aspects of the office environment, a purely stimulus centred approach to hazards and health is incomplete. The "engineering approach" (Cox et al., 2000, p. 32f) conceives stress as a stimulus characteristic of the environment and describes it in terms of load or as an aversive or noxious element of the environment. This approach, however, does not adequately account for the existing data because it neglects contextual factors and the interplay of different factors of the environment as well as the interactions of persons with their environments. Noise stress, for example, is not caused only by intensity and frequency of noise but also by characteristics of the persons exposed to it (such as sensitivity to noise, Windlinger, 2008) and their tasks (Banbury, Macken, Tremblay & Jones, 2001; Melamed, Fried & Froom, 2001). Furthermore, awareness of the presence of a potentially harmful substance influences reported symptoms (Dalton, Wysocki, Brody & Lawley, 1997).

Because of this incompleteness, the physico-chemical pathway is complemented by a psycho-physiological pathway which describes the aspects of the work environment which have the potential for causing psychological and/or physical harm. Thus, the psycho-physiological pathway corresponds to the models of experienced stress described above (chapter 4.2). In psycho-physiological models of stress the theoretical concept of stressors is used to describe stressful characteristics that can be applied to a wide range of occupations and that cannot be identified by direct physical or chemical measurement (M. Marmot, Siegrist & Theorell, 2006). In action-regulation theory an important class of stressors are regulation problems. Extra regulation due to regulation problems has been shown to lead to psychosomatic discomfort and to higher levels of irritation in white collar workers (Leitner, 1993). Similar findings are reported for such diverse settings as urban transit operators (B. A. Greiner et al., 1997) or office work with computers (Zapf, 1993).

According to the JDR-model, health impairment can be the result of a specific set of working conditions. These conditions concern job demands that represent characteristics of the job that potentially bring on strain which may overtax the employee's adaptive capability (Bakker & Demerouti, 2007). The health impairment process is linked to performance-protection strategies (Hockey, 1997) that are employed under the influence of environmental demands. Performance protection is achieved through activation and/or increased subjective effort (i.e. action regulation on a higher hierarchical level, see chapter 4.1.1). With greater activation and/or effort the physiological costs for the individual increase. The long-term effect of such compensation may be energy depletion and psychosomatic or burnout symptoms. The health impairment effect of job demands may be mitigated by resources (other than the ones used for compensation). This mitigation, however, seems to be limited to resources that correspond to specific demands of a given job (Van der Doef & Maes, 1999). According to the JDR-model resources also have motivational potential and can lead to high work engagement and performance. This motivational process may in turn be attenuated by job demands (Bakker & Demerouti, 2007).

Regarding their relationship with health, job demands (sensu JDR) can be considered as stressors. They describe features of a job that increase the probability of stress reactions and stress outcomes. The relationship between stress and health can be described on several levels. The experience of stress is associated with changes in cognitions, emotions, behaviour, and physiological functions, all of which can be detrimental to health.

Typical health related outcomes of stress are psychosomatic complaints (Frese, 1985) and burnout (exhaustion and disengagement, Demerouti et al., 2001) on the psychological level. On the physiological/medical level, stress has an effect on the cardiac system. For example, the risk of coronary heart disease is higher for individuals in high-strain jobs, i.e. jobs with high demands and low control (Karasek & Theorell, 1990). The cardiac system is also affected by hormones. Chronic work stress increases the release of catecholamines (epinephrine and norepinephrine) and corticosteroids (cortisol), which can contribute to the development of illnesses, such as coronary heart diseases. Stress also impairs the functioning of the immune system and contributes to the development of musculoskeletal disorders. Furthermore, stress affects psychophysiological disorders such as digestive system diseases and recurrent headaches (Sarafino, 2008). Stress-related health problems are to some extent mediated by health-related behaviours (Adler & Katthews, 1994). Individuals under stress engage less in health-promoting behaviours, probably because of the emotional and behavioural demands of these behaviours. Additionally, individuals under stress may try to cope with stress by engaging in behaviours with potentially health-damaging consequences, such as smoking, higher fat diet, or less frequent exercise (D. M. Ng & Jeffery, 2003).

Work stress or a combination of high strain and low control (Karasek & Theorell, 1990) and effort-reward imbalance (Siegrist, 1996), respectively, seems to

increase coronary heart disease risk (M. Marmot et al., 2006). The association between stress at work and health related symptoms is often interpreted as a direct causal relationship. There is evidence in support of this claim. Alternative explanations, such as third variables producing spurious correlations between experienced stress and psychosomatic complaints or the reverse causation hypothesis that ill health leads to more experienced stress, do not explain the data (Frese, 1985). Longitudinal studies provide further evidence for the causal link between working conditions and the experience of stress and psychosomatic symptoms (Frese, 1985). Schaufeli, Bakker & Van Rhenen (2009) present evidence from a longitudinal study where increases in job demands and decreases in job resources led to increased future burnout scores, even after controlling for initial burnout.
In summary, the causal link between work stress and physiological symptoms is empirically well established. However, research has mainly focused job-related stress and the effects of work environments on stress and stress related health symptoms are not well known.

5.4.3. Interactions between the pathways

The interactions between the physico-chemical and the psycho-physiological pathways from hazard to harm can be described as an interrelationship of stressors. Both physico-chemical and psycho-physiological hazards can be described as stressors, i.e. as features of the work environment that increase the probability of stress reactions and stress-related outcomes. This view is mirrored in the medical concept of allostatic load. The allostatic load theory (McEwen, 1998) describes a general mechanism for the explanation of stress and physical disease that encompasses both classes of hazards. Allostasis is defined as the ability to achieve stability through change. This ability comes with the price of allostatic load, which is described as the wear and tear on the organism that results from chronic overactivity or underactivity of the allostatic systems (autonomic nervous system, hypothalamic–pituitary–adrenal system, cardiovascular, metabolic, and immune systems) (McEwen, 1998). Allostatic load describes the somatic aspects of the performance protection strategies described in the previous chapter.

Four types of interrelationships of stressors can be distinguished (Frese, 1995).
(1) A simple model of an interrelationship of stressors is the additive model. According to this model, effects of different stressors add up in their effects on psychophysiological problems. (2) Another simple model is masking. In this case, a single salient and very intense stressor (e.g. extreme heat or noise) overshadows all other potential stressors.
(3) A third model of interrelationships of stressor is the model of interactive impact. Interaction between two stressors can result in an exponential total effect when one stressors acts as a condition that increases the harmful effects of the second stressor. On the other hand, stressors may compensate their detrimental

effects. In a longer time frame, such relationships can be analysed as (4) reciprocal effects of stressors.
The empirical distinction between these models of interrelationships is difficult. Even in the case of an influential theory such as the job demand-control model (Karasek, 1979), the mechanism relating two types of stressors is not fully understood or empirically demonstrated. The job demand-control model postulates that jobs with a combination of high demands and low control (high strain jobs) are associated with an increased risk for health problems. The question whether high job demands and low control act as additive or interactive stressors is not solved. In a review of studies from 63 samples, 25 samples support additive effects and 13 samples do not show additive effects (Van der Doef & Maes, 1999).

Regarding the relationship between the built environment and health, mechanisms connect physical and psychosocial stressors or the corresponding biomedical and psychosocial processes to the facets of the built environment and psychosocial environment are not well understood (G. W. Evans, 2003). Number and intensity of stressors generally seem to additively affect psycho-physiological health (Frese, 1985). However, interactive combinations or patterns of physical and psychosocial stressors may exacerbate their respective effects (G. W. Evans, 2001; Lepore & Evans, 1996).

5.4.4. Objective and subjective measures of stressors

The interrelationship between physical and psychosocial stressors or hazards raises the question of their perception and measurement. Perceptions of potential hazards and expectations towards a potential hazard affect how individuals respond to it (Dalton et al., 1997). Generally, an environmental condition only becomes psychologically relevant (i.e. can cause psychological stress) when it is perceived (see chapter 4). Perceptions therefore at least partially mediate the impact of objective stressors on important outcomes (Frese & Zapf, 1999). Perceived environmental conditions are also the basis of self-report measures of stress. Self-reports, however, are prone to distortions through personality characteristics and response styles (Frese & Zapf, 1988; Spector, 1992). Furthermore, the outcomes (i.e. strain) may influence the perception of stressors. Thus, health status can affect the perception of stressors, e.g. when individuals with poor health overestimate the stressfulness of their jobs.
Such distortions through self-report measures may inflate stressor-strain relationships. Therefore, more objective methods for assessing stressors and their impacts on health and well-being are sought (Frese, 1985; Frese & Zapf, 1988; R. L. Kahn & Byosiere, 1992). Objective measures share their independence from self-reports of job incumbents (Semmer et al., 1996) and are therefore often assumed to produce more reliable and valid data. However, these measures also contain measurement errors and biases, though different ones than self-report measures (Semmer & Zapf, 1989; Semmer et al., 1996). In some studies the observation and assessment of working conditions and environment by trained

independent raters is used as data source (e.g. Frese, 1985; B. A. Greiner et al., 1997). Sources of errors involved in the assessment by outsiders are insufficient possession of information and overgeneralisation, neglect of rarely occurring events, and reliance on observable behaviour (Semmer et al., 1996).
A second reason for seeking objective data is the pragmatic goal of research. In workplace research the relationship between the objective stress situation and outcomes is of interest, because based on this knowledge healthy and functional workplaces can be designed (Frese & Zapf, 1999).
In addition to correlations between the objective work situation and health, correlations between objective stress situations and perceived stress situations have been found (Frese, 1985). Furthermore, there is evidence that stress perceptions act as mediators rather than moderators in the stress process (Frese & Zapf, 1999).
Studies on the objective stress situations have shown that there is a correlation between the objective work situation and health (Frese, 1985; B. A. Greiner, Krause, Ragland & Fisher, 1998; B. A. Greiner et al., 1997). In these studies, the correlations between objective stressor measures and strain are smaller than the correlations between self-report measures of stressors and strain. This finding suggests that relationships between self-reported stressors and strain are inflated but not artefactual. These findings point out the explanatory value of subjective experience for stress-related outcomes.

Similar results are reported from SBS studies. Various studies found associations between perceived exposures and self-reported SBS symptoms (Brauer, 2005). The few studies using objective measurements of exposures, however, show inconsistent findings (Wargocki, Sundell, Bischof, Brundrett, Fanger, Gyntelberg, Hanssen, Harrison, Pickering, Seppänen & Wouters, 2002b). Taken together, these studies allow the conclusion that higher ventilation rates seem to be associated with higher perceived air quality and less SBS symptoms. These findings suggest an at least partial mediation of the effect of ventilation rates on health by perceived air quality.

The interplay between objective conditions and subjective experience is a core issue in workplace research. Knowledge about objective conditions and their perception would allow evidence based design of facilities. Research on the relationship of objective and perceived properties of physical work environments, however, is only in its infancy.

In summary, the experience of stress increases the amount of explained variance in symptoms of ill health compared to objectively measured conditions alone. There is evidence that this increase in explained variance is not due to methodological artefacts but is substantial.

5.4.5. The sick building syndrome

In research on the relationship between health and office workplaces the association between buildings and health is often captured with the term “sick building syndrome” (SBS). There is no general consensus on the definition of this phenomenon. SBS is not a singular syndrome that could be regarded as a medical disease entity (Jaakkola, 1998). Rather, Sick Building Syndrome (SBS) usually denotes a set of „symptoms of general malaise associated with occupancy of certain workplaces“ (Hedge, Erickson & Rubin, 1992, p. 286). There seems to be some agreement on typical SBS symptoms (Brauer, 2005). They include mucous membrane symptoms and general symptoms such as fatigue and headache. Some researchers also include skin symptoms and lower respiratory symptoms.
Many studies conclude that SBS has a multifactorial aetiology. The mechanisms of the SBS process, however, are not fully understood (Brauer, 2005; Lahtinen, Huuhtanen & Reijula, 1998. One reason for this lack of understanding is the conceptual unclarity of the SBS phenomenon. It may cover a number of different health outcomes of different aetiological natures. Furthermore, there is no agreement on the temporal relationship between exposure in a building and symptoms and this relationship often is not included in field studies (Brauer, 2005; Burge, 2004). Finally, there is disagreement about the unit of analysis and whether the term SBS refers to a population or an individual (Brauer, 2005).

In addition to associations between self-reported exposures to the indoor environment and reported symptoms (e.g. Pejtersen, Allermann, Kristensen & Poulsen, 2006) or objective measurements of exposures and reported symptoms (e.g. Wargocki et al., 2002b), psychosocial work characteristics have been found to contribute to SBS symptoms (Hedge et al., 1995; A. F. Marmot et al., 2006; Wallace, nelson, Highsmith & Dunteman, 1993; Zweers, Preller, Brunekreef & Boleij, 1992). These factors include work and environmental satisfaction, heavy workload or job stress. Person-related factors found to contribute to the reporting of SBS symptoms are depression (Hedge et al., 1995), female sex (Burge, 2004; Runeson, Norbäck & Stattin, 2003; Zweers et al., 1992), allergies (Wallace et al., 1993; Zweers et al., 1992), age (Runeson et al., 2003), sense of coherence (Runeson et al., 2003), and asthma (Chao, Schwartz, Milton & Burge, 2003).

Lahtinen et al.(1998) conclude from a review of SBS literature that the relationship between chemical, physical and biological environmental exposure on the one hand and personal, psychosocial and work related factors on the other hand seems to be an interactive one: the latter factors seem to increase the vulnerability of the individual to the environmental exposure. In accordance with the dual pathway model (Cox et al., 2000) stress can also be an outcome of environmental exposure when environmental problems lead to fears and anxiety (Lahtinen et al., 1998). There is evidence from a longitudinal study that a reverse causation may be a better explanation of SBS and health associations, i.e. having mucous membrane symptoms may lead to increased reporting of complaints about the indoor environment (Brauer, Budtz-Jorgensen & Mikkelsen, 2008). This study, however, is based on a random population sample and thus consists of people working in a very broad variety of buildings. The association between symptoms and characteristics of the indoor environments remains unexamined.

The discussion of SBS shows the complexity of the relationship between various factors in work environments. It illustrates the importance of integrating physical and psychosocial factors in research of indoor environments. Regarding the job-demands resources framework both, physical and psychosocial factors or hazard can be regarded as demands.

5.5. Individual work performance

Individual performance refers to employee's behaviours that are directed at meeting organisational goals (Campbell, McCloy, Oppler & Sager, 1993). Not all employee behaviour, however, leads to scalable outcomes. It may therefore be more adequate to describe individual work performance in terms of behaviour (and not of outcomes) (Sonnentag & Frese, 2002). Borman and Motowidlo (1993) distinguish between task and contextual performance. Task performance describes the effectiveness of employees' activities that contribute the organisation's "technical core", i.e. activities that normally are part of formal job descriptions. These contributions are either direct (implementation of a part of the organisational technical process, e.g. in the case of production workers) or indirect (provision of materials and services, e.g. in the case of managers or staff personnel). Contextual performance refers to voluntary activities which are not formally part of the job, i.e. contributions to organisational effectiveness through shaping of the organisational, social, and psychological context. Contextual performance includes behaviours such as helping co-workers, making suggestions to improve work, or contributing to a positive organisational climate.

Influences on individual work performance is analysed from different perspectives and with different goals (Roe, 1999; Sonnentag & Frese, 2002). Personnel selection research aims at identifying stable traits that explain and predict individual differences in job performance. Engineering psychologists are interested in the influence of environmental factors and manipulations on performance of elementary artificial tasks in order to study basic cognitive processes in performance (Wickens & Hollands, 2000). Work psychology seeks to understand the regulation processes that guide work performance.

The individual differences perspective of human personnel selection research revealed that generally, individual performance can be understood as jointly determined by individual knowledge, skill, and motivation (Campbell, 1999). These categories seem to be better predictors of work performance than personality factors. Evidence from a meta-analysis shows that the relationships between personality factors and work performance are rather small (Barrick & Mount, 1991). By contrast, meta-analyses provide evidence for a relatively strong

relationship between cognitive ability and job performance (Bobko, Roth & Potosky, 1999; Schmidt & Hunter, 1998).
These findings are complemented by research on situational factors that influence human work performance. The situational influences perspective investigates factors in the individual work environment that stimulate, facilitate, and support or hinder performance. The work environment may hinder performance through interference with the translation of abilities and motivation into performance. A model of constraining factors has been presented by Peters and O'Connor (1980). These factors identified include job-related information, tools and equipment, materials and supplies, budgetary support, required services and help from others, time availability, and physical work environment. Laboratory experiments have provided support that these factors act as performance inhibitors and have a negative impact on employee satisfaction (Peters, O'Connor & Rudolf, 1980). These findings were replicated in a field setting with three managerial samples (O'Connor et al., 1984). These studies indicate that higher situational constraints are associated with lower employee satisfaction. Although the results are statistically significant, the magnitude of the constraint-performance association was smaller than expected: the association was marginal for performance (1% explained variance) and small for satisfaction measures (3% explained variance for general satisfaction, 10% explained variance for work satisfaction). However, the findings are consistent with results from laboratory research and thus support the construct validity of regulation problems as postulated by action regulation theory.
Further factors in the work environment that influence work performance are comfort parameters such as light (Veitch, 2005), temperature (Wyon & Wargocki, 2005b) or noise (Sundstrom et al., 1994). These factors are discussed in more detail in chapter 6.2.

The prevailing approach of the models of work environments that stimulate, facilitate, and support performance is the job characteristics model (Hackman & Oldham, 1976). This model assumes that characteristics of jobs affect critical psychological states which in turn have an effect on personal and work outcomes (Figure 18). This model has dominated job design research (Humphrey, Nahrgang & Morgeson, 2007; Morgeson & Campion, 2003). As a consequence of this focus on motivational work features, other aspects of work (social environment, contextual aspects) have received much less attention. Essentially, the job characteristics model is a motivational model of job performance. Meta-analyses show that there are small positive correlations between job characteristics and objective performance (supervisor ratings or objective data) (Fried & Ferris, 1987). A replication and extension of Fried and Ferris's (1987) meta-analysis by Humphrey et al. (2007) shows that autonomy has a positive relationship with objective performance and that autonomy, task identity, task significance, and feedback from the job (but not skill variety) have positive correlations with subjective performance.
As a motivational model of job design, the job characteristics model focuses on a limited set of work features and neglects other aspects of work such as

environmental and contextual aspects (Humphrey et al., 2007; Morgeson & Campion, 2003). Humphrey et al. (2007) extend this focus and integrate motivational, social, and work context characteristics. In their meta-analysis they show that fourteen work characteristics explain on average 43% of the variance in nineteen worker attitudes and behaviours. Motivational characteristics were found to explain 25% of the variance in subjective performance; social characteristics explained an additional 9%. Work context characteristics were found to explain unique variance in job satisfaction (4%) and in stress (16%) but not in performance.

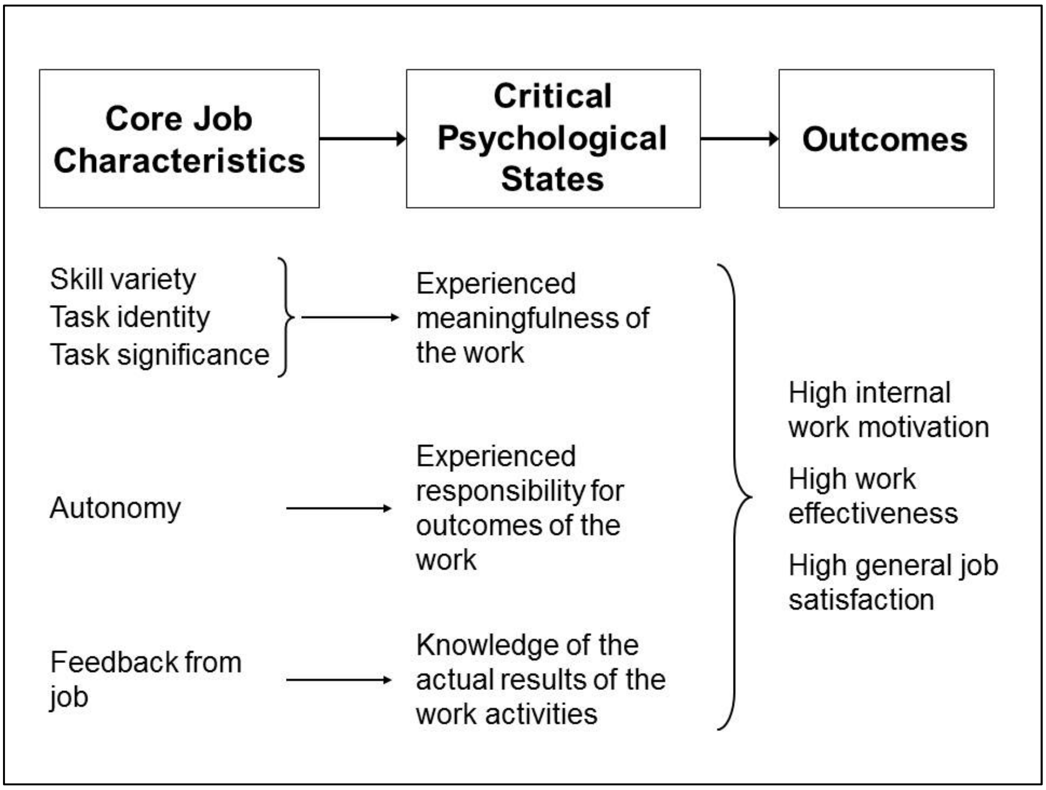


Figure 18. Job characteristics model (Oldham, 1996, modified)

Though stemming from different theoretical and methodological traditions, action regulation theory and the job characteristics model formulate very similar dimensions of job design that affect performance and well-being (Kompier, 2003). Action regulation theory combines the situational influence perspective with a performance regulation perspective: based on a model of action regulation (see chapter 4.1), job features are identified. The action regulation theory perspective on performance focuses on regulation problems (see chapter 4.1.4) and on action-relevant knowledge bases. The development of goals and execution plans and the cognitive regulation of action are dependent on mental representations of the important parameters of work tasks and contextual conditions (Frese & Zapf, 1994). This background knowledge is acquired in learning processes that involve practice. Intellectual understanding evolves with practical experience. Therefore, control is a crucial characteristic of job design because it allows for the evolution

of task relevant knowledge through learning experiences. Furthermore, control allows for choosing adequate strategies to deal with situations and to plan ahead. Thus workers with high control (and a certain amount of experience, i.e. task and action relevant knowledge) can react more flexibly and perform better than workers with low control.
While control refers to regulation possibilities, complexity of tasks refers to regulation requirements (see chapter 4.1). Complexity is an important feature of jobs because it can lead to qualitative or quantitative regulation overload or stress.
Similarly to control, variety is considered an important feature of tasks. Variety describes the amount of different actions required by the task (Frese & Zapf, 1994). In addition to learning experiences and full utilisation of skills and knowledge, variety also prevents strain injuries from repetitive movements. A further important characteristic of jobs from the perspective of action regulation theory is the completeness of action. This concept refers to the number of steps associated with a task. An action is considered complete when it involves all regulation steps in the action process, in particular goal setting, plan development, decision making, execution monitoring, and feedback. Both, acquisition of task relevant knowledge and action regulation can be supported by co-workers and supervisors. Therefore, co-operation and social support is a further job characteristic considered important in action regulation theory.

While performance is the major issue in workplace interventions from an organisational perspective, there is little agreement on the measurement of work performance. Management of productivity and assessment of performance of knowledge work are a much debated challenge (Drucker, 1999). Measuring work performance of knowledge workers in relation to work environments poses several problems (van der Voordt, 2003). Although from a methodological point of view objective measures would be preferred, they are often either unavailable or inappropriate for the tasks because most office work cannot be measured as output. Removing the consideration of performance from the research design is no desirable alternative, therefore subjective performance measures are used as substitutes for objective performance measures (Dess & Robinson Jr, 1984).

Recent research on the basis of the Job Demands-Resources model integrates the issues discussed above and suggests work engagement as a proxy measure for individual work performance (Bakker & Leiter, 2010). Work engagement is viewed as a positive indicator of work-related adjustment (Demerouti & Cropanzano, 2010). It is described as a positive, fulfilling, work-related state of mind. The experience of work engagement is characterised by vigour, dedication, and absorption (Schaufeli & Bakker, 2004). Vigour refers to high levels of energy while working. Dedication is described as a sense of significance, enthusiasm, inspiration, and pride. Vigour and dedication are the positive opposites of exhaustion and cynicism; two dimensions that characterise the core of the burnout construct (Demerouti & Bakker, 2008). The third dimensions of work engagement,

absorption, is characterised by being fully concentrated and happily engrossed in one's work.
Work engagement is a motivational construct and as such has a stronger effect on job performance than other related constructs, such as job satisfaction, for example. Therefore, it is considered as an important antecedent of performance and may serve as a proxy measure for work performance (Demerouti & Cropanzano, 2010). Work engagement is the result of the configuration of job demands (regulation problems) and resources (such as the job characteristics described in the job characteristics model and social support). Work engagement thus provides a theoretical link between demands, resources, and job performance.

5.6. Interrelations among outcomes

The five outcome dimensions discussed above are not independent. Attitudinal reactions (job and environmental satisfaction, commitment) are evaluative judgments summarizing cognitive and affective reactions that result from accommodation and adaptation in work environments. From the action-regulation theory point of view, work situations associated with many regulation problems are likely to cause dissatisfaction and to reduce organisational commitment. Performance may remain constant even in the presence of regulation problems because problems are compensated by extra regulation efforts. There is evidence that these extra efforts in such situations can impair health. The attitudinal, behavioural, and health-related outcome dimensions therefore are interrelated. The relationship between job satisfaction and job performance is discussed in chapter 5.1. The mean correlations reported range between 0.17 and 0.30 (Iaffaldano & Muchinsky, 1985; Judge et al., 2001). Similar size correlations are reported for the relationship between satisfaction and health measures (Warr, 2005).

The relationship between job and environmental satisfaction is theoretically and empirically unclear. Environmental satisfaction can be regarded a facet of job satisfaction (Sundstrom, 1986). This view is based on a facet approach to job satisfaction that views job satisfaction as a construct composed of specific and separate areas of satisfaction. The problem of such an approach, however, lies in the selection of facets. A facet approach to job satisfaction may neglect aspects of a job that are important to employees and may include facets that are unimportant. A theoretical alternative is the conceptualisation of job satisfaction as an overall construct. Measures following this approach allow employees to consider all the aspects of their jobs they consider relevant. As a consequence, facet satisfaction or a combination of facet satisfactions is something different from overall satisfaction. This proposition is confirmed by medium correlations between global and facet job satisfaction in empirical studies (Highhouse & Becker, 1993; Ironson, Smith, Brannick, Gibson & Paul, 1989). Global satisfaction measures correlate higher with organisational outcomes such as job performance than facet

measures (Iaffaldano & Muchinsky, 1985). This higher correlation, however, comes with the price of reduced interpretability of the content of job satisfaction and therefore has little value for guiding interventions in organisations.
Empirical research has tended to find environmental satisfaction to be a facet of job satisfaction (J. R. Carlopio, 1996; Veitch et al., 2007). These findings, however, are equivocal and other studies failed to replicate the results (Newsham et al., 2009).

Job satisfaction and organisational commitment are highly correlated in empirical studies (Gaertner, 1999; Meyer, Stanley, Herscovitch & Topolnytsky, 2002). The causal relation between the two constructs, however, remains unclear. While Gaertner's (1999) results indicate that job satisfaction might function as a mediator between characteristics of work settings and commitment, most researchers consider job satisfaction and organisational commitment as two mutually dependent outcomes (J. R. Carlopio, 1996; Meyer et al., 2002; Van Scotter, 2000).

6. The Office Environment

Offices are defined by their form and their function. Office environments are designed for certain purposes. These purposes are derived from the user organisation's work patterns and culture and from users' needs. Office environments consist in a system of different facets of the physical environment, such as the office building, office room layouts, workstations, and ambient conditions (Sundstrom, 1986). Perceptions of office environments, i.e. office characteristics, can be clustered into ambient environment, material environment, and socio-spatial environment (McCoy & Evans, 2005; Sundstrom, 1986). These aspects of the office environment are influenced by characteristics of the office building, location, and spatial organisation of offices. Employees are regarded as active users of offices. Their experience is not determined by office design but they exert control over their environment (see Figure 19 for an overview).

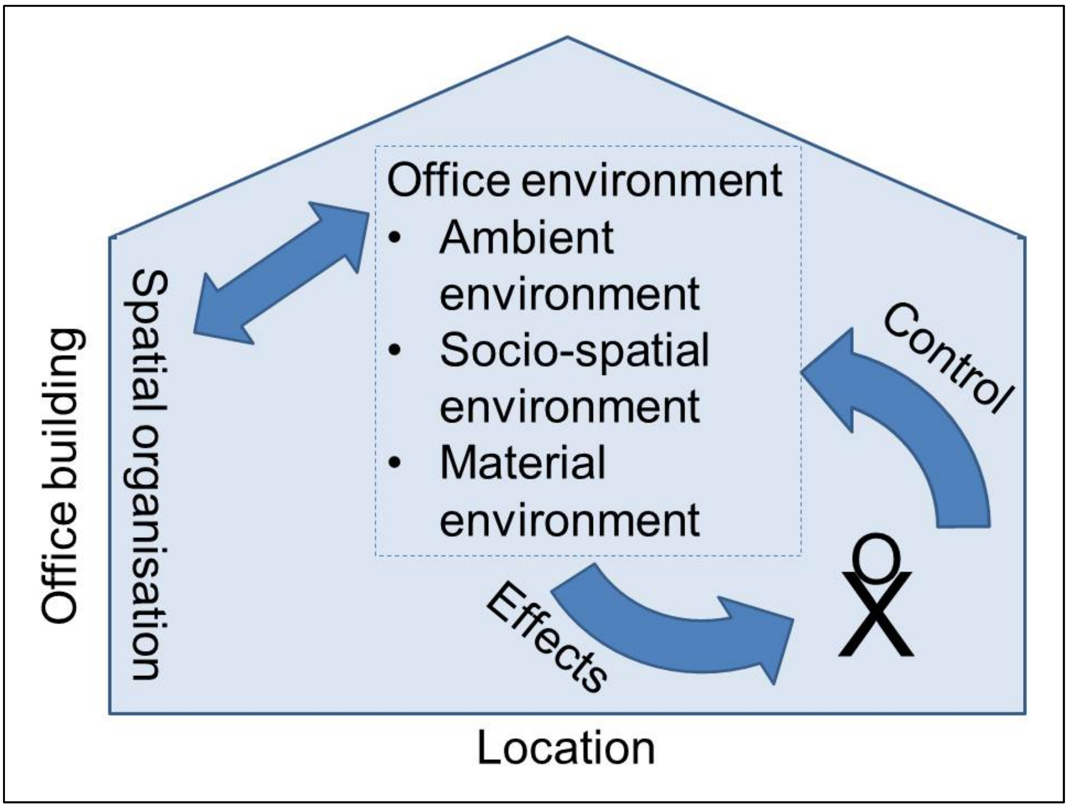


Figure 19. Conceptual model of the office environment

At present, there is little evidence for an assessment of the relative importance of these facets regarding satisfaction, commitment, performance, and health. Marans and Spreckelmeyer (1982) found that assessments of larger environmental settings (i.e. the office building) are influenced by office users' feelings about their immediate workplace. This finding is stated more precisely by Donald (1994) on the basis of a survey of user experiences of office spaces. In this study, no general distinction in the evaluations between the office and the immediate workspace was found. More precisely, a specific distinction between evaluations of the workspace and the wider office was only found regarding socio-spatial phenomena such as privacy and communication but not for services and non-social spaces.

In this chapter, the relationship between office environment facets and outcomes (job satisfaction, environmental satisfaction, organisational commitment, health, individual performance) are discussed.
Characteristics of office environments can be classified into environmental conditions and socio-spatial environmental variables (Baron, 1994; Haynes, 2007; Sutton & Rafaeli, 1987). The most frequently discussed physical aspects are environmental stressors such as noise, temperature, lighting, and air quality (see reviews by Baron, 1994; G. W. Evans, 2001; G. W. Evans & Cohen, 1987; McCoy & Evans, 2005; Rashid & Zimring, 2008). As for the socio-spatial variables, privacy and crowding are the most prevalent (Baron, 1994; G. W. Evans, 2001; G. W. Evans & Cohen, 1987). In addition to environmental conditions and socio-spatial environmental variables as categories of environmental stressors, office design is proposed as a third category here. This category includes the location of the office building, use of space, material aspects such as furniture, fixture and equipment, and natural views (Donald, 1994; McCoy & Evans, 2005; Rashid & Zimring, 2008).
The three categories of office environment characteristics interact in real office buildings. However, for analytic and descriptive convenience, the effects of the stressors are discussed separately.

Theoretically most environmental influences follow an inverted U-shaped function between physical stimulation levels and human reactions: Too much stimulation causes overload and too little stimulation causes sensory deprivation (G. W. Evans & Cohen, 1987). Both of these mechanisms produce stress. In reality the stimulation levels are limited by legislation, technical standards, and design practice. For example, while too much lighting causes glare and thus reduces satisfaction and performance, an adequate level of light at the workstation may remain unnoticed (and therefore not promote satisfaction, well-being, and performance). On the other hand, the presence of a window near the workstation may have positive consequences and may act as a buffer for the effects of other stressors (e.g. job stress, Leather, Pyrgas, Beale & Lawrence, 1998). Therefore, office environment characteristics are not only discussed under the focus of stress but also regarding their potential contributions to satisfaction, commitment, health, and performance.

6.1. Office building and location

The integration of physical building data in office building evaluation has received little attention. Current reviews of the building-health relationship (e.g. Rashid &

Zimring, 2008) or building-productivity relationship (e.g. Preiser & Vischer, 2005; van der Voordt, 2003; Davis, Leach & Clegg, 2011) do not include building location, form, and outdoor environment. Instead they focus on indoor environment and its relationship with health or satisfaction[10].
In a review of office concepts on worker health and performance De Croon et al. (2005) state that there is not enough evidence to conclude on the effect of office location on long-term reactions such as health or productivity. Clements-Croome & Li (2000) identified a small effect of the outdoor environment on productivity but this effect was marginal compared to the effect of the indoor environment.
There is limited evidence about the impact of office building properties on building users' satisfaction, performance, or health. The notable exception is research on effects of windows on office users. Windows are important for three reasons (McCoy, 2002): (1) they allow for views from the workspace, (2) they influence lighting quality and the satisfaction with lighting (see chapter 6.2.3), and (3) openable windows have an impact on perceived indoor air quality (see chapter 6.2.2). Furthermore, operable windows provide an opportunity for adaption of thermal comfort and provide a thus sense of control over the environment (Barlow & Fiala, 2007, see also chapter 6.2.4).

Views of a natural environment have been shown to enhance office workers health and satisfaction (R. Kaplan, 1993). Views of a natural environment from a hospital room are known to shorten recovery time for surgery and reducing pain medications (Ulrich, 1984). R. Kaplan (1993) argues that windows are not only important as sources of light, sunshine and information about the weather, but that the quality of the views from the windows is important as well. According to her research the psychological benefits of views from the workplace are fully fostered only if there is a minimum of natural elements: "the elements of nature that seem to make such a strong difference need not be any more than a few trees, some landscaping, or some signs of vegetation. In fact, the presence of other buildings or parking lots does not seem to be a problem, as long as the natural world is there too" (R. Kaplan, 1993, p. 199). Further evidence for this argument comes from a study on direct and indirect effects of windows on job satisfaction and well-being (Leather et al., 1998). They found that sunlight penetration had a direct positive effect on job satisfaction, intention to quit, and general well-being. The view of natural elements buffered negative impacts of job stress on intention to quit and had a similar (marginal) effect on general well-being.
Green surroundings thus seem to be an important factor contributing to the quality of an office building's location. The view of a natural environment may be a more important aspect of windows than access to daylight because in many European countries access to daylight is mandatory by legislation (Van Meel et al., 2006). Thus not amount and size of windows but the quality of what can be seen through the windows makes a difference in the quality of an office building's location.

[10] Rashid & Zimring (2008) propose an architectural and/or interior design category in their review of the empirical literature on the relationship between indoor environment and stress in health care and office settings. However, they do not discuss the influences of elements of this category on stress.

Apart from windows and views from the workplace, location did not receive much attention in research on user perceptions of office buildings.

Although methods for assessment of building location, form, and outdoor environment are available (Baird, Gray, Isaacs, Kernohan & McIndoe, 1996; Preiser & Vischer, 2005; van der Voordt & van Wegen, 2005) results from such building quality assessments have not been connected to user-related data. Instead these methods are used for matching demand and supply with focus on function and/or economic aspects (Baird et al., 1996). Methods used in building quality assessment usually are expert-based methods and do not involve user surveys. Where data from both sources have been collected, convergence between users' assessments and the view of designers and facilities managers is usually low (see Chigot, 2005 for a review of convergences of subjective and objective assessments of noise in offices). The reason for this difference may be an emphasis on the purpose of a facility or building by the users. Building users may stress the usability of their surroundings while designers and facilities managers focus on functionality (K. Alexander, 2008). Consequently, user assessments of facilities (usability) are strongly and systematically related to measures of the user-oriented outcomes (e.g. performance, well-being, health) while engineering assessments of facilities are not (see Roberts, 2009 for a study illustrating this argumentation in school facilities) (Windlinger, Nenonen & Airo, 2010).

Empirical evidence on the effects of office location and office building on office users would be desirable for real estate companies and architects because it would allow evidence-based design. From a theoretical perspective, knowledge about office locations and office buildings are desirable as an extension and complement to available knowledge on office indoor environments.

6.2. Office Indoor Environmental Conditions and Comfort

Office indoor environmental conditions include ambient conditions such as noise, climate and air quality, lighting. Additionally, control over environmental conditions and functional quality of workplaces are considered important aspects of the ambient environment in offices (McCoy & Evans, 2005).

Summarizing findings from post-occupancy evaluations, Leaman & Bordass (2005) state that overall comfort and self-assessed performance correlate strongly on the level of buildings and therefore overall comfort should be considered an important variable. In these studies, overall comfort was used as an umbrella concept that covers office users' perceptions of noise, climate, ventilation, and lighting taken together in an overall assessment. However, Humphreys (2005) provides evidence that overall comfort measures obscure the nature of satisfaction and dissatisfaction with the indoor environment. In a study including 26 offices in

Europe they found differences between aspect and overall environmental comfort. Furthermore, the relative importance of different aspects differed between countries and it was impossible to develop a model that represents the data from occupants' assessments.

Different aspects of the office indoor environment are therefore discussed separately in this chapter and the literature for each aspect is discussed in relation to effects on users' health, performance, and attitudes (see Gifford, 2002).

6.2.1. Noise

Noise can be defined as unwanted sound (Gifford, 2002). Low-intensity noise is typical for office environments and among the most common annoying sources in offices (Banbury & Berry, 2005; Sundstrom, 1986).
There is extensive evidence on the effects of informational content of perceived office noise: Nemecek and Grandjean (1973) report that noise produced by colleagues in the same office room is the most frequently named source of disturbing noise, independent of its intensity. In a survey of more than 2000 clerical workers in different office types Sundstrom et al. (1994) found that 54% complained about one or more sources of noise. The most frequent sources of dissatisfaction with acoustics in this research are telephones ringing and people talking face-to-face or on the phone. Similar results are reported by Jensen, Arens & Zagreus (2005) who review survey results from 142 buildings. Their analyses confirm that the three sources of office noise mentioned above are the most important sources in a variety of offices types.

The negative effects of noise on health and well-being are mostly mediated by experience of stress. Noise in offices can overtax processing capacities but does not reach intensity levels that are dangerous for the human ear. Thus, not noise levels, but noise events and qualities (i.e. nonphysical characteristics of sound) are stressful. However, noise in offices may produce neuroendocrine reactions and alter stress hormone levels in absence of perceived stress (G. W. Evans & Johnson, 2000). Prolonged elevation of hormone levels contributes to a variety of health problems (Cox et al., 2000; McEwen, 1998), such as increased cardiovascular risk.

In addition to the quality of noise, the type of work tasks has to be considered: different tasks are not affected to the same degree by office noise (Banbury & Berry, 1998). Particularly, task irrelevant background speech interferes with verbal performance (Banbury et al., 2001): The higher the informational content and intensity of noise the longer the time needed to complete tasks is needed and the more errors are made. Noisy and informational rich environments coupled with complex tasks lead office users to abandon work on tasks or to leave tasks incomplete. The reason for this behaviour is an unfavourable effort-output calculation caused by noise that requires more effort and time to be invested in order to achieve satisfying results (Sust & Lazarus, 2002). Office noise is therefore a problem particularly important for knowledge workers. There seems to be no habituation to sounds that possibly impair concentration in offices (Banbury & Berry, 2005). As a result, permanent compensatory efforts are needed in order to maintain concentration on work tasks. This compensatory efforts may lead to overtaxing of resources and consequently to health problems and performance decrements.

There is some evidence that office noise reduces work motivation. In a laboratory experiment, Evans & Johnson (2000) compared stress experience and motivation of a group of clerical workers in a low-intensity noise condition that simulated typical open-office levels with workers in a control condition. Their results suggest that stress experience as measured in workers urinary epinephrine levels was higher in the experimental condition. Perceived stress, however, did not differ between the two groups. Motivation measures after a three-hour exposition to the office environment indicated that subjects in the experimental condition were less motivated.

Office noise leads to disturbance and disruption of work and negatively influences office environment satisfaction (Lee & Brand, 2005) and job satisfaction (Sundstrom et al., 1994). Leather et al., 2002) investigated the influence of environmental noise on job satisfaction, well-being, and organisational commitment. Contrary to other research (e.g. Sundstrom et al., 1994) no direct effects were found. However, reduced environmental noise seems to buffer negative effects of psychosocial job stress on job satisfaction, well-being, and organisational commitment.

In summary, the distracting influences of office noise are well documented as well as its negative effect on office environment satisfaction, job satisfaction, motivation, and health. There are indications that non-physical qualities of noise are more important than the environmental noise level (intensity). The problems associated with noise are especially serious in open office structures (as compared to private office rooms) (Jensen et al., 2005; Kaarlela-Tuomaala, Helenius, Keskinen & Hongisto, 2009; Pejtersen et al., 2006).

6.2.2. Indoor Climate, Thermal Comfort, and Indoor Air Quality

Climate refers to thermal comfort and is mainly affected by air and radiant temperature, relative humidity, and air movement. The thermal environment causes adaptive responses: in warm environments internal heat production is lowered in order to avoid sweating. As a consequence arousal is lower and may lead to a slower work rate. Most of the time, office workers are not seriously affected by indoor climate because they can adjust the temperature or air movement or adjust their clothing (Brager & de Dear, 1998). Users thereby react to changes in thermal conditions and perceptions of office temperatures are

closely related to physically measured temperatures (Hedge, Erickson & Rubin, 1996).
Indoor air quality is a second element of the indoor atmosphere that influences health satisfaction, and work behaviour. Air quality refers to the freshness, cleanliness, and pleasantness of the respirable atmosphere. Because of the multitude of influencing factors and especially potential contaminants, Fanger (2006) proposes to define air quality as the degree to which human requirements are met. Following this proposition, air quality assessments can be conceptualised as a comfort measure.

Several studies show that thermal comfort has an important impact on overall environmental satisfaction (J. R. Carlopio, 1996; Veitch et al., 2007). In addition to thermal variables, perceived control of environmental conditions exerts influence on thermal comfort (Paciuk, 1990).

Indoor climate's influence on health is usually researched in connection with air quality and Sick Building Syndrome symptoms (Rashid & Zimring, 2008; Wyon & Wargocki, 2005b).
Fang, Wyon, Clausen & Fanger (2004) found significant effects of temperature and relative humidity on fatigue and headache: Air temperatures above 23°C with relative humidity above 50% amplified the intensity of these symptoms compared to a 20°C / 40% relative humidity condition.
Additionally, type of ventilation, office layout, temperature and humidity influence the transmission of common respiratory illnesses (Fisk, 2000). Similar results are reported by Witterseh et al. (2004). They found significant effects of raised temperature on mucous membrane irritation (eye, nose and throat dryness) and headache.
Mendell & Mirer (2009) present data from 95 air conditioned office building and about 4000 employees that suggest that the relationship between temperature and SBS symptoms is subject to seasonal differences. In their analyses, increasing the mean temperature from 21.6°C to 24.8°C in winter leads to a substantial increase in most SBS symptoms while the same temperature increment in summer results in a decrease of most symptoms.

Air quality refers to the attributes of respirable indoor air such as its composition or degree of cleanliness. Indoor air can be contaminated by combustion gases (e.g. carbon monoxide, carbon dioxide), volatile organic compounds (e.g. formaldehyde), respirable particulates, and microbiological organisms (such as bacteria or fungi) (Hedge, 2000). Ventilation rates lower than 10L/s per person seem to increase SBS symptoms and ventilation rates of 25L/s per person seem to further reduce SBS symptoms (Fisk et al., 2009; Seppänen & Fisk, 2004; Wargocki et al., 2002b). Experimental research showed that air pollution in offices through a 20 year old carpet from a building with SBS history seems to cause physical symptoms such as irritation of nose, eyes, and throat (Wargocki, Lagercrantz, Witterseh, Sundell, Wyon & Fanger, 2002a). From the studies reported by Wargocki et al. (2002a) pollution seems to be the cause of dry air perception because perceptions disappeared when the source of pollution was removed although the relative humidity remained unchanged.

Several studies agree on different consequences of different ventilation systems on SBS symptoms (Seppänen & Fisk, 2004; Zweers et al., 1992). These studies show that the prevalence of such symptoms is higher in air-conditioned buildings than in naturally or mechanically ventilated buildings.

From a meta-analysis of twenty-three studies examining the relationship between temperature and performance Pilcher, Nadler & Busch (2002) conclude that the greatest detriment in performance occurs under the coldest and hottest conditions investigated: On average, thermal conditions below 10°C led to a decrement of fourteen per cent and temperatures above 32°C to a decrement of fifteen per cent in performance. Temperatures between 10°C - 18°C and 26.5°C - 32°C respectively led to a smaller decrement in performance of about eight per cent on average. Effects of temperature exposure on performance depend on the type of task. Cold temperatures of about 18°C seem to negatively affect performance in reasoning, learning, and memory tasks while warmer conditions (above 26.5°C) seem to result in small improvements in performance of these tasks. Contrary, attentional, perceptual, and mathematical tasks seem to be more negatively affected by hot temperatures than cold temperatures. Pilcher et al., 2002 suggest to conclude from these results that in a typical work environment where employees are involved in a variety of tasks and environmental conditions the best estimate of the effect of temperature exposure on performance is described as an inverted U-shaped curve with an optimal temperature range of 18°C to 26.5°C.
The conclusions of Pilcher et al., 2002 are supported by a laboratory experiment using a relatively long duration of exposure to controlled thermal conditions of 280 minutes (Fang et al., 2004). In this study, no performance differences were found between conditions of 20°C/40% relative humidity, 23°C/50% RH, 26°C/60% RH. However, SBS symptoms were alleviated at low levels of air temperature and relative humidity.
This study also showed that the impact on perceived air quality by decreasing the ventilation rate can be counteracted by a decrement of temperature and relative humidity. This result substantiates the interdependence of climate (temperature and relative humidity) and indoor air quality.
Given that thermal comfort can be adjusted by clothing, air quality may exert more important influences on performance. However, in laboratory experiments only tendencies of performance improvements through better indoor air quality could be showed (Wargocki et al., 2002a). Wyon & Wargocki (2005a) summarise two field studies on the impact of ventilation on performance in call centres. The findings from these studies suggest that suggest that indoor air quality may have a larger effect on performance of office workers in the field than would be expected from laboratory experiments. According to these studies, poor indoor air quality can reduce the performance of office workers by 6 to 10%. This finding supports the claim that perceived indoor air quality (PIAQ) may be more important for explaining SBS than physically measured variables (Hedge et al., 1996). Klitzman

and Stellman (1989) provide evidence that assessments of the physical environment are distinct from assessments of general working conditions. Thus, employees who report problems with the physical environment cannot be characterised as generally dissatisfied workers exhibiting a tendency to complain about various aspects of their working conditions. Perceived indoor air quality may therefore be a valid measure of environmental effects on humans and IAQ is usually defined and assessed as the acceptance by a high percentage of people (Fanger, 2006). However, perceived air quality should not be considered as a universal measure because the sensory effects of pollutants are not always linked to their toxicity (Seppänen & Fisk, 2004). For example, harmful gases such as radon or carbon monoxide are not sensed.

6.2.3. Lighting

Studies of lighting conditions for offices have resulted in an amount of knowledge on the lighting conditions needed for high levels of performance and to avoid visual discomfort (Boyce, 2003). This knowledge has been adopted by lighting practitioners and today offices lit in a way that limits visual performance or causes extreme visual discomfort are rarely to be found (Boyce, Veitch, Newsham, Jones, Heerwagen, Myer & Hunter, 2006). This body of knowledge, however, is largely based on laboratory studies and it can be assumed that in real offices and work settings effects of the larger office environmental context may interact with visibility and lighting issues. Furthermore, effects in field studies would allow the investigation of longer time exposures to lighting conditions than typically used in laboratory research.

Lighting influences health through biological and psychological mechanisms. Among the biological routes, neurotransmitters and hormones that are implicated in the control of circadian rhythms by light play an important role (Veitch, 2005). Low light exposure correlates with reduced activation and depressive symptoms. Positioning of light sources in workplace lighting can contribute to glare and discomfort related to glare, such as eyestrain and headaches. These symptoms can also be attributable to subliminal effects of low-frequency flickering of fluorescent lights (Veitch, 2005).

Studies investigating a direct effect of lighting conditions on task performance have failed to identify such a link (Boyce et al., 2006; Veitch, Newsham, Boyce & Jones, 2008). This may be due to the limited range of variations of current office lighting practices (Boyce et al., 2006), to tasks employed in laboratory studies (Veitch et al., 2008), or to the adaptive capability of the human visual system (Veitch, 2005).

Lighting, however, seems to have an influence of overall environmental satisfaction (Veitch et al., 2007; Veitch et al., 2008). This link seems to be quite strong. In the study of Veitch et al. (2008) appraisal of lighting conditions predicted subjects’ ratings of office spaces as attractive and their positive mood.

The latter two variables in turn predicted overall discomfort and satisfaction with the work environment. Veitch et al. (2007) report a direct effect of lighting conditions assessment and overall environmental satisfaction. The size of this effect is comparable to the one between assessment of ventilation and overall environmental satisfaction.
Two elements that have been shown to be especially important for satisfaction with lighting are control and daylight. Control over lighting conditions has several benefits. Control addresses the problem of individual differences in lighting preferences and needs (Veitch, 2005). Having control over lighting in a simulated office environment resulted in improved mood, comfort, and environmental satisfaction but not in improved performance (Newsham, Veitch, Arsenault & Duval, 2004). Generally, office users tend to react favourably to having such control (Moore, Carter & Slater, 2004).
In addition to control, natural daylight is preferable in office settings. It has positive effects on job satisfaction and general well-being of office occupants (Leather et al., 1998). Newsham et al. (2009) report a positive effect of the availability of an outside window on satisfaction with lighting. In a large field study in North America, Veitch et al. (2007) found that the strongest predictor of satisfaction with lighting was the presence of a window in the workstation. Physiological and psychological benefits of windows in the workplace are so great that many European countries require access to windows for most workers. Most office workers consider windows an important feature of the workplace (Galasiu & Veitch, 2006). Windows are so important that they even render less problematic the discomfort with glare, especially when windows provide pleasant views (Galasiu & Veitch, 2006).

6.2.4. Control over office work environment

As described above, control is a central element in lighting. Control refers to the degree to which a person has the possibility to exert influence over the environment in order to adjust conditions to own goals, needs, and interests such as comfort or functionality. Control over the office work environment may include decisions among several workspace options, i.e. choice among different settings within an office building or choice of location (e.g. telework).
Objective control is determined by the logic of physical structures and infrastructures. Subjective control refers to the perception of control in a situation. It develops from repeated experience with choices regarding the physical environment, in which a person learns how to obtain desired outcomes, such as comfort for example. Subjective and objective control is not always congruent. Perceived control seems to have a stronger relationship with work-related outcomes than objective control (Dupré, Barling & LeBlanc, 2005; Paciuk, 1990).

Insufficient personal control is an important component of stress: The degree of experienced stress is dependent of the degree of control. The availability of control may moderate the relationships between environmental conditions and employee-related outcomes. Different mechanisms play a role in the explanation of this relationship (Frese, 1989; Ganster & Fusilier, 1989):

- Control implies the possibility to reduce, avoid, or eliminate stressors.
- Control allows the alignment of work activities and external conditions. The impact of stressors can thereby be reduced or modified (without changing the stressors).
- The availability of control as a knowledge of basic controllability renders the appraisal of situations less threatening. This is even true when actual control is not exercised (Glass & Singer, 1972).
- Availability of control fulfils a fundamental need for control and therefore prevents stress.
- Perceived control is associated with a belief that stress situations can be coped with successfully. Therefore active coping strategies will be employed and sustained.

Effects of environmental control in offices on health have not been researched. However, there is evidence that ergonomics training in offices increase knowledge about health relevant set-ups of office furniture and improve musculoskeletal health (Huang, Robertson & Chang, 2004; Robertson, Amick III, DeRango, Rooney, Bazzani, Harrist & Moore, 2009). Several studies indicate that SBS symptoms are much lower when individual workers are allowed to control their own thermal environment (Wyon, 1996; A. F. Marmot et al., 2006). Employees experiencing stress, however, are less likely to use control options (G. W. Evans & Johnson, 2000).

Results from post-occupancy evaluations (Leaman, 2003) indicate that employees assess their productivity to be higher when they have control over heating, cooling, ventilation, noise, and lighting in their work environment. Where this control is not available it may be counterbalanced by proactive and quick reactions of facility managers. Control over noise seems to be the most important facet of control over the physical work environment (Leaman & Bordass, 2005). This may be due to the fact that noise is a stressor by definition. Control over non-stressful conditions seems to be relatively unimportant and does not affect satisfaction, mood, performance, and health (Veitch & Newsham, 2000). Thus, control in good environmental conditions is less important.

Lee & Brand (2005) found positive influences of perceived control over the own workspace on job satisfaction. In this study also positive effects of control over the work environment and the availability of a variety of work environments, a precondition for behavioural control, on group cohesiveness were found.
Paciuk (1990) reports the influence of perceived control over the office environment on thermal comfort. McLaney and Hurrell Jr. (1988) analysed different forms of control (task, decision, resource, and physical environment control). In a study of 675 employees in the healthcare sector they found that all facets of control except decisional control were positively related to job satisfaction. Interactions of stressors and control did not significantly relate to job satisfaction.

Therefore personal control is considered not as a moderator but as a direct influence on job satisfaction.

6.3. Spatial organisation of offices

Person-based environmental variables neglect the fact that office settings are generally shared by several persons. Offices are spatially organised and interpersonal relationships and their individual consequences are affected by the spatial organisation. In this chapter, office layout, arrangement of space, and density are discussed as the main physical elements of spatial organisation. The socio-spatial environment and its impacts on interpersonal and individual perceptions and processes are discussed in chapter 6.4.

6.3.1. Office Layout and arrangement of space

Spatial arrangements in offices encompass the subdivision of available space and the size, shape, and allocation of units of space. Layout refers to furniture configuration, amount of space for individual and shared spaces, and circulation routes. The most discussed facet of office layout and spatial arrangement is office openness (e.g. Becker & Sims, 2001; Brill et al., 2001 who represent two opposite positions, Brill et al., 2001 advocating closed and Becker & Sims, 2001 promoting open offices). The “open plan vs. closed offices” debate is unsolved. Empirical evidence is not consistent and for some questions not sufficient (De Croon et al., 2005). In this chapter, empirical literature on office layout and arrangement of space is reviewed.
According to the nature of the subject, research on spatial arrangements in offices is mostly based on studies in field settings (as opposed to the research on office environment conditions and comfort described in chapter 6.2).

The effects of office openness have been examined in four longitudinal studies. Oldham (1988) examined moves from open-plan offices to either an open office with relatively low levels of spatial density or to an office with three partitions surrounding employees’ workspaces. While these moves had positive effects on employees' perceptions of crowding, privacy, and office satisfaction, they did not affect self-rated performance.
In the second longitudinal field study, Brennan, Chugh & Kline (2002) examined moves from solo or two-person offices to group offices with four to nine users. They found that self-rated performance significantly decreased after the moves. Furthermore, there was no improvement in self-rated work performance in a second post-move survey after an adjustment phase of 6 months following the move and 5 months after the first post-move survey.
In a longitudinal quasi-experimental study Oldham & Brass (1979) examined how the physical environment affected office users’ attitudes and motivation as well as job characteristics. In this research, workers at a newspaper organization moved from a traditional office setting to an open-plan office arrangement. This change

led to a significant reduction in job satisfaction and co-worker satisfaction. This effect persisted over time and there were no differences in the measures after nine and after eighteen weeks after the office changeover.
In a similar longitudinal study, Zalesny & Farace (1987) found a reduction in work satisfaction after a move from solo offices or partially open offices to an open plan office.

Cross-sectional studies of office openness and performance indicate that the degree of openness may have a negative impact on individual performance. Sundstrom, Burt & Kamp (1980) found that supervisor ratings of job performance of routine office work (clerical, secretarial work) were correlated positively with number of enclosed sides and satisfaction with workspace. The ratings were negatively correlated with number of neighbours and noise in the office environment.
Oldham, Kulik & Stepina (1991) report a small but significant correlation between interpersonal distance and performance ($r = .18$) but not between the number of enclosures or spatial density and performance. Stimulus-screening skills and job complexity seem to moderate the relations between environmental characteristics and employee reactions in this study. Employees exhibited the lowest performance when their jobs were low in complexity, their stimulus-screening skills were weak, and they worked in dense areas, areas with few enclosures, or close to colleagues.

The relationship between office layout and health has been a topic in only few studies. Sutton & Rafaeli (1987) did not find statistically significant relationships between layout and somatic complaints. Jaakkola & Heinonen (1995) report a higher risk of the common cold for workers sharing offices than for those in single offices. Fried (1990) explored the joint moderating effect of two central workspace characteristics (number of people and number of enclosures) on the relationships between behavioural interferences (distractions and disturbances) and responses among individuals with high and low ability to screen[11]. The results suggest that individual reactions (work fatigue and psychosomatic complaints) to behavioural interferences at work are intensified by the joint presence of few enclosures and high number of people in the setting; however, this intensification effect appears to hold primarily among individuals with low screening ability. Thus, the joint moderating effect of workspace characteristics itself appears to be buffered by personal ability to screen.

In a field study with various outcomes, Oldham & Fried (1987) investigated the effects of four workspace characteristics (social density, room darkness, number of enclosures, and interpersonal distance) on three employee reactions (turnover, satisfaction, and withdrawal from the office during discretionary periods). The authors report main effects for all independent on all dependent variables (with few exceptions in the relationships that involve turnover). The independent and

[11] Stimulus screening refers to automatic screening of irrelevant stimuli and habituation to distracting and irrelevant cues in the environment (Mehrabian, 1977).

joint effects of the workspace characteristics accounted for 24% of the variance in employee turnover, 31% of the variance in work satisfaction, and 34% of the variance in discretionary withdrawal. Further analyses revealed that employees reacted negatively when the characteristics involved in the interactions were present simultaneously at high levels.
Oldham et al. (1991) report correlations between job satisfaction and interpersonal distance ($r = .12$) and number of enclosures ($r = .22$). Sundstrom et al. (1980) found workspace satisfaction to correlate positively with number of enclosed sides, distance to adjacent colleague, and private workspace. In their study, job satisfaction was positively correlated with private workplace and negatively correlated with visibility to supervisor.

Further evidence for the relationship between office layout and satisfaction comes from a laboratory experiment (Block & Stokes, 1989). These authors investigated the role of individual characteristics, office size, and task complexity on satisfaction and performance. Office size varied between one person (private condition) and four persons and spatial density (i.e. workspace per person) was held constant. Results showed significant differences among the two density groups in regards to satisfaction with their environment. Subjects in solo offices indicated greater satisfaction than those in the four-person offices. In this study, an interaction between task complexity and density could be shown. For complex tasks satisfaction with the office environment was significantly higher in solo offices. For simple tasks, however, satisfaction did not differ between the two density groups. The same pattern was identified for task performance: task performance on simple tasks was better in the non-private condition. Task performance on complex tasks was better in the private condition than in the non-private condition. Individual characteristics (sex, introversion-extraversion) did not influence satisfaction with the work environment or task performance.

Open offices are often implemented assuming that communication among employees is improved and social relations will be enhanced (Sundstrom, 1986). Open office structures are expected to facilitate the development of social relations and this should improve employee morale and satisfaction (Oldham & Brass, 1979). Empirical evidence on the relationship between office layout and social relations, however, is equivocal.
Oldham & Brass (1979) report a highly significant reduction in interpersonal satisfaction in their quasi-experimental study on a change from a traditional office setting to an open-plan office arrangement. In the longitudinal study of Brennan et al., 2002 similar effects were found. Employees were significantly less satisfied with team member relations in the open office layout than they had been in the traditional offices they occupied before. Furthermore, this dissatisfaction did not lessen after the office users had been in their new offices for six months.
Oldham & Rotchford (1983) report a small significant correlation between workspace density and employee perceptions of conflict as existing in the offices. On the other hand, correlations between office openness and conflict and between office density and conflict did not reach statistical significance. Fried et al. (2001)

analysed a complex interplay of workspace density, job complexity, and tenure on co-worker satisfaction. In their cross-sectional study of 93 office workers of a university in the USA they found that co-worker satisfaction decreases with increasing densities only for employees with high job complexity and high job tenure. All other combinations of job complexity and job tenure resulted in small increments in co-worker satisfaction with increasing density.

Compared to office openness the building blocks of office layout, workstations, have received less attention. Brill et al. (2001) studied workspace size per office user. They found that 87% of employees hat workspace sizes smaller than 100 ft^2 (ca. 9.3 m^2) and 40% less than 64 ft^2 (ca. 6 m^2). Office users with larger workspaces considered their spaces as appropriate and were more satisfied with their workspaces than office users with smaller workspaces. Similar results are reported by (Charles & Veitch, 2002; Veitch et al., 2003). In their studies larger workstations were associated with higher satisfaction with privacy.
Regarding storage space and quality, O'Neill (1994) reports direct effects on workspace satisfaction and performance. Additionally, he found indirect effects, mediated by privacy or distractions, respectively.

Scientific research on office layout and arrangement of space is based on traditional office structures with assigned workspaces. Research taking into consideration qualities and ratios of dedicated and shared spaces (e.g. for collaborative activities) seems to be lacking. In a literature review, De Croon et al. (2005) identified three studies that investigated the effects of office use (such as desk-sharing) on short-term reactions (satisfaction and stress) and four studies that examined its effects on long-term reactions (health and performance). They conclude that evidence is insufficient to make inferences about the effect of desk-sharing.

In a longitudinal study Meijer, Frings-Dresen & Sluiter (2009) analysed the change from a traditional to a non-territorial multi-space office concept with desk-sharing within departments in a Dutch regional government institute. 138 employees participated in the study that included three measurement points in time: a baseline and two follow-up surveys six and fifteen months after the change. The outcomes studied were work-related fatigue, general health, change in health status, upper extremity complaints, and perceived productivity. For most of the outcomes no significant differences were found for the first post change survey as compared to the baseline. Only quantity of work performed decreased significantly. Comparisons of the outcomes between the second follow-up and the baseline revealed a significant improvement in general health and a decrease in prevalence of upper extremity complaints. Self-assessments of performance in the second follow-up were at the same level as in the baseline measurement. Thus, the perceived reduction in quantity of work in the first follow-up may have been due to adjustments to the new work environment or due to the change itself. The authors conclude that innovative office concepts may have no or limited effects on work-related fatigue, health changes and productivity but may have some positive effects on workers' general health and upper extremity complaints in the long term.

To summarise, the research evidence on office openness is equivocal. Research suggests that in open office structures satisfaction and performance is lower compared to traditional cell offices. Furthermore health and social relations seem to be negatively affected by office openness. The empirical basis for these effects, however, is small and the size of the effects is unknown.

6.3.2. Density

Density and proximity refer to measures of available space per office user and distances to co-workers in the office. Two forms of density can be distinguished: social density refers to the (absolute) number of people in a setting, e.g. number of occupants in an office. Spatial density describes the space available to each person (Hayduck, 1983).
Social density, therefore, is associated with office openness. Open offices accommodate more users and thus have larger values of social density. On the other hand, spatial density is less dependent of office layout as it describes spatial limitations to office users independent of office layout. Interpersonal distance or proximity refers to the distance to the nearest co-worker in the office workspace.
Empirical studies on density have mainly addressed satisfaction and only to a lesser degree performance, health, or social behaviour.
The direct influence of density on health has not been studied. Rather, health related effects of density are studied with a focus on individual experience that is captured with the concept of crowding (see chapter 6.4.3). May, Oldham & Rathert (2005) report evidence that crowding fully mediates the relation between spatial density and work area satisfaction.

The relationship of density on performance has been examined in a series of laboratory experiments by Paulus, Annis, Seta, Schkade & Matthews (1976). In these experiments the effects of group size (social density), room size (spatial density) and interpersonal proximity on task performance were examined. The authors present evidence that increasing social density, increasing spatial density, and increasing proximity led to decrements in task performance independently. Field studies show small positive correlations between performance and proximity (Oldham et al., 1991) and high negative correlations between social density and supervisory ratings of performance (Sundstrom et al., 1980). A study with clerical employees reported in Sundstrom et al. (1980) showed a similar negative correlation between self-assessed performance and number of colleagues. In the same studies, no significant relationship between satisfaction with workspace and social density for either of two job types (supervisory and clerical) was found. In an additional study Sundstrom, Town, Brown, Forman & McGee (1982c) also did not find significant relationships between number of workspaces in the room (social density) and satisfaction with workspace for any type of job. Oldham &

Fried (1987) examined independent and joint effects workspace characteristics on employee reactions. In their analysis, no significant correlation between social density and work satisfaction was found.

A significant positive relationship between social density and office satisfaction is reported by Hedge, Burge, Robertson, Wilson & Harris-Bass (1989) on the basis of a study of 4373 office workers in 28 buildings. The main focus of this study was on sick buildings syndrome but the relationship between social density and environmental satisfaction was also addressed. Social density was measured via reported office type. Office type was categorised in solo, group (2-4, 5-9, and 10-29 persons), and larger offices with occupancy rates of 30 and more persons. Results show a small significant positive correlation between office type (social density) and environmental satisfaction.
In a similar SBS study from Denmark, Pejtersen et al. (2006) report a small but statistically significant negative correlation between office size and job satisfaction. Their finding is based on a cross-sectional survey of 2301 occupants of 22 office buildings.

In summary, results for social density effects on satisfaction are inconclusive. Furthermore, the practical relevance of social density can be questioned because it focuses on the number of office occupants without including a measure of the office itself. Depending on the size of the office, adding occupants into an office can either increase or decrease negative effects. Thus, social density measures should be complemented with spatial density measures that combine office size with number of occupants.

Spatial density measures are included in Oldham (1988) study of several moves between different types of offices, including a move from an open-plan office to a lower-density open-plan office. Data regarding this move were collected from sixteen insurance workers before the change and thirteen of them participated also in data collection after the move. The calculation of spatial density (room size divided by number of users) prior to the move resulted in approximately 11.25 m^2 per employee, after the move it increased to approximately 23.4 m^2 per employee. No other design or personnel changes are reported in this study. Comparisons of satisfaction prior and post to the move reveals that the move from an open-plan office to a low-density open-plan office had significant positive effects on both office and work satisfaction. Results from another move in the same insurance company reported in Oldham (1988) confirmed these findings only partly. In this move, employees changed from an open-plan office to another open-plan office with approximately the same size of workplaces (13.9 m^2 per person) and with a multiple-height partition system (fabric-covered, sound absorbing partitions of 2 and 3 metres height). The only design changes in this move involved the introduction of partitions; there were no other design or personnel changes. 40 and 27 employees respectively participated in pre- and post-move surveys. The results show a highly significant increase in office satisfaction but no corresponding increase in work satisfaction. Thus regarding work satisfaction, employees moving to a low-density open office responded more positively than employees moving to an office with partitions. The low-density office may have provided protection from overstimulation and at the same time allowed employees to observe how their own work relates to the work of co-workers. This may have led to higher levels in work satisfaction. A second explanation offered by Oldham (1988) lies in the possible enhancement of interpersonal satisfaction due to the visual presence of others in the low-density office which may contribute to increased satisfaction with work itself.

In a cross-sectional field study by Oldham & Rotchford (1983), data were obtained from 109 clerical workers in a university, whose offices accommodated between 2 and 31 employees. Average spatial density was 10.04 m^2 per occupant (standard deviation: 4.7).
Results uncovered a significant negative correlation between spatial density and both office and work satisfaction (but not between openness and office or work satisfaction). Thus, higher spatial density was associated with lower office satisfaction. On the other hand, Oldham et al. (1991) did not find a correlation between office density and job satisfaction.
This finding is confirmed in a study with 541 managers from fourteen organisations (O'Neill, 1994). Also in this study a significant negative relationship between spatial density and environmental satisfaction is reported. Compared to other studies, the spatial density in this study was low for all employees. Spatial density in this study was calculated by dividing the total usable space per floor by the average number of employees per floor. This calculation includes hallways, meeting rooms, support spaces, etc. Density ranged from 29.7 to 45 m^2 per person with a mean of 41.85 m^2 per person and a standard deviation of 7.23. These values, however, may not represent the appropriate space per person as the real size of personal space is smaller.

Szilagyi & Holland (1980) report an increase in work satisfaction in a relocation and office concept change study. In this study 96 professional employees in a petroleum-related organization participated. The changes in density occurred as a result of a relocation.
Work satisfaction measured four months before and four months after the change differed in relation to density changes: increased density in the new situation led to significantly higher work satisfaction, decreased density led to significantly lower work satisfaction and for a group where there was no change in density also no change in work satisfaction was observed. In this study highly skilled professionals were analysed. Their work required a high degree of interaction and information flow. In contrast to this study, Oldham (1988) researched clerical workers in an insurance company whose duties were settling fire or automobile insurance claims. The different results regarding the density-job satisfaction relationship of the studies may be due to the job complexity of the employees studied. There is some evidence for this interpretation: Fried et al. (2001) found significant three-way interactive effects of workspace density, job complexity, and tenure on job satisfaction, co-worker satisfaction, and organisational commitment.

The strongest negative relation between density and reactions was found when job complexity and organisational tenure were simultaneously high.

Another study by Sutton & Rafaeli (1987), however, finds no relationship between spatial density and job satisfaction. Sutton & Rafaeli (1987) analysed data collected from 109 clerical workers at a university (48% worked in traditional offices, 19% worked in open-plan offices with partitions, and 33% worked in open-plan offices with no partitions). Spatial density in this study was not significantly related to job satisfaction or satisfaction with work station. Given the average size of 3 m^2 per occupant in this study was extremely small, the result is surprising. An explanation may be that the majority of study participants (67%) worked in offices that were enclosed (private offices or open-plan with partitions). This enclosure may have overpowered the negative effects of having a small space.

Even though Szilagyi & Holland (1980) report positive effects of higher density such as better friendship opportunities, exchange of information, and higher job satisfaction, the majority of empirical studies report undesirable consequences of density.
The studies referred to here, however, mainly focus on strain caused by proximity of colleagues. The presence of colleagues may also be a resource. There is evidence for the positive influence of proximity on the frequency of information exchange (Allen, 1977; Kraut, Egido & Galegher, 1988). Proximity therefore may contribute to forming and cohesion of social groups and thus affect social support. This argument is supported by evidence for different qualities of social relations in different office structures (Windlinger & Zäch, 2007). In this study, social relations in office rooms with higher social density were assessed as more positive by the office users.

6.4. Socio-spatial environment

The variables discussed so far relate to physical aspects of office work environments. Their effects on behaviour and health are mediated by perception and information processing and they have a physical reality apart from human beings (Baron, 1994). Other aspects of the office work environment reflect the fact that such settings are generally shared by a number of persons. These aspects relate to the physical presence of other persons in a specific location. The most important of these factors are privacy, interruptions and distractions, and crowding. As compared to density measures that refer to objective states of spatial limitations, privacy and crowding are experiential states while interruptions and distractions refer more to action. Privacy and crowding are found to mediate the influence of job level and the spatial organisation of offices such as office openness or density on satisfaction (James Carlopio & Gardner, 1995; Oldham & Rotchford, 1983).
Becker (2004) and Oseland (2009) refer to Dunbar’s number as a heuristic for group or floor plate size. Dunbar (1993) discovered that due to the cognitive

capacity of the human brain the size of social networks is limited to around 150 members. The relevance of Dunbar's number for office design has not been researched. However, Becker (2004) reports anecdotal evidence for human scale office buildings. Office buildings with around 150 people facilitate mutual knowledge of work activities and social networks.

The central assumption of action regulation theory is the cognitive control of action. Actions are performed on the basis of cognitive schemata or plans, using cognitive and energetic resources. The plans are developed either ad hoc in a process of problem solving or retrieved from memory. Cognitive control of action includes the use of strategies to attain goals, monitoring of on-going action, and meta-cognitive supervision (Frese & Zapf, 1994). Aspects of the socio-spatial environment may affect action-regulation in several ways (Zijlstra et al., 1999). They may call for modifications of plans in order to include requirements from the socio-spatial environment and to change the strategy for completing original goals within constraints of the environment. Furthermore, they may put additional demands on resources needed for action-regulation. Both of these influences on action-regulation may have an effect on a worker's readiness to perform through affecting his psychological and psycho-physiological state.

6.4.1. Privacy

Privacy in work environments denotes the regulation of interaction between self and others and/or environmental stimuli (Kupritz, 1998). Privacy refers to retreat from people, management of information, or regulation of interpersonal interaction (Sundstrom, 1986). In the context of office workplace research, privacy is usually conceived as based on regulation of interaction. This concept derives from the idea that people strive to maintain an optimum level of interaction with others (Sundstrom, 1986). Privacy thus exists as long as an individual or a group has selective control over access by other people (Altman, 1975) or environmental stimuli (such as noise, speech, observation) (Kupritz, 1998). When control over interaction with external entities fails, crowding (too much social stimulation) or social isolation (too little social stimulation) may occur as a consequence. In situations of excessive or too little social stimulation individuals attempt to correct the situation through privacy regulation mechanisms such as verbal and nonverbal behaviours, including the use of the physical environment to regulate contact with others (Margulis, 2003). The functions or purposes of privacy regulation are personal autonomy, emotional release from tensions of social life, self-evaluation (integrating experience into meaningful patterns), limited and protected communication, and self-identity (Margulis, 2003).

Privacy may influence satisfaction with the physical environment by helping people maintain adequate control over information and interaction. There is considerable empirical evidence that perceived privacy is the most important predictor of overall office satisfaction (Klitzman & Stellman, 1989; Newsham et al., 2009; Veitch et al., 2007) and may also be a predictor of job satisfaction (Newsham et al., 2009). Environmental experiences, such as privacy, are considered very effective in explaining the relationship between office environment factors and office satisfaction (Oldham & Rotchford, 1983).

In addition to affecting satisfaction, privacy may aid performance by limiting interruptions during complex individual work or by supporting confidential conversations. On the other hand, privacy may reduce performance by shielding people from the motivating effects of social facilitation or visibility to co-workers (Sundstrom, 1986). A field study (Sundstrom, Town, Rice, Konar, Mandel & Brill, 1982b, cited from Sundstrom, 1987) assessed privacy and office satisfaction, job satisfaction, and job performance. 389 office workers completed a survey before and after changing offices. For each facet of privacy (control over accessibility, isolation from intrusions, speech privacy) three groups were formed according to whether privacy increased, decreased, or stayed the same. All three facets of privacy were linked to office satisfaction but not to job satisfaction or performance.

Oldham et al. (1991) present data suggesting that privacy (i.e. a high degree of enclosure and barriers) increases performance and job satisfaction on simple jobs and reduces performance and job satisfaction on complex jobs. Duvall-Early & Benedict (1992) report a strong correlation between perceived privacy and job satisfaction for a sample of secretaries and administrative assistants.

One purpose of privacy regulation is the protection of communication. Open-plan offices are supposed to facilitate communication and provide lower levels of privacy than solo offices. Reduced privacy correlates with lower levels of informal interaction among people working in open-plan offices (Hatch, 1987; Oldham & Brass, 1979; Oldham & Rotchford, 1983). There is, however, also contradictory evidence documenting increased levels of informal interaction among employees in open-plan office layouts (Allen & Gerstberger, 1973; Szilagyi & Holland, 1980). One way toward reconciling these findings may be a closer examination of the communication contents and work related communication requirements. This would allow to study in more detail whether increased communication in open-plan offices is desirable and necessary or unwanted and interfering. One study showed that, compared to enclosed offices, in open-plan offices supervisory feedback is greater but confidential communication occurs less often (Sundstrom, Herbert & Brown, 1982a).

Privacy ratings are influenced by a variety of environmental factors. Office openness is strongly negatively correlated with privacy (De Croon et al., 2005). Sundstrom and colleagues (Sundstrom et al., 1980; Sundstrom et al., 1982c) report a monotone relationship between the number of partitions or walls of a workspace and the reported privacy of this workspace. Similarly, Maher & von Hippel (2005) maintain that in open-plan offices the only predictor of perceived privacy was the height of partitions. Other objective measures used in this study

(number of partitions, interpersonal distance, and density) were not significantly correlated with perceived privacy.
According to a study by Duvall-Early & Benedict (1992), the best predictor of perceived privacy is the presence of a door. The second best predictor is a co-worker not visible. Kupritz's (1998) study points to the importance of spatial barriers rather than physical barriers. In her study having minimal traffic routed through the worker's area and being positioned away from major traffic areas were ranked as more important than physical barriers. Ferguson (1983) found aural distractions to be more important for perceived privacy than degree of openness. These results suggest that a set of design components and consequences of design decisions explain perceived privacy of office users.

6.4.2. Distractions and Interruptions

Privacy at the workplace concerns the regulation of social contacts and therefore has important implications for distractions and interruptions through colleagues. In many occupations, workers are interrupted so often that only about 40 per cent of task oriented work can be completed uninterrupted (Mark, Gonzalez & Harris, 2005). Interruptions refer to attentional distractions that place greater demands on cognitive processing resources (Speier, Vessey & Valacich, 2003). In contrast to distractions, interruptions cannot be ignored because they use the same sensory channel as an action that is referred to as a primary activity and the regulation of which is being impaired.
Distractions and interruptions can be regarded as annoying and frustrating because they keep people from their work. In more monotonous work situations, however, interruptions may be welcome distractions (Zijlstra et al., 1999). From the action-theory point of view distractions and interruptions are studied focussing the demands they pose.
Interruptions may affect regulation processes in several ways: they call for a modification of the action plan to include the interrupting event. Thereby interruptions require a change in the plan for achieving the original goal and command the adaptation to the new constraints. Thus, interruptions put an additional demand on resources needed for the regulation of an action as a whole and for action execution specifically. On the longer run interruptions may affect a worker's subsequent readiness to perform by influencing the worker's psychological and psycho-physiological state.
As predicted by action-regulation considerations, interruptions have been shown to lead to changes in execution strategies. In an experimental simulation study of office work with interruptions (Zijlstra et al., 1999), task execution strategies were modified in such way that the deterioration in the performance of the main task was avoided. The deterioration was compensated for by additional effort. In some cases interruptions were even overcompensated and performance in situations with interruptions was higher than without interruptions. These compensations came with the price of negative impacts on the emotional level. Interruptions were associated with a decrease in positive emotion as well as with higher levels of

effort expenditure. This indicates that interruptions are associated with subjective costs and post additional demands on people's resources.

Studies on office noise (see chapter 6.2.1) demonstrate that noise is an important source of office dissatisfaction. Among the sources of noise in offices, noise from colleagues' conversations is the most often mentioned source of unwanted noise, independent of the sound intensity. Speech sounds in the acoustic background reduce mental work performance because they interfere with verbal working memory (Banbury & Berry, 1998; Smith-Jackson & Klein, 2009). Therefore the quality of noise and its consequences for the cognitive processes may be more important for the performance of knowledge workers than the presence or intensity of noise per se.

Empirical results on the effects of interruptions are equivocal. Oldham & Brass (1979) and Zalesny & Farace (1987) each report a significant reduction of employees' ability to concentrate on the job due to interruptions after a move from a conventional to an open-plan office. Sundstrom et al. (1982c) found distractions to be a significant predictor for job satisfaction but not for satisfaction with workspace. Perceived privacy, on the other hand, was a significant predictor for satisfaction with workspace but not for job satisfaction. Sutton & Rafaeli (1987) report results from a study with a similar sample and similar office types that are exactly reverse. In their study distractions were a predictor of satisfaction with workspace but not of job satisfaction. Sundstrom et al. (1994) report negative correlations of disturbance by noise and satisfaction with the environment and between disturbance by noise and job satisfaction but not between disturbance by noise and self-assessed or supervisor-rated performance.
In a longitudinal study of 31 workers who moved from private offices to open-plan offices, Kaarlela-Tuomaala et al. (2009) found significant increases of negative effects of the acoustic environment, including increased distraction, reduced privacy, and increased concentration difficulties. Self-rated loss of work performance due to noise doubled in the open-plan offices. Also on team level negative performance effects were apparent. Cooperation became less pleasant and direct and information flow did not change. Thus team level benefits associated with open-plan offices could not be realised. These unwanted effects might be attributed to the change process and the loss of status due to the move into open-plan offices. This interpretation, however, is unlikely because work motivation did not change between the two settings. There were no significant changes in psychological well-being, psycho-physiological symptoms, and feelings of tiredness and overstrain either.
Similar results were found in a comparative study of large and small group offices (Windlinger & Zäch, 2007). In this study higher values of reported interruptions were found in larger offices. This result, however, was not matched by a corresponding difference on psycho-physiological symptoms, psychological well-being, or recovery state.

6.4.3. Crowding

People feel crowded when there are felt to be too many people in a particular place (Davies, 2009). Crowding is the experiential counterpart of density as an objective measure (Stokols, 1972). Current conceptualizations of crowding consider the loss of perceived personal control as the core of the phenomenon (Davies, 2009). The perceived loss of personal control over the relationship between self and environment in situations of high social density is assumed to be the critical determinant of feelings of crowding or crowding stress. From a perspective of action-regulation, feelings of crowding are the result of impairments of action planning and/or action execution that arises through an imbalance of situative demands, requirements of the action, and individual resources (Schultz-Gambard, 1996).

The physical environment is therefore a conductive force of behaviour in as much as spatial changes lead to changes in the perception of personal control. Research evidence shows that employees in dense conditions feel more crowded than those in conditions of low density (Oldham, 1988; Oldham & Rotchford, 1983). However, density becomes a problem in office design only when it causes dysfunctional conditions for action (Schultz-Gambard & Hommel, 1987). For example the move to a new building reported by Szilagyi & Holland (1980) increased the social density. Increased density was associated with facilitation of work, higher information exchange, greater job feedback, friendship opportunities, and work satisfaction. Therefore, crowding is a powerful indicator that density in an organisation is dysfunctional for action. This approach recognises the importance of considering the nature of the work in office design and office configuration change that the sociotechnical systems perspective calls for.

Crowding has been associated with elevated blood pressure in laboratory and field studies (G. W. Evans & Cohen, 2004). A common strategy for coping with crowding stress is social withdrawal. When density leads to crowding, withdrawal from the work area during discretionary break periods (Oldham & Rotchford, 1983) or tardiness (May et al., 2005) may be the consequences.
Consequences of crowding on health and satisfaction are rarely discussed in isolation and empirical studies tend to use crowding as a dependent variable, often in combination with privacy and density. Crowding is considered an indicator of stress in relation to density in these studies. May et al. (2005), for example, show that crowding fully mediates the impact of social density on affective-attitudinal (work area satisfaction) and behavioural reactions (tardiness).

The three aspects of the socio-spatial environment discussed above share a common topic. Privacy describes the regulation of stimulation levels in order to protect resources or control demand levels in relation to work goals. Interruptions and distractions refer to required modifications of action plans or investment of more effort needed in order to deal with interruptions or re-orientation of attention to tasks. Crowding, eventually, relates action regulation to control over environmental demands in relation to requirements of work tasks and individual resources. Thus, the common topic is the protection of resources and regulation of demands. These functions of regulation are related to job tasks. The breakdown or impairment of these functions leads to investments of additional effort that may overtax task related regulation capacities. Situations of high regulation demands caused by the social environment may result in social stress because capacities for coping with social problems are not available. Thus, situations characterised by low privacy, high crowding and high levels of interruptions and distractions may aggravate social problems.

6.5. Effects of office design: Conclusions

Table 1 summarizes the relationship between aspects of office design and outcomes. A variety of office design elements have been found to have an impact on satisfaction, health, and performance. Organisational commitment has been analysed in connection with individual and environmental variables (Fried et al., 2001; Leather et al., 2002) and relationships between these dimensions are complex.

There is strong evidence for beneficial effects of windows or daylight and views respectively. These effects are so important that daylight is required by law in many European regulations of working conditions. Apart from windows, there is little evidence linking design aspects of office buildings and locations to the outcomes focused here. Noise is a negative aspect of the environment by definition. Noise is consistently related to reduced satisfaction, lower levels of health, and reduced individual performance. Research on indoor air quality has focused effects on health and performance. Influences of indoor air quality on these two outcome categories are often operationalized as ventilation rates and have been shown to have an impact on health and individual performance. Studies on lighting in offices identified lighting and daylight as important determinants of environmental satisfaction. Daylight contributes to positive health while poor lighting conditions may impair health. Effects of lighting on performance are inconclusive. Noise, air quality, and lighting are elements of the work environment that can be controlled by office users to higher or lesser degrees. Control over workplace environmental conditions has been shown to have a positive effect on satisfaction, health measures, and performance.

Elements of the spatial organisation of offices, such as layout and density, have been studied mostly in settings where density and openness of offices were increased. Both, increasing office openness and increasing spatial density, have negative impacts on satisfaction and performance measures. Empirical results relating social density to satisfaction measures are equivocal. For the study of the socio-spatial environment in offices, privacy and interruptions are two important variables, describing at least partly the same experiences. Privacy is an important determinant of environmental satisfaction. Its impact on job satisfaction and performance, however, is equivocal. Interruptions have been shown to reduce both, job and environmental satisfaction and performance. Crowding has been researched as an indicator of social stress and evidence indicates that crowding mediates the impact of social density on outcome variables such as environmental satisfaction.

Table 1. Overview of the relationship between office design variables and outcomes based on literature review chapters 6.1 to 6.4

	Outcomes				
	Job satisfaction	Environmental satisfaction	Organisational commitment	Health	Individual work performance
Windows	+	+		+	
Noise	-	-		-	-
Thermal Comfort		+			
Indoor Air Quality / thermal discomfort				-	-
Lighting		+		-	0
Daylight	+	+		+	
Control over office environment	+			+	+
Layout: openness	-	-			-
Social density	0	0			-
Spatial density	-	-			
Privacy	0	+			0
Interruptions	-	-			-
Crowding					

+ positive influence
- negative influence
0 inconclusive evidence
Empty no evidence

Altogether, these findings show that office environments play an important role in work life. However, there are some shortcomings in the evidence available. Published research on office environments is of limited practical value because the facets studied remain unrelated to the physical design of office buildings, use of space, furniture, and equipment. Current research is not sufficiently oriented towards physical structures and therefore does not allow the derivation of design implications.

There are several methodological deficiencies in the literature reviewed in chapters 6.1 to 6.4. In most of the studies only single dimensions and few variables have been examined. Multidimensional models necessary for the analysis of complex effects of interdependent effects of work environments have been analysed only recently (e.g. Lee and Brand, 2005). Furthermore, longitudinal research designs accounting for individual variances due to changes in the office environment have not often been used or have been used without adequate control groups. Similarly, most of the available research results do not control for work design. Work design is considered an important determining factor of overall job satisfaction (Hackman & Oldham, 1980) and has been shown to interact with environmental conditions (Oldham et al., 1991; Szilagyi & Holland, 1980). Work design can vary considerably between organisations and this can obscure cross-sectional comparisons of office work environments. For example, scope of action (also termed control or autonomy) is considered a crucial job characteristic with important consequences for satisfaction, health, and performance (see chapter 7).

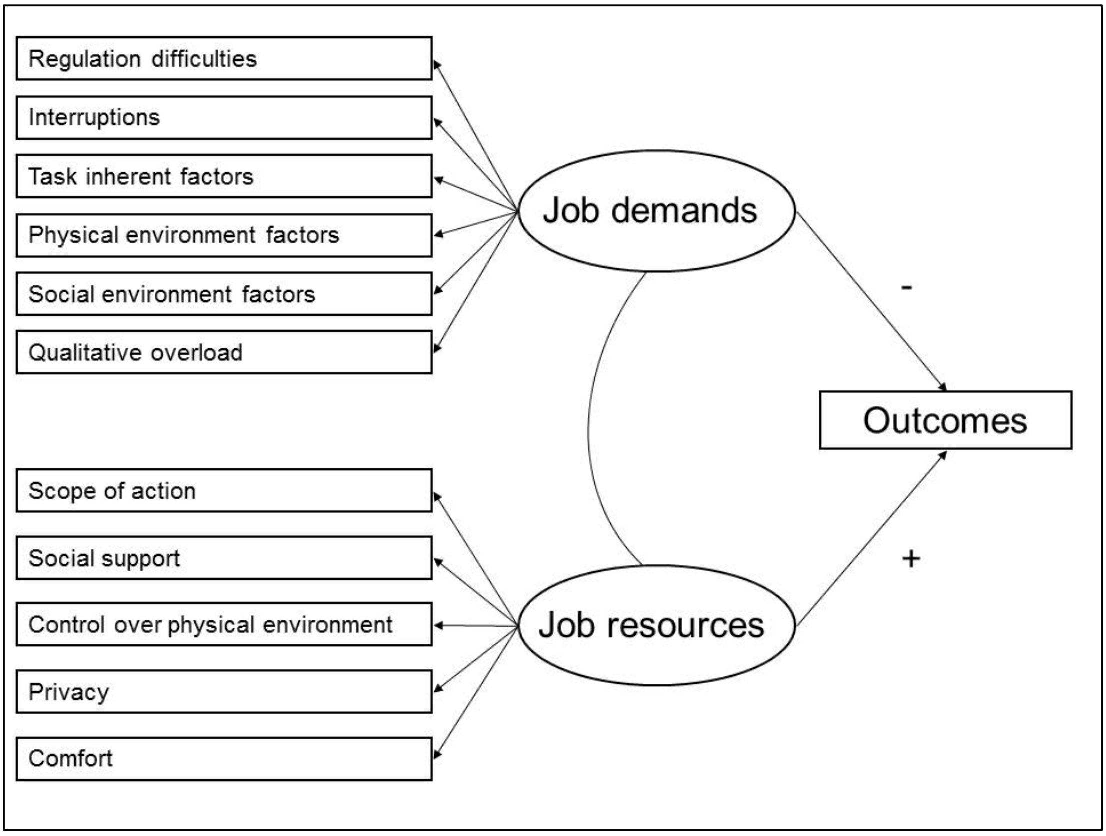


Figure 20. Job Demands-Resources model for the analysis of office work

In addition to methodological shortcomings, the theoretical basis of current workplace research has to be called into question. The evidence available is mostly based on isolated case studies, addresses a limited number of topic areas (mainly ambient conditions and office layout) and a limited number of outcomes (occupant comfort and attitudes). The limitation in research focus reflects the absence of a theoretical framework of the effects of office design. In this thesis, the Job Demands-Resources model is used as a research framework. Job demands and resources are related to the concept of stressors from action-regulation theory and to the concept of comfort. Office environments contain elements that impede action regulation (i.e. stressors) and resources, i.e. aspects that are important for dealing with demands/stressors. Daylight, control over the environment, thermal comfort, and privacy belong to this category. Job demands rooted in the environment are noise, discomfort, lighting, air quality, lighting, density, office openness, and interruptions. Figure 20 illustrates the preliminary Job Demands-Resources model incorporating these elements of office environments.

7. The Work environment: Job design

Work design consists of attributes of the task, job, and social and organisational environment (Humphrey et al., 2007). Work and job design are important sources of influence for individual, group, and organisational outcomes (Morgeson & Campion, 2003; S. Parker & Wall, 1998). At the core of work design is job design, i.e. the design of the content and structure of jobs that employees perform. The focus of job design is on the nature of work activities, i.e. the tasks and activities that employees complete in their work on a daily basis (Frese & Zapf, 1994; Oldham, 1996). Reactions to job design may interact with perceptions and reactions related to office environment design. However, empirical evidence regarding this interplay is equivocal (Oldham & Brass, 1979; Oldham & Rotchford, 1983; Pejtersen et al., 2006; Szilagyi & Holland, 1980). However, there is a consensus about the important role of both, job design and office design, as factors contributing to occupational stress and health (G. W. Evans, Becker, Zahn, Bilotta & Keesee, 2012; A. F. Marmot et al., 2006).

Job design theory has been dominated by the job characteristics model (Hackman & Oldham, 1976) (Figure 21). Recent extensions of this model and other developments in job design expand the narrow focus on task properties and include the physical and social environment (Humphrey et al., 2007). The job characteristics model, the action-regulation approach to job design and some recent extension of these approaches are presented in the following chapters.

7.1. Motivational approach to job design

The dominant approach of the models of work environments that stimulate, facilitate, and support performance is the job characteristics model (Hackman & Oldham, 1976). This model assumes that characteristics of jobs affect critical psychological states which in turn have an effect on personal and work outcomes (Figure 21). This model has dominated job design research (Humphrey et al., 2007; Morgeson & Campion, 2003) and as a consequence of this focus on motivational work features other aspects of work (physical and social environment, contextual aspects) have received much less attention. Essentially, the job characteristics model is a motivational model of job performance as it posits that the combination of core job characteristics define the motivating potential of a job. Despite some theoretical and empirical problems (see S. Parker & Wall, 1998) the effect of specific job characteristics on the outcomes has found support in many studies.

Hackman & Oldham's (1976) basic assumption is that a worker experiences positive affect when he cares about the task (experienced meaningfulness), when he personally has performed well on a work task (experienced responsibility), and when he learns (knowledge of results). The three psychological states contributing to positive affect are defined as follows (Hackman & Oldham, 1976):

- Experienced meaningfulness refers to the degree to which a worker experiences his or her work as generally meaningful, valuable, and worthwhile.
- Experienced responsibility is the degree to which a worker feels accountable and responsible for outcomes of the work he or she does.
- Knowledge of results describes the degree to which the worker knows and understands how effectively he or she is performing the job.

When all of the psychological states are present, positive affect should result. This positive affect is reinforcing and serves as an incentive to perform well in the future. Thus, an internally reinforcing state of affairs should lead to intrinsic work motivation which in turn results in self-generated rewards.

The fuel for this self-perpetuating cycle comes from the job characteristics that contribute to the psychological states (Figure 21). Three job characteristics add up to determine perceived meaningfulness of a job: (1) skill variety describes the degree to which a job requires a variety of different activities which involve different skills of the worker, (2) task identity refers to the degree to which a job involves completion of a whole and identifiable piece of work, or a job from beginning to an end with a visible outcome, and (3) task significance refers to the degree to which a job has an impact on other people.

Experienced responsibility is predicted by autonomy which describes the extent to which a job provides choice and discretion of scheduling work and determining procedures for carrying it out. Knowledge of results, eventually, is fostered by feedback, defined as the degree to which the job itself provides information about the worker's performance.

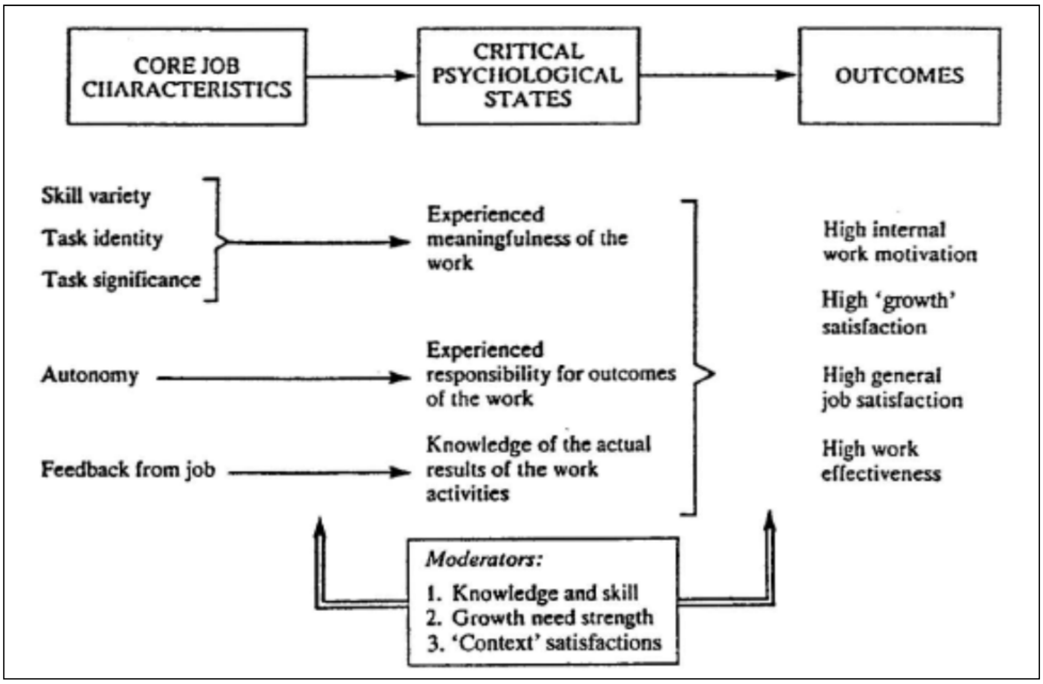


Figure 21. Job characteristics model (Oldham, 1996)

A meta-analysis of job characteristics (Fried & Ferris, 1987) indicates that the relationships between variety and task identity on the one hand and job

satisfaction on the other hand are substantially higher than the correlations with performance. Furthermore, variety has a stronger relationship with motivation than task identity. This meta-analysis shows that there are small positive correlations between job characteristics and objective performance (supervisor ratings or objective data). A replication and extension of Fried & Ferris' meta-analysis by Humphrey et al. (2007) shows that autonomy is positively related to objective performance and that autonomy, task identity, task significance, and feedback from the job (but not skill variety) have positive correlations with subjective performance.
As a motivational model of job design, the job characteristics model focuses on a limited set of work features and neglects other aspects of work such as environmental, social, and contextual aspects (Humphrey et al., 2007; Morgeson & Campion, 2003). Humphrey et al. (2007) extend this focus and integrate motivational, social, and work context characteristics. In their meta-analysis they show that fourteen work characteristics explain on average 43% of the variance in nineteen worker attitudes and behaviours. Motivational characteristics were found to explain 25% of the variance in subjective performance; social characteristics explained an additional 9%. Work context characteristics were found to explain unique variance in job satisfaction (4%) and in stress (16%) but not in performance.
These results confirm the findings that job characteristics have a stronger effect on attitudinal outcomes (e.g. satisfaction) than on behavioural ones (e.g. performance). Furthermore, this research points to several directions for extension of the job characteristics model.

7.2. Action-regulation approach to job design

The action regulation approach to job design extends the motivational perspective and combines it with a learning and development aspects of working. Frese & Zapf (1994) argue that a motivational approach to job design is incomplete because increases in motivation alone do not lead to higher productivity, while a better understanding of a job does. Thus, the action-regulation approach puts an emphasis on cognitive processes.
Action regulation theory combines a situational influence perspective with a performance regulation perspective: based on a model of action regulation (see chapter 4.1), related job features are identified. The action regulation perspective on performance focuses on regulation requirements and regulation problems (see chapter 4.1.4) and on knowledge bases relevant for actions. The development of goals and execution of plans and the cognitive regulation of action are dependent on mental representations of the important parameters of work tasks and contextual conditions (Frese & Zapf, 1994). This background knowledge is acquired in learning processes that involve practice; intellectual understanding evolves with practical experience. Therefore, control is a crucial characteristic of job design because it allows for the evolution of task relevant knowledge through learning experiences. Furthermore, control allows for choosing adequate

strategies to deal with situations and to plan ahead. Thus workers with high control (and a certain amount of experience, i.e. task and action relevant knowledge) can react more flexibly and perform better than workers with low control. While control refers to regulation possibilities, complexity of tasks refers to regulation requirements (see chapter 4.1). Complexity is an important feature of jobs because it can lead to qualitative or quantitative regulation overload or stress.
Similarly to control, variety is considered an important feature of tasks. Variety describes the amount of different actions required by the task (Frese & Zapf, 1994). In addition to learning experiences and full utilisation of skills and knowledge, variety also prevents strain injuries from repetitive movements.
A further important characteristic of jobs from the perspective of action regulation theory is the completeness of action (also labelled holistic job). This concept refers to the number of steps associated with a task. An action is considered complete when it involves all regulation steps in the action process, in particular goal setting, plan development, decision making, execution monitoring, and feedback.
Both, acquisition of task relevant knowledge and action regulation can be supported by co-workers and supervisors. Therefore, co-operation and social support is a further job characteristic considered important in action regulation theory.

Although the theoretical roots of action-regulation theory are different from the motivational approach the critical job characteristics from a regulation requirement point of view turn out to be similar to the ones identified from a motivational approach. Both approaches stress the importance of autonomy or control and consider skill variety, feedback, task identity to be important job characteristics (see Kompier, 2003 for a detailed discussion). A major difference between the two perspectives relates to the emphasis on either the subjective appraisal of the environment or on the objective environment. While the job characteristics model emphasizes perceptions, the action regulation approach is directed more at the objective environment. Additionally, the compensation mechanism among skill variety, task identity, and task significance in the job characteristics model does not have a match with a similar mechanism in the action-regulation approach to job design. Rather from the latter perspective the job characteristics are of the same importance.

7.3. Interdisciplinary approach to job design

A more comprehensive extension of the motivational job characteristics approach to job design has been developed by Campion and colleagues (Campion, 1988; Campion & McClelland, 1993; Campion, Mumford, Morgeson & Nahrgang, 2005; Campion & Thayer, 1985). This approach recognises that in different scientific disciplines distinct approaches to job design have been developed and that

research in each of the disciplines has been conducted relatively independently of other approaches.
The interdisciplinary approach combines the motivational approach from organisational psychology with the mechanistic approach from industrial engineering, the biological approach from work physiology, and the perceptual/motor approach from experimental psychology. The different approaches to job design influence different outcomes which include benefits as well as costs (Campion & Thayer, 1985). In some cases costs and benefits represent seemingly irreconcilable trade-offs between different approaches. For example, mechanistic job design may increase efficiency at the cost of reduced job satisfaction.
The interdisciplinary approach to job design emphasizes that different job (re)design goals require different approaches (Campion et al., 2005). Thus, it overcomes limitations of the motivational approach that does not distinguish between different types of job design and extends the perspective of design interventions and underlying values (S. Parker & Wall, 1998). The question remains open to what extent job design goals and approaches can be combined. Morgeson & Campion (2002) conducted a longitudinal quasi-experiment examining the possibility to differentially change jobs in terms of their motivational and mechanistic properties. Their findings indicate that trade-offs previously considered inherent in job design do not always occur. The nature of such contingencies, however, remains to be researched.

There may also be crossover effects between different levels of work design. In a longitudinal quasi-experiment, Oldham & Brass (1979) studied the influence of change in the physical environment on employee satisfaction and motivation. Employees of a newspaper organisation moved from traditional offices to an open-plan office arrangement. There were no changes in the jobs themselves, but moving to the new office environment decreased the perception of several job characteristics. Oldham & Brass (1979) found that the job characteristics mediated the relationship between the physical office setting and employee satisfaction and motivation and concluded that the physical setting influences employee motivation and satisfaction by changing their perceptions of specific job characteristics.
In a similar longitudinal study Szilagyi & Holland (1980) found increased density to increase the perception of the job characteristic feedback and to decrease the perception of autonomy. In their study decreased density reduced perceived feedback and increased autonomy, respectively.

7.4. Extensions of the focus of job design

Recent extensions of the focus of job design concern the physical and social environment and knowledge characteristics of jobs (Grant, Fried & Juillerat, 2010 for an overview).
The integration of the physical environment into job design theory and research has been called for by several authors of job and work design reviews (Grant et

al., 2010; Morgeson & Campion, 2003; Oldham, 1996). However, the findings on the effects of spatial configurations and the design physical environment summarised above (chapter 6) have not yet been integrated with job design theory.
Another dimension of job design theory development is the social environment (Grant & Parker, 2009). The focus of the development lies on relational and proactive aspects of work design. This perspective also acknowledges the interaction of social and physical environment and there seems to be consensus on the fact that office and workspace design affect social interactions. However, more research and richer theory is needed in order to explore the nature of office and workspace design influences on social and relational characteristics of work (Grant & Parker, 2009).
Further developments concern the role of social support, interdependence, interaction outside the organisation, and feedback from others. These social characteristics of jobs play an important role on employee attitudes and experiences. Meta-analytical findings show that after controlling for task and knowledge characteristics these four social characteristics explain an incremental variance of seventeen per cent in job satisfaction, eighteen per cent in role ambiguity and conflict, forty per cent in organizational commitment, twenty-four per cent in turnover intentions, and nine per cent in subjective performance (Humphrey et al., 2007).

In the tradition of action regulation research the focus in studies of the social environment is on social stressors. Social stressors include social animosities, conflicts with colleagues and supervisors, and negative group climate (Dormann & Zapf, 2002). Compared to other stressors, however, there is little research on social stressors in organisations. Social stressors have a negative impact on job satisfaction (Harris, Harvey & Kacmar, 2009) and contribute to burnout (Dormann & Zapf, 2004).

7.5. Effects of job design: Conclusions

Different approaches to define job characteristics and the interaction between the worker and the work environment overlap remarkably (Kompier, 2003 for an overview). The job design features from the job characteristics model are paralleled by concepts from action-regulation theory. Variety, autonomy, and task identity are dimensions of job design considered important in both approaches. Feedback is subsumed in completeness of action in the action-regulation approach while it is a discrete feature in the job characteristics model. Whereas the job characteristics model focuses on affect and motivation, the action-regulation approach emphasises cognitive processes and the planning and execution of actions. Contrary to the job characteristics model, the action-regulation approach highlights the role of regulation problems and job demands on the one hand and acknowledges the role of social support as a resource for coping with high demands on the other hand. Furthermore, the action-regulation approach is applicable to stress and health topics in work environments. These topics are difficult to reconcile with the job characteristics model because this approach focuses on motivation, performance, and satisfaction.

The Job Demands-Resources model is proposed as a general framework for the assessment of risk factors associated with negative outcomes of job design on health, satisfaction, and performance. It is based on the assumption that while all occupations have their own specific risk factors, these factors can be classified into job demands and resources. Demands and resources are defined from a functional point of view. In this thesis the action-regulation approach is used to derive the content dimensions of demands and resources in the work environment (Figure 20). The integration of job design and the design of physical work environments has been called for by many scholars (e.g. Kompier, 2003; Oldham, 1996). The application of an integrated view of job and environmental design in office environments is particularly relevant given the shift from a manufacturing to a service-oriented economy and the lack of theoretical models and empirical studies in office work environments.
There is tentative evidence for an interaction between office design and job design. In a longitudinal study Szilagyi & Holland (1980) found increased density to increase the perception of the job characteristic feedback and to decrease the perception of autonomy while decreased density led to a reduction in perceived feedback and increased autonomy. Oldham & Brass (1979) found job characteristics to mediate the relationship between the physical office setting and employee satisfaction and motivation. They concluded that changes in the physical setting may alter employees' perceptions of job characteristics. Furthermore, features of office design influence important outcomes of job design such as job satisfaction, health status, and performance of employees.
The effects of job and office design on these outcomes can be included within the Job Demands-Resources framework. The original field of research and development of the Job Demands-Resources was burnout (Demerouti et al., 2001). The model was subsequently developed to include other outcomes, such as satisfaction and performance (Bakker & Demerouti, 2007; Bakker, Demerouti & Verbeke, 2004). Thus, the Job Demands-Resources model can be used as an empirically well supported framework for the study of the joint effects of job and office design.

8. Theoretical Model

The main goal of this thesis consists in the analysis of the extent to which the physical environment in offices has an influence on employees' well-being (satisfaction and health), commitment, and job performance. Effects of the office environment are analysed per se and in relation to influences of work design and the social environment. The theoretical working model therefore integrates three classes of stressors that are relevant for action-regulation within the Job Demands-Resources framework: task, environmental, and social stressors.
In chapter 3 I stated that the JDR framework does not specify the content of demands and resources but only their function. Indeed, it is a basic assumption of the JDR approach that every occupation has its own specific risk factors associated with job stress and these factors can be categorized in job demands and job resources. Therefore the relevant variables for the study of office environmental influences on employees were developed through theoretical considerations (chapter 4) and the review of the literature (chapters 5 to 7).

On the basis of action-regulation theory, stressors and resources can be described for and applied to office work (see chapter 4). Based on the review of the literature on effects of the office environment, the contents of stressors and resources are more precisely defined (see chapter 6). Finally, literature on job design provides additional information on task related demands and resources (chapter 7). The working model integrating these effects is presented in Figure 22. It contains a theory-based classification of job demands and job resources pertaining to the physical, job design, or social environment.

In this working model, job demands refer to stressors i.e. features of the work environment that increase the probability of stress reactions and stress-related outcomes (R. L. Kahn & Byosiere, 1992, Semmer, McGrath & Beehr, 2005). From the perspective of action-regulation theory stressors are characterised by their function of disturbing the cognitive regulation of action. Thus in this thesis job demands refer to aspects of the job related to the office environment, job design for office workers, and the social environment. These aspects require sustained mental effort and are associated with psychological cost because they impede or overtax cognitive regulation of action or increase regulation uncertainty.
Job resources in the present working model refer to aspects of the job related to the office environment, job design for office workers, and the social environment that are functional in achieving goals, reduce demands and the associated psychological costs, and stimulate personal learning and development. Resources related to the physical office environment increase environmental comfort, a concept that refers to the satisfaction with the relationship between individual goals and physical, functional, and psychological aspects of the physical work environment. Job demands and job resources are interdependent and there may

be interactions between the two classes or their elements respectively (Bakker & Demerouti, 2007).
Whereas job demands and resources in the JDR approach relate to the cognitive regulation of individual action the terms demand and workplace resource (supply) have been used in workplace research (e.g. Duffy, 2000; Nutt, 2004; Rabeneck, 2008) referring to needs, requirements, and expectations (demand) and services (resources). Thus, while demands and resources in the JDR approach are hypothetical and psychological constructs, demand-supply models of workplace management represent the economic and Facilities Management perspective. The FM and JDR perspectives are connected and the management of spatial resources (and financial, human, and informational resources; see Nutt, 2000) define the contexts for employee's perceptions and experiences of demands and resources.

Job demands relating to office environment characteristics are classified as regulation difficulties and interruptions, elements that are considered as regulation obstacles in action-regulation theory. Furthermore, physical environment factors consist in elements that may lead to overtaxing regulation. Further elements relevant for overtaxing regulation are task inherent factors that can be described as quantitative overload and elements of the social environment. Finally, qualitative overload is classified as a job demand because it may lead to regulation uncertainty.
Job resources consist in the aspects of job design that have been identified by motivational and action-theoretical approaches. The aspects included in the working model are scope of action (named autonomy in the job characteristics model), variety, and completeness of action (named holistic job in the action-regulation approach and task identity in the job characteristics model). In addition, the importance of social support has been stressed by various approaches and this construct is also included as a resource. As for the characteristics of the office environment, control over the environment, privacy, and comfort have been identified as resources in the literature review. Their inclusion in the working model as job resources is in line with the action-regulation approach. All of these constructs refer to regulation possibilities and are therefore enabling individual regulation.

The outcomes included in the model are satisfaction, organisational commitment, health, individual work performance, and social relations. While social support is a standard element in job design research, outcomes on the inter-individual level have largely been neglected in research on physical workplace and job design (Grant et al., 2010). There is limited negative evidence of workplace openness effects on interpersonal relations. Only recently social relations have been taken up in job design research and theory (Grant & Parker, 2009; Kilduff & Brass, 2010). The focus of these approaches is on description of how jobs are socially embedded based on interdependence and interactions among co-workers. Interpersonal relations may be regarded as a contextual performance outcome and as such constitute an important extension of current performance measures. The core of social relations as contextual performance outcome consists in interpersonal citizenship behaviours, i.e. “behaviours that assist, support, and develop organisation members through cooperative and facilitative efforts that go beyond expectations” (Coleman & Borman, 2000 p.36). Social environment outcomes are therefore integrated in the research for explorative purposes and the dependence of work climate and social stress on office design parameters is analysed in the first study.

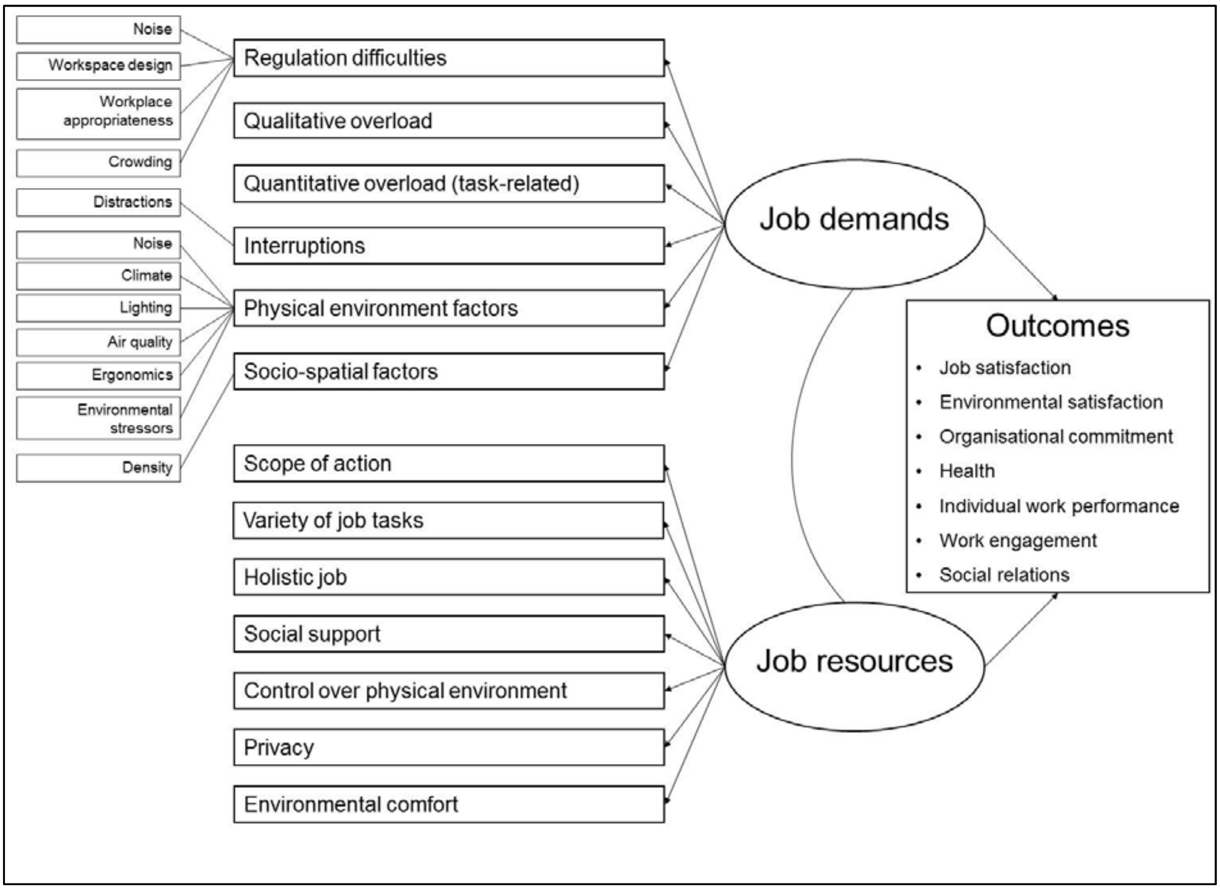


Figure 22. Working model for the analysis of office work

A limitation of the working model (and the theoretical frameworks which forms its basis) is the disregard of person-variables such as individual preferences, personal taste, or individual dispositions. The reason for this disregard may be the limited theoretical and practical value: Situational influences may - on the average - be stronger than individual factors for *changes* in the focused outcomes (relative to a baseline that may be strongly influenced by person-related variables). Additionally, the work environment can be altered more easily than the nature of the employees. However, for the facility manager and the human resource manager it is important to know whether reactions to changes in office environments are based on effects of design or have their causes in individual preferences.

9. Study 1: Effects of change in physical office environments

The focus of the first study is the identification of office users' perceptions and reactions that are changed as a consequence of change in office design. For this analysis longitudinal data from 4 office change projects are analysed and set in relation to a control group. Furthermore, effect sizes of the changes in perceptions and reactions are analysed. Additionally to the longitudinal analyses, data from both, pre-change and post-change surveys are used for the exploration of relationships between perceptions of office environments and employees' reactions.

Action regulation theory emphasises the role of the perceived environment for the regulation of individual action. Therefore, perceptions of the environment are focussed in this study.

This study is comparable to previous longitudinal studies (Brennan et al., 2002; Oldham, 1988; Oldham & Brass, 1979; Sundstrom et al., 1994; Zalesny & Farace, 1987) but conducted in a different environment. Apart from differences in the geographical and cultural setting, contemporary office structures in Switzerland are different from the open-space offices analysed in the North American studies. Like in other European countries, Switzerland's most prevalent office type is the cellular (individual or group) office (Van Meel, 2000). Only recently open office environments have been implemented; usually as some form of multi-space office (see footnote 1, p.17) rather than cubicle-type open-plan offices.

Furthermore, information and communication technology today plays a more central role in office work than at the time of the few longitudinal studies documented in literature. This study, therefore, extents available evidence on the effects of contemporary office design on office users on three dimensions: (a) the socio-geographical area and cultural context, (b) the technological environment and work conditions of the 21st century, and (c) contemporary forms of office design, such as the multi-space office.

9.1. Aim and research questions

Based on the available evidence three classes of factors are relevant for action-regulation. These classes consist of environmental, job-related, and social influences. According to the job-demands resources model, all of the elements in these classes may either be demands or resources for the job incumbents. However, little is known about the relative importance of different influencing factors and their combined effects. This research focuses on the effects of the physical and socio-spatial office environment while taking into account the influences from the social and job design environment.

The aim of the study is twofold. The first aim consists in the analysis of effects of interventions in office environments on office users' perceptions and reactions. It is assumed that job characteristics remain unchanged by interventions in the office environments. However, perceptions and assessments of the office environmental characteristics (environmental stressors, lighting, indoor climate, workplace appropriateness, work and storage spaces, workspace quality, distractions, noise, privacy, crowding, and control) are expected to change. The goal of this study is the identification of effects of office environments on office users' perceptions and user level outcomes. The research aims at identifying direction and size of such effects. Furthermore, job characteristics are examined in order to detect unintended changes between the two points of measurement. For exploratory purposes, social environment outcomes are included in the analyses. Specifically the influence of office design on work climate and social stress is examined.

Based on these research questions the following hypotheses are formulated:

Hypothesis 1a: Employees in the experimental groups will report changes in perceived characteristics of the office environment between time 1 (pre-change) and time 2 (post-change).

Hypothesis 1b: Employees in the control group will not report changes in perceived characteristics of the office environment between time 1 (pre-change) and time 2 (post-change).

Hypothesis 1c: Employees in the experimental groups will not report changes in job characteristics between time 1 (pre-change) and time 2 (post-change).

Hypothesis 1d: Employees in the control group will not report changes in job characteristics between time 1 (pre-change) and time 2 (post-change).

It is assumed that perceived office characteristics have an impact on job satisfaction, environmental satisfaction, organisational commitment, health, and individual work performance. Specifically, the following set of hypotheses is formulated:

Hypothesis 2a: Changes in the perceived office environment between time 1 and time 2 as reported by employees in the experimental groups will be accompanied by changes in job satisfaction.

Hypothesis 2b: Changes in the perceived office environment between time 1 and time 2 as reported by employees in the experimental groups will be accompanied by changes in environmental satisfaction.

Hypothesis 2c: Changes in the perceived office environment between time 1 and time 2 as reported by employees in the experimental groups will be accompanied by changes in organisational commitment.

Hypothesis 2d: Changes in the perceived office environment between time 1 and time 2 as reported by employees in the experimental groups will be accompanied by changes in health.

Hypothesis 2e: Changes in the perceived office environment between time 1 and time 2 as reported by employees in the experimental groups will be accompanied by changes in individual work performance.

There is only little research on influences of office design on the social environment and results are equivocal. However, density seems to be related with undesirable consequences. Therefore negative effects of changes in the office environment (i.e. increase of social density) on social variables are expected.

> *Hypothesis 3*: Employees in the experimental groups will report more negative perceptions of the social environment (work climate and social stress) between time 1 and time 2.

The second aim of the study consists in the extension of the analysis of changes within variables to causal relationships. Changes in the influencing environmental and the outcome variables are related to each other while controlling for job characteristics. The goal of these analyses is the identification of influences of job and office environment characteristics on satisfaction, organisational commitment, health, and individual job performance.

The general research question for these analyses consist in the extent to which environmental characteristics contribute to additional variance explanation for job satisfaction, organisational commitment, health, and performance in relation to known influence factors (i.e. job characteristics). Furthermore the contribution to variance explanation for environmental satisfaction by job characteristics is analysed.

Hypotheses are formulated on the basis of the theoretical model and the literature review (Chapters 5-8, summarised in Table 1). In this review the evidence regarding the relationship between the design of office environments and organisational commitment was inconclusive. Therefore no hypotheses can be formulated for this outcome. The hypotheses for the other outcomes are formulated as follows:

> *Hypothesis 4*: Perceived office noise will have a negative influence on *(4a)* job satisfaction, *(4b)* environmental satisfaction, and *(4c)* individual performance.
>
> *Hypothesis 5*: The assessment of indoor climate will explain variance in *(5a)* environmental satisfaction, *(5b)* health, and *(5c)* individual performance.
>
> *Hypothesis 6*: The assessment of lighting will explain variance in *(6a)* environmental satisfaction, *(6b)* job satisfaction, *(6c)* health, and *(6d)* individual performance.
>
> *Hypothesis 7*: Control over the individual work environment in the office will increase *(7a)* job satisfaction and *(7b)* individual performance.
>
> *Hypothesis 8*: Social density will reduce *(8a)* job satisfaction, *(8b)* environmental satisfaction and *(8c)* individual performance.
>
> *Hypothesis 9*: The assessment of perceived privacy will explain variance in *(9a)* job satisfaction and *(9b)* environmental satisfaction.
>
> *Hypothesis 10*: Distraction will have a negative impact on *(10a)* job satisfaction, *(10b)* environmental satisfaction and *(10c)* individual performance.

Hypothesis 11: Crowding will have a negative impact on *(11a)* job satisfaction, *(11b)* environmental satisfaction, *(11c)* health, and *(11d)* individual performance.
Hypothesis 12: workplace appropriateness will have a positive impact on *(12a)* job satisfaction, *(12b)* environmental satisfaction, *(12c)* health, and *(12d)* individual performance.
Hypothesis 13: workspace quality will have a positive impact on *(13a)* job satisfaction, *(13b)* environmental satisfaction, *(13c)* health, and *(13d)* individual performance.

Taken together, the analyses related to the two aims of the study will result in evidence on the direction and size of office environmental influences on office users and provide information which elements of office environments can be considered as demands and which as resources. In order to achieve these goals, instruments for the measurement of the relevant variables are researched in the literature. The psychometric quality of these measurements is examined, in order to have a sound methodology for the two studies.

9.2. Method

9.2.1. Research design

A longitudinal quasi-experimental research design with a control group was employed for the first study. The choice of this design is based on the following arguments. The first study on effects of office and job design on office users is situated in complex real world settings. In their daily work contexts employees are influenced by factors that have little or no relation to office design (e.g. team structure, management, and workload) and therefore are considered as confounding factors. Studying office users in controlled conditions in laboratory situations, however, severely weakens the validity and generalizability of the findings. The removal of any potential environmental factor from its natural context distorts the ecological validity of the relationships examined (G. W. Evans, 2001). In order to obtain ecologically valid and thus more generalizable evidence therefore investigations in natural occupational contexts are preferable. However, investigations in such environments pose the problem of limited control over the conditions under which data collection is carried out. Subjects participating in the analyses cannot be assigned to different conditions randomly. Thus, influences of subject-related confounding factors cannot be eliminated. There is a need therefore to apply a research design that allows for causal conclusions under suboptimal conditions (i.e. influences of potentially many intervening variables, not equivalent research and control groups[12]). A research approach that attempts to provide a solution to these problems is the quasi-experimental design (T. D.

[12] Not equivalent research and control groups refer to the problem that members of the groups may differ in specific attributes and this difference has to be accepted because the composition of the groups cannot be controlled.

Cook, Campbell & Peracchio, 1990; Grant & Wall, 2009; Shadish, Cook & Campbell, 2002): Instead of trying to control the threats to validity prior to data collection (as is the case in experimental research designs), quasi-experimental designs are constructed in a way that allows the elimination of threats to validity after data have been collected, e.g. by introducing additional control groups, variables or measurements. Compared to experimental research the validity of quasi-experimental research is more vulnerable due to the limited control over the research conditions mentioned above.

Effects of office design on office users become evident when office environments are changed. Naturally occurring quasi-experiments permit the analysis of effects of office environment changes alone. When office environments in an organisation are changed, most other factors that potentially affect office users' reactions remain constant (e.g. task content, organisational structure, team composition). Thus, with naturally occurring quasi-experiments the causal influence of office design can be investigated when pre- and post-change data are collected in a longitudinal research design (Shadish et al., 2002).

Due to the emotional effects of office change, the choice measurements interval is important. Change processes and reactions to change in organisations are supposed to follow a "change curve". Models of change processes postulate a phase of reduced productivity combined with resistance and feelings of depression and frustration (sometimes called the valley of despair or "death valley of change", Elrod II & Tippett, 2002) before change is accepted, coped with, and more positive feelings and forces develop that finally lead to new stable states. These models of change processes, however, have not been tested empirically and it is not clear whether the processes are similar and synchronous for all groups involved in change processes.
Among the longitudinal studies of office design effects, two use repeated post-change measurements: Oldham & Brass (1979) measured user assessment of their office environment before change as well as nine and eighteen weeks after the change respectively. There were no significant differences between the two post-change surveys. In a longitudinal study, Brennan et al. (2002) collected data four weeks and six months after office relocation. The comparisons between the two waves of post change data collection did not reveal any significant differences either. According to this empirical evidence we can tentatively conclude that user assessments after office environment change are stable already after a period of four to nine weeks. The influence and effect of change processes accordingly do not seem to extend over a longer period of time after a change has been completed.

The design of the first study allows different comparisons of groups (Figure 23). (1.) Data from the pre-move survey can be used to check the equivalence of the experimental and the control group. (2.) Data from the post-move survey can be used to perform a manipulation check. This check should reveal differences in pre- and post-move data for the experimental group but not for the control group.

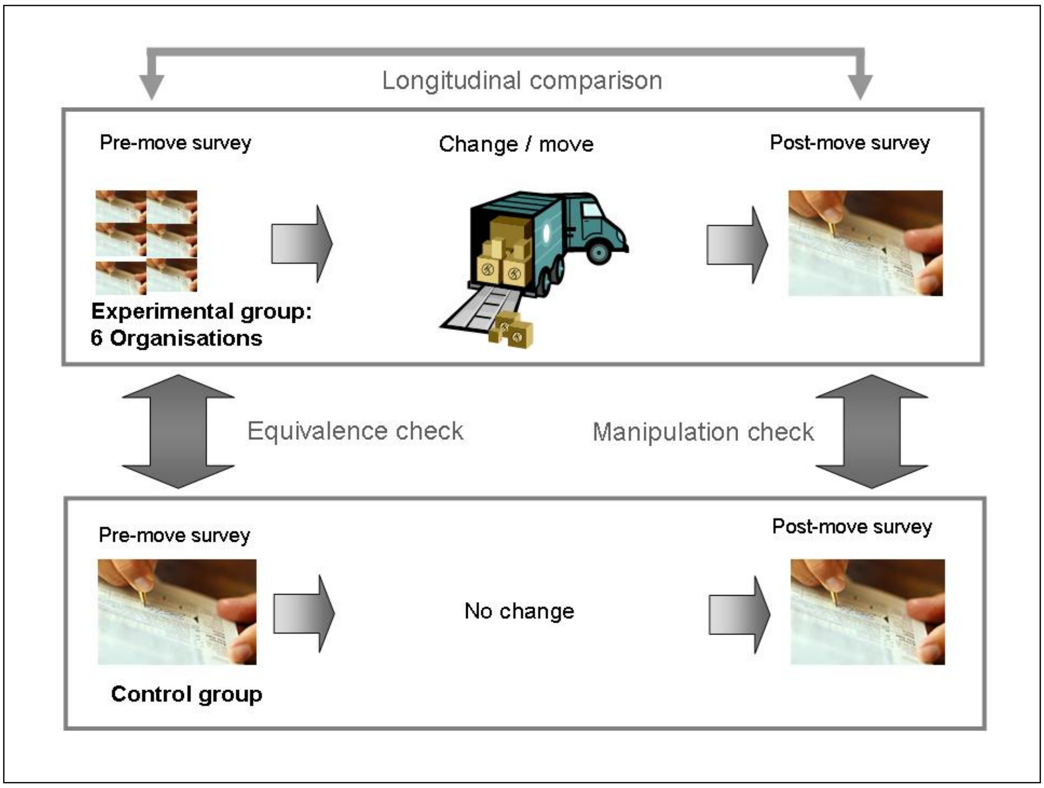


Figure 23. Research design of first study

A successful manipulation check is a strong indicator for causal interpretation of longitudinal comparisons of within the experimental group. (3.) Within-subjects longitudinal comparisons can be carried out with pre- and post-move data from subjects that participated in both waves of data collection. (4.) Pre- and post-move samples do not contain exactly the same persons. Data from both points in time can be used for between-groups longitudinal comparisons. (5.) Data from either data collection wave can be used to analyse the relationships between variables. Models of size and direction of relationships between variables can be analysed, including models of reverse causation.

9.2.2. Sample and data collection

Six organisations or organisational units of different size, business, and with different office concepts participated in the research. One additional organisational unit in a different organisation where no change of office environments took place served as the control group.
The sample of organisations can be characterised as a convenience sample (Robson, 2011). Several organisations in which office environment related change was about to happen in the German speaking part of Switzerland were asked to participate. Six organisations volunteered to do so (see Table 2). An additional organisation that did not plan any office related changes volunteered as control group. One organisation from the public administration sector had already completed the change at the time of the data collection. This organisation was included in the sample because of the number of employee data that could be

collected for modelling the effects of the office environment on the outcomes. In one financial services company the post-change data could not be collected due to reasons internal to this organisation. Data from this organisation is used for the analyses of relationships between variables.

Table 2. List of participant organisations in first study

Organisation	Sector	Change	Note
A	Real estate agency	Relocation and centralisation (2 to 1)	
B	Financial services	Relocation of departments within same location	
C	Technology	Relocation	
D	Fashion and accessories	New office layout in same building	
E	Public Administration	Relocation and centralisation (8 to 1)	Only post-change data
F	Financial services	Relocation	Only pre-change data
Control	Financial Services	No change	

The participating organisations and their employees requested and were assured of confidentiality. Therefore, detailed information of the organisations and the office designs (layout plans, photographs) cannot be reported[13].

Organisation A is a Swiss real estate agency with around 390 employees. Its services include real estate management, tenancy management, building management, trade and consulting. Organisation A has offices in the largest Swiss cities. The change in organisation A consisted in the co-location of employees from two buildings with around 120 and 70 employees to a new location.

Organisation B is an international IT-infrastructure management company for the financial services industry. This organisation employs over 2’000 persons in Switzerland. The participants in the study are located in the Zürich headquarters. The change consists in relocation of departments within the same building and the introduction of a new multi-space office design.

Organisation C is a technology unit of an international industry company. The company has over 5’000 employees in Switzerland. The unit that participated in this study is a local branch office (around 130 persons). The change consists in the move from an out-dated office building of the 1970ies to a new multi-space office in the same region, about 3 kilometres away.

Organisation D is a wholesale unit of an international fashion and accessories company. The unit studied consists of around 30 employees. The change in the office environment is a change in the office layout in the same building.

[13] While this is a limitation compared to standards of reporting scientific studies, it also illustrates conditions in conducting independent research in the domain of office design (see also Mylonas & Carstairs, 2007) and illustrates organisations’ restraint and caution in communication regarding organisational workplace management.

Organisation E is an organisational unit of the administration of the Canton of Zürich[14]. The unit has around 700 employees. For this organisation only post-change data are available because the change, a relocation and centralisation, had already been terminated at the time of data collection.
Organisation F is a globally active financial services company with headquarters in the city-centre of Zürich and over 11'000 employees (about 3'500 in Switzerland). For this organisation, only pre-change data could be collected.

Table 3. Overview of the office structures (social density) in the participating organisations before and after change

	Organisation	A	B	C	D	E	F	Control	Overall total
Before change	Mean	2.3	10.6	5.0	3.3	-	5.4	4.8	6.4
	Median	2	7	4	3	-	4	4	4
	Standard deviation	1.2	11.7	4.9	1.2	-	5.8	4.2	8.4
	Minimum	1	1	1	1	-	2	1	1
	Maximum	6	60	30	6	-	35	22	60
After change	Mean	48.6	65.0	23.1	27.9	37.5	-	4.7	37.8
	Median	35	60	20	32	45	-	4	40
	Standard deviation	39.6	45.3	15.8	8.6	19.4	-	4.2	32.0
	Minimum	2	1	1	9	1	-	1	1
	Maximum	100	160	55	34	81	-	20	160
	m^2 floor space per workspace	8.5	6.7	10.6	10.4	9.2	-	9.0	
Ratio of social density post/pre	Median	15.0	8.3	5.6	9.3			1.0	
	Mean	27.9	14.8	8.4	10.2			1.0	
	Standard deviation	28.8	23.9	8.9	6.3			.29	

All six organisations in the experimental group changed their office concepts from small group offices (average 4 persons per office room) to openly structured offices (average 38 persons per room). In four cases the change included relocations; in two cases the change included centralisation (see Table 4 for an overview of the sample and Table 3 for an overview of office structures). The participating organisations declared that the changes of office concepts were not related to other organisational changes. Table 4 shows the description of the samples. The total number of participants is 568 for the pre-move survey and 682 for the post-move survey. The longitudinal sample (i.e. sample of subjects who participated in both waves of data collection) contains 260 participants.

All of the changes in office structures were similar. Office structures were changed from small group cell offices to open structured offices. The magnitude of the change in the office structures can be described using the post/pre change ratio of social density (Table 3). The median values for this ratio range from 5.6 to

[14] Cantons of Switzerland are the member states of the federal state of Switzerland.

15, i.e. social density values are increased roughly by factors 5 to 15 in the new office structures.

Table 4. Description of samples

	Organisation	**A**	**B**	**C**	**D**	**E**	**F**	**Control**	**Total**
Before change	N pre change	113	206	57	26	NA	33	133	568
	Age (mode)	31-35	36-40	36-40	NA		36-40	41-45	36-40
	Tenure (mode)	3-4	5-6	5-6	1-2		10-15	5-6	5-6
	Female	73 (65%)	73 (28%)	9 (12%)	17 (65%)		18 (55%)	15 (12%)	205 (32%)
	Male	40 (35%)	189 (72%)	67 (88%)	9 (35%)		15 (45%)	117 (88%)	437 (68%)
After change	N post change	80	115	62	26	311	NA	88	682
	Age (mode)	36-40	36-40	41-45	NA	46-50		41-45	41-45
	Tenure (mode)	5-6	5-6	7-8	1-2	7-8		3-4	5-6
	Female	52 (65%)	25 (17%)	9 (12%)	17 (65%)	NA		15 (16%)	118 (28%)
	Male	28 (35%)	119 (83%)	67 (88%)	9 (35%)	NA		78 (84%)	301 (72%)
	N longitudinal	41	81	45	24			69	260

In all cases the new structures were implemented as multi-space offices. Multi-space office describes an office type with a mixed structure. Employees have personal workstations and can use different spaces and rooms according to their tasks and needs (e.g. focus rooms, conference and meeting rooms, espresso bars, lounges). Workstation zones and other zones are usually separated by non-transparent elements such as shelves, walls, or service points (print and copy stations). Individual workstations are visually separated by panels between desks facing each other and 120cm high shelves (three folders) in the back. Arrangement of workstations is either in blocks of four or in pairs with layouts with two opposite workstations or two workstations arranged in a Z-layout. Figure 24 shows an example of a multi-space layout part with workstations arranged in a Z-layout. Desks in this office are adjustable for height. The shelves adjacent to the desks are about 85cm (two folders) high; the shelves in the back of the workstations are about 120cm (three folders) high. The example shows meeting and conference rooms of different sizes and five focus rooms. The bench in the upper right part of Figure 24 is for project team’s use or used as touch-down workspace.

Figure 25 shows a part of multi-space layout with block and pair wise arrangements of workspaces. Integrated in the zone is a small meeting room with glass walls on two sides. Furthermore, there is a meeting table integrated in the workstation zone. All shelves are about 120cm high (three folders) in this office.

Figure 24. Part of post-move multi-space layout in organisation D

Data collection was carried out using web-based surveys. Subjects are employees who experience changes in their office work environment, mostly due to relocations. Employees were invited to participate in web-based surveys before they move to new buildings or office design was changed. A second wave of data collection was carried out in each organisation after the relocation/change. The average response rate in both the pre- and post-move survey is 53% (Table 6).

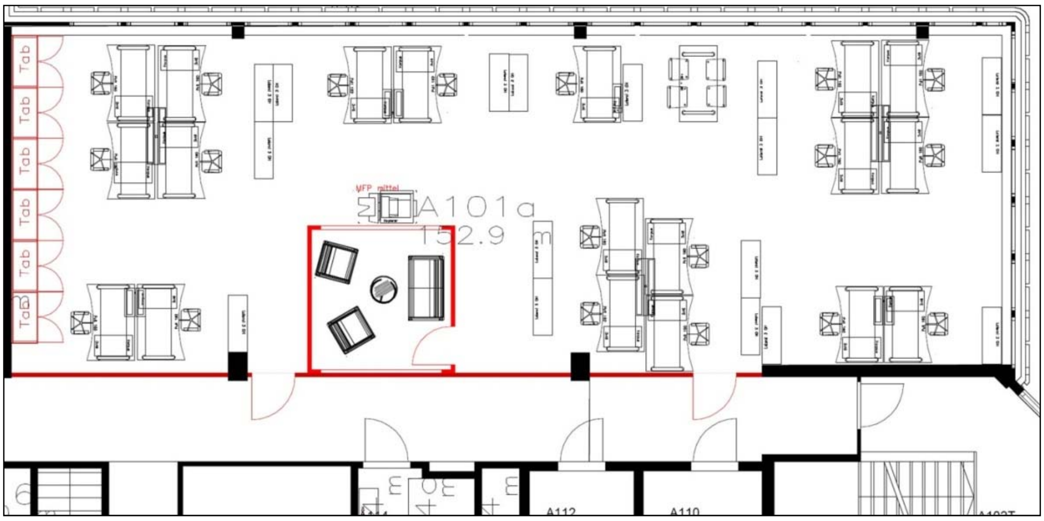


Figure 25. Part of post-move multi-space layout in organisation B

The participating organisations set limits for the length of the questionnaire. In order to stick to these limitations, the questionnaire was presented in different versions in the data collection per organisation (Table 5). This procedure implies restrictions for the number of subjects in the analyses but allows for different combinations of variables in order to fully explore the relationships. In some cases scales that had to be omitted due to space restrictions were replaced with single item measures (notably for the outcome measure environmental satisfaction). The versions of the questionnaire differ in their focus on influencing variables and dependent variables. Version A includes job characteristics, workspace characteristics, and social stressors as influencing factors and job satisfaction, environmental satisfaction, and individual job performance as outcome measures. Version B focuses on environmental conditions and workload as influencing factors and job satisfaction, environmental satisfaction, organisational commitment, and health status as outcome variables. The crucial variables privacy, job satisfaction, and environmental satisfaction are included in both versions. Version C includes job characteristics, environmental characteristics, privacy, and job and environmental satisfaction. Version D integrates different dimensions of stressors, namely environmental, social, and task-related stressors and incorporates workspace features and privacy as influencing variables. It contains job satisfaction, environmental satisfaction, organisational commitment, and health status as outcome variables.

The surveys were administered online with the exception of organisation A that insisted on a paper version of the questionnaires. The data quality of online and paper-and-pencil surveys is considered equivalent (Tuten, Urban & Bosnjak, 2002). Online surveys may even lead to higher quality data because this form provides a higher degree of perceived anonymity and thus the answers are less influenced by social desirability (Tuten et al., 2002). Reips (2002) discusses context effects of online surveys and concludes that online-specific surface characteristics of surveys (such as pop-up menus) do not seem to make a difference as compared to paper versions. There seems, however, to be an influence of the presentation mode. The presentation of all questions on one page (online) evokes different cognitive contexts than the presentation of groups of questions on multiple pages sequentially. The questions were therefore grouped thematically and presented on multiple pages. Demographic and control variables were placed at the end of the questionnaire because they demand less cognitive effort. At the end of the questionnaires participants had the opportunity to add comments.

Before the surveys started, all participants received E-mail containing information about the project, the data collection procedure and the timeframe of the survey. In order to enhance the acceptance of the surveys, this letter had been signed by the responsible manager in the organisation and the research project manager. The online surveys were started with personalised e-mail invitations. This guaranteed that each participant could complete the questionnaire only once. The participants could suspend the completion of the questionnaires. Feedback about the results was given to the participants by the managers within the participating organisations.

Table 5. Overview over questionnaire versions

Scale / Construct	Sub-scales	Questionnaire version			
		A	B	C	D
General information	Job title, education, age, gender, job tenure, Degree of employment, time at own workstation, social density	x	x	x	x
Job characteristics	Scope of action	x		x	
	Variety	x		x	
	Holistic job	x		x	
	Social support	x		x	
	Co-operation	x		x	
	Cognitive demand at work		x		x
	Quantitative overload at work		x		x
	Interruptions		x		x
	Information and participation		x		x
	Benefits		x		x
Rating of work environment	Environmental stressors	x			x
	Work and storage spaces	x			x
	Workspace quality	x			x
	Lighting		x	x	
	Indoor climate		x	x	
	Workplace appropriateness		x	x	
Privacy			x		x
Control		x		x	
Office noise		x		x	
Distraction		x		x	
Crowding		x		x	
Preference for enclosed area		x	x	x	x
Job satisfaction	Job satisfaction	x	x	x	x
Environmental satisfaction	Work area satisfaction	x			x
	Overall environmental satisfaction		x	x	
Social climate	Social stressors	x		x	
	Relations between colleagues	x	x	x	x
Job performance	Self-assessed job performance	x		x	
	Self-assessed job performance based on feedback	x		x	
Perceived productivity (situational)		x		x	
Health symptoms			x		x
Commitment			x		x
Work climate			x		x

Participants were guaranteed anonymity and confidentiality of data in both, the information mail and the invitation to participate in the survey. Data have been accessible only for the research team.

The pre-change survey took place six to fourteen weeks before the change. The post-change survey was conducted nine to twenty-four weeks after the change. The time-lag between the two measurements ranges from fifteen to thirty weeks.

Table 6. Response rates for both points of measurement

Organisation	A	B	C	D	E	F	Control	Total
Response rate pre-change	113 of 192 = 59%	206 of 362 = 60%	57 of 137 = 42%	26 of 30 = 87%	NA	33 of 51 = 65%	133 of 291 = 46%	568 of 1063 = 53%
Response rate post-change	80 of 165 = 48%	115 of 169 = 68%	62 of 137 = 45%	26 of 30 = 87%	311 of 497 = 63%	NA	88 of 293 = 30%	682 of 1291 = 53%
Longitudinal sample	41	81	45	24			69	260

9.2.3. Statistical analysis

Data analysis was carried out in four steps. First, the psychometric quality of the measures was analysed. Second, repeated-measures analyses of covariance (ANCOVA) were used in order to analyse the effects of interventions in office environments on office users' perceptions and reactions. Third, cross-sectional hierarchical regression analyses were used for the analysis of relationships between influencing and outcome variables. Fourth, these analyses were complemented by longitudinal hierarchical regression analyses. The cross-sectional regression analyses benefit from greater sample sizes and are therefore capable of identifying small effects. The longitudinal regression analyses were used to confirm these results and are considered as a strong argument for causality. However, due to the smaller size of the longitudinal sample, these analyses can only discover medium to large size effects (Miles & Shevlin, 2001).

The first step of the statistical analyses consists in the examination of construct validity, internal consistency, and test-retest reliability (section 9.2.5).
In the second step, longitudinal comparisons of means were carried out using repeated-measures ANCOVA. Repeated-measures ANCOVA allow the combination of comparisons of means of measurements performed on the same subjects (within-subject comparison) with comparisons between groups (e.g. for the comparison of experimental and control groups) (Twisk, 2008). Furthermore, covariates can be integrated in repeated-measures ANCOVA models i.e. variables that are not part of the main research focus but are known to have an influence on the dependent variable can be included in repeated-measures ANCOVAs as covariates. The effects of covariates are thus controlled for by this statistical procedure. The repeated-measures ANCOVAs were performed using the repeated measures general linear model procedure of IBM SPSS Statistics 17.0.

In addition to the significance level of the statistical analyses, an estimate of the effect size is provided. Effect sizes provide information about the meaningfulness or importance of an effect that reaches beyond significance of a test statistic. Effect sizes are standardised information about the magnitude of observed effects based on the proportion of explained variance (within-subject and/or between group differences) in relation to the total variance.
Effect sizes provide an objective measure of the importance of an effect by quantifying the size of the difference between groups. Cohen's (1992) widely accepted suggestions describe
$r = .10$ as a small effect (the effect explains 1% of the total variance),
$r = .30$ as a medium effect (the effect explains 9% of the total variance), and
$r = .50$ as a large effect (the effect explains 25% of the total variance).
These values correspond to partial eta square statistics ($\eta^{2)}$ as a standard effect size in analyses of variance. Partial eta squared is the proportion of the effect plus error variance that is attributed to the effect of interest. This measure of effect size is recommended for more complex factorial and covariate designs such as in the present study (Tabachnick & Fidell, 2007). Partial eta squares describe effect sizes as follows:
$\eta^2 = .01$ a small effect
$\eta^2 = .10$ a medium effect
$\eta^2 = .25$ a large effect.

Effect sizes provide additional information on the most important aspect of an intervention – the magnitude of its consequences – as compared to its statistical significance (which combines effect size with sample size). It is therefore an important measure for interpreting effectiveness of interventions.

The third step consists in cross-sectional regression analyses. With this type of statistical analysis, relationships among variables are analysed using data from one point in time. For the analysis of relationships all available data are used, i.e. also data from organisations E and F (where either pre- or post-change data could not be collected). The rationale for using all data is the enlargement of the dataset that allows the detection of smaller effects (as compared to the smaller longitudinal sample). Furthermore, the aim of these analyses lies in the development of a general model of effects of office environmental characteristics on outcomes, and not of a model that is restricted to certain office typologies. Specifically, the aim is the identification of demands and resources in job and office environments.

Regression analyses are performed in order to identify the relationships between job characteristics and the office environment with outcomes (job satisfaction, environmental satisfaction, organisational commitment, health, individual work performance).
More specifically, the degree to which characteristics of the office environment contribute to additional variance explanation (i.e. in addition to known influence factors) for outcomes (job satisfaction, commitment, health, performance) and the

degree to which job characteristics contribute to variance explanation in environmental satisfaction.

The statistical regression strategy for these analyses is a hierarchical (or sequential) blockwise entry strategy. The goal of regression analyses is to identify a set of values (regression coefficients) for predictor variables that bring the predicted values of dependent variables (outcomes) as close as possible to the values obtained by measurement[15]. Because predictor variables may correlate, the sequence of entering additional predictors in the regression model in order to explain more variance in the outcomes is important. In hierarchical regression predictors are selected on the basis of prior research. Predictors known to influence certain outcomes are entered into the model first and in order of their importance in predicting the outcome. After these predictors have been entered, further possible predictors are entered and it is checked whether they contribute to additional variance explanation (i.e. a more precise regression model).

Assumptions of regression analysis were checked for each analysis and tests for number of outliers, multicollinearity[16], independence of error terms, normality, linearity, and homoscedasticity[17] of residuals were included in the statistical procedures. The analysis of residuals was included because normally distributed residuals indicate that also the individual variables are normally distributed (Tabachnick & Fidell, 2007, p. 81f). The results of the regression analyses did not indicate a deviation from the assumption of normal distribution.

The fourth step consists in longitudinal hierarchical regression analyses. This set of analyses deals with relationships among variables. While with the repeated measures ANCOVAs the effects of changing the office environment are analysed, the relationships among variables is analysed using longitudinal regressions. This approach aims at establishing causal models, i.e. the examination of variables that may account for group differences in change over time. Specifically, the following analyses examine the causal influence of office environment variables on outcomes.
In order to analyse causal influences from environmental factors on outcomes, longitudinal cross-lagged panel regression models are analysed (Figure 26). Cross-lagged panel analysis requires at least two variables measured at two points in time. Six correlations can then be computed from these four variables: two synchronous correlations (variables are correlated at the same point in time), two autocorrelations (correlation of the same variable across points of time), and two cross-lagged correlations (correlation of two different variables across two

[15] Regression analyses examine statistical relationships between variables and do not imply that these relationships are causal. Causality is inferred on the basis of theory, logic and research design.
[16] Multicollinearity describes the strength of correlations between predictor variables in regression models. High collinearity between predictors makes impossible to obtain unique estimates of the regression coefficients because there is a number of combinations of coefficients that would work similarly well.
[17] Homoscedasticity describes the degree to which the residuals at each level of the predictor variables have similar variances. Heteroscedasticity weakens regression analyses (Tabachnick & Fidell, 2007).

points of time). The rationale for cross-lagged panel analyses is that comparisons of the cross-lagged correlations are indicative of the causal priority of the variables (Taris, 2000). If one cross-lagged correlation is significantly stronger than the second cross-lagged correlation, one could conclude causal priority. However, correlations are not sufficient for the interpretation of causality and may be misleading, e.g. in the case where the variables measured are correlated to a third variable and where controlling for this third variable would render associations between the study variables not significant (Taris, 2000). Furthermore cross-lagged correlations may be inflated by variance in the variable measured at time 2 that is due to the autocorrelation (A1-A2, B1-B2) or to the cross-sectional correlation (A2-B2).
The current recommendation for coping with these sources of error and estimating longitudinal effects is the use of hierarchical regression (Taris, 2000). These analyses examine if the change in office design not only affects synchronous correlations but also the cross-lagged correlation. If a variable is identified as a causal agent, regression weights from the causal variable on the outcome at time 2 should be significant at both points in time. Using this approach cross-sectional correlations can be analysed as correlated change and it can be shown that the intervention not only affects levels of office environmental variables but also outcome variables.

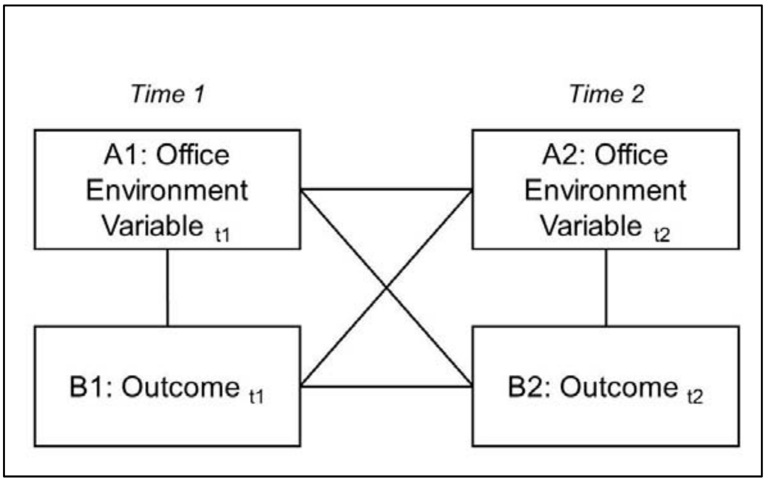


Figure 26. Cross-lagged panel design

Instead of using the difference between prescore and postscore of independent variables as measure, Cohen, Cohen, West & Aiken (2003) suggest to apply a model for regressed change. Their proposal aims at reducing the effect of the time 1 level of the influencing variable. To achieve this goal, the autocorrelation of the influencing variable between the two points of time is partialed out and changes in the outcome can be attributed to the difference between prescore and postscore. Hierarchical regression analyses were conducted. The regressions took the following form: the first block contains the time 1 variable of the dependent variable. In the following block, control variables were entered (e.g., gender, age, job complexity, job design). Demographic variables were statistically controlled

because they may affect well-being (Warr, 1990) and work performance (T. W. H. Ng & Feldman, 2008, 2010). Job design variables were also included as control variables because the effect of changes in the office environments on the outcomes was in the focus of the analyses. Therefore the well-documented effects of job design (see chapter 7) were statistically controlled for.
In Block 3 the time 1 independent variables were entered and in block 4 the time 2 influencing variable (Figure 26).
A significant relationship between the outcome and the influencing variable in block 3 indicates a lagged effect of the independent variable on change in the outcome. A significant relationship in block 4 indicates that a change in the influencing variable is associated with change in the outcome.

9.2.4. Measures

Despite decades of research in office environmental quality and effects of office environment on office users, none of the instruments (mainly questionnaires) used in this research became accepted as a standard or has inspired or dominated research. Questionnaire developments (e.g. J. R. Carlopio, 1996; Charles et al., 2003; Stokols & Scharf, 1990; Vischer, 1989) have not been taken up by researchers. At present no standards for measuring perceived office environmental quality are established in the research community. For my research, therefore, scales measuring office users' assessments and reactions from different sources were compiled and used for data collection. Questionnaires used for the surveys were built using scales that have proved useful in similar research. Scales were used only if the internal consistency (Cronbach's Alpha) had been reported in the original research reports. Most of the scales used are 5 or 7 point rating scales. A detailed description of the scales is given in the appendix. All scales were recoded so positive values represent positive assessments, ratings, expressions of satisfaction, high comfort etcetera (see Table 7 for an overview). Job complexity was derived from questionnaire information on job title. Two experts independently rated job complexity from this information.

Table 7. Polarity of scales

	Scale	**Low values**	**High values**
Job characteristics	*Scope of action*	Low control, low degree of autonomy, few decision possibilities	High control, high degree of autonomy, many decision possibilities
	Variety	Few skills and abilities required	Many skills and abilities required
	Holistic job	Highly fragmented job	Own work is clearly perceived as contribution to larger entity, e.g. product
	Social support	Low social support	High social support
	Co-operation	Few opportunities for co-operation	Many opportunities for co-operation
	Cognitive demand at work	High qualitative overload	No qualitative overload

	Quantitative overload at work	Strong time pressure or high quantitative overload	No time pressure or quantitative overload
	Information and participation	Insufficient information and low participation	Sufficient information and high participation
	Benefits	Insufficient opportunities for development and advancement	Good opportunities for development and advancement
	Job complexity	Very simple job	Very complex job
Office environment	*Environmental stressors*	Many environmental stressors, inadequate environment	No environmental stressors, adequate environment
	Lighting	Poor lighting conditions	Excellent lighting conditions
	Indoor climate	Poor indoor climate	Excellent indoor climate
	Workplace appropriateness	Inadequate workspace	Highly adequate workspace
	Work and storage space	Not enough work and storage space	Enough work and storage space
	Workspace quality	Inappropriate and unappealing office furniture	Highly appropriate and appealing office furniture
	Distractions	Many auditory and visual distractions	Few auditory and visual distractions
	Office noise	Much disturbing noise	Little disturbing noise
	Privacy	Low privacy	High privacy
	Crowding	High crowding stress	Low crowding stress
	Control	Low control over own working environment	High control over own working environment
	Preference for enclosed area	Preference for open office environment	Preference for enclosed office environment
outcomes	*Job satisfaction*	Low job satisfaction	High job satisfaction
	Work area satisfaction	Low work area satisfaction	High work area satisfaction
	Overall environmental satisfaction	Low overall environmental satisfaction	High overall environmental satisfaction
	Organisational commitment	Low organisational commitment	High organisational commitment
	Health symptoms	Bad health, high frequency of psychosomatic symptoms	Good health, low frequency of psychosomatic symptoms
	Self-assessed job performance	Low performance	High performance
	Self-assessed job performance based on feedbacks	Low performance	High performance
	Situational job performance	Low performance	High performance
	Social support (social climate)	Low social support	High social support
	Psychological climate	Bad psychological climate	Good psychological climate
	Social stress (colleagues)	Many social stressors (colleagues)	Few social stressors (colleagues)
	Social stress (supervisors)	Many social stressors (supervisors)	Few social stressors (supervisors)

9.2.4.1. Job Characteristics and office environment

Screening of work characteristics was measured with the short questionnaire for work analysis (KFZA, Prümper, Hartmannsgruber & Frese, 1995). This questionnaire contains short versions of scales from various German work analysis instruments developed on the basis of action-regulation theory. It is composed of 24 items and includes dimensions listed below. Participants respond on 5-point-scales ranging from "very little" to "very much" or "not at all" to "very much so".

- *Scope of action* (control, autonomy) was measured with three items regarding decision possibilities with regard to procedures, equipment, time frame, and sequence of actions (e.g. "If you consider all your activities, to what extent you can determine their order yourself?").
- *Variety* was measured with three items regarding the degree to which skills and abilities can be applied for dealing with work tasks, deciding, and learning new things on the job (e.g. "Generally speaking, I have frequently changing and varied tasks at my work.").
- *Holistic job* (task identity) is composed of two items referring to the degree to which own work is perceived as part of a product as a larger entity and the possibility to assess the own work performance on the basis of the own results (e.g. "At work I can see from the results whether or not my work is good.").
- *Social support* is measured with three questions regarding the degree to which job incumbents can rely on other persons in their work environment. Social support describes the quality of social interactions with colleagues and supervisors (e.g. "I can rely on my colleagues, if work becomes difficult.").
- *Co-operation* is measured with three items referring to necessities and opportunities for communication, co-operation, and feedback at work (e.g. "Work requires close co-operation with other people in the organisation.").
- *Cognitive demand* is composed of two questions on cognitive overload caused by overtaxing information processing through overly complicated formulation of goals (e.g. "There are things in this job which are too complicated."). Cognitive overload is characterised by high demands on concentration caused by the amount of information that must be kept in working memory.
- *Quantitative overload* is measured using two items on pressure of time and high workload (e.g. "I have too much work.").
- *Interruptions* are assessed via two items on regulation obstacles caused by organisational problems leading to the inability to complete work tasks as planned (e.g. "I am repeatedly interrupted (e.g. by the telephone) when I am trying to get my work done.").
- *Information and participation* is composed of two questions regarding organisational information flows and possibilities to participate in change processes (e.g. "In our organisation we receive sufficient information about important matters and procedures.").

- *Benefits* are measured with two questions on compensation system, chances for promotion, and training (e.g. “Our organisation offers good opportunities for professional development.”).
- *Environmental stressors* is measured with two items that relate to the physical and technical work environment and refer to stress inducing sensory conditions such as noise, dust, temperature, and lighting (e.g. “In my workplace, the rooms and fittings are inadequate.”).

Job complexity was assessed by averaging experts’ ratings on two items. The first item, task complexity, provides an overall assessment of number of job elements, decision necessities, required skill level, and sophistication of the job (Fried et al., 2002; Melamed et al., 2001). The second item, interaction complexity, describes regulation necessities with respect to complex relationships to people, including leading teams (Jex, Adams, Elacqua & Bachrach, 2002). The items were assessed on a 4-point-scale with 1 indicating a very simple job and 4 indicating a very complex job.

Social stress was measured using the short form of a scale measuring social stressors in the workplace (Frese & Zapf, 1987). This version of the scale consists of ten items (e.g. “My line manager plays us off against each other.”) that are responded to on a 7-point scale ranging from “yes, very much so” to “no, not at all”.

Environmental features rating (EFR, Charles et al., 2003; Veitch et al., 2002), a set of questions about various aspects of the physical office environment. The EFR scale is based on previously validated rating scales for office settings (Stokols & Scharf, 1990) and has been applied and validated in several studies at the Institute for Research in Construction (IRC, National Research Council Canada) (Newsham et al., 2009; Newsham, Veitch & Charles, 2008; Veitch et al., 2007). It consists of 18 items asking for ratings of features of the office environment such as “Amount of light for computer work” or “Temperature in your work area”. The original 7-point-scale end points “very unsatisfactory” and “very satisfactory” were replaced by “very poor” to “excellent” because there is no adequate German translation. One item (EFR7) on the amount of noise from other employee’s conversations was excluded from the scale because perceived noise was measured with a separate scale.

Further scales for data collection on aspects of the office environment were used:

- *Work and storages spaces* are assessed by two items from (Brennan et al., 2002) regarding the provision of storage and surface spaces at the individual workspace (e.g. “I have enough storage space at my workspace.”; 7-point-scale range from “disagree strongly” to “agree strongly”).
- Satisfaction with stile and quality of office *furniture* and adequacy of physical environment for work tasks was measured using three items for workspace quality from Lee & Brand (2005) such as “I like the style/quality of my

furniture". The participants responded on a 7-point-scale ranging from "disagree strongly" to "agree strongly".

- Visual and acoustical *distractions* were measured using three items from Lee & Brand (2005), e.g. "I experience auditory distractions in my work area". The 7-point-scale ranges from "yes, all the time" to "no, never".
- Subjective assessment of *noise* in the office environment was measured using a scale by Leather et al. (2002). On this scale employees are asked to give a rating of five sources of noise (e.g. telephone calls of colleagues) in terms of frequency with which they disturb their concentration (on a 7-point-scale ranging from "does never disturb" to "continuously disturbs").

9.2.4.2. Attitudinal measures

Privacy was measured using six items from Oldham (1988) that represent the two subscales task privacy and communication privacy. Task privacy describes the amount to which employees can concentrate on their work. A sample item is "I am able to concentrate fully on my job while at work". Communication privacy is the degree to which employees can hold private and personal conversations with colleagues. A sample item for this scale is "I can talk with my co-workers in confidence while at my workstation". The statements were rated on a 5-point-scale ranging from "very inaccurate" to "very accurate".
The six items taken from Oldham (1988) were complemented with an item taken from Zalesny & Farace (1987) ("Sometimes I'm disturbed by colleagues who walk by my workplace", reverse coded).

Crowding refers to employees' perception of high social density associated with a loss of perceived personal control. Crowding was measured using an index based on the average of four items such as "Employees must work too closely together in my work area". (May et al., 2005; Oldham, 1988). Statements were rated by the study participants on a 7-point-scale ranging from "disagree strongly" to "agree strongly".

Control over the individual work environment was operationalized with five items taken from Lee & Brand (2005). Control refers to the perceived ability to influence the physical environment by adjusting, changing or modifying parameters of the physical environment. Statements such as "I determine the organization/appearance of my work area" are rated on a 7-point-scale ranging from "yes, very much so" to "no, not at all".

Two items measuring the *preference for working in an enclosed area* were adapted from Lee & Brand (2005). These items include the preference for isolated workspaces and the assessment of the degree to which work is more effective in an isolated workspace. A sample item is "I prefer a completely open office (no partitions) to cell offices". Respondents rate the accuracy of this statement on a 7-point-scale ranging from "yes, very much so" to "no, not at all".

9.2.4.3. Outcomes

A scale for *job satisfaction* was taken from Baillod & Semmer (1994). It consists of four items (e.g. “I hope my work situation will always stay as good as it is now.”) that build an index for general job satisfaction. The scale format refers to the frequency in which the respondent thinks about his/her work ranging from 1 (never) through 7 (always).

Environmental (work area) satisfaction was measured using three items on work area satisfaction from May et al. (2005). These items refer to satisfaction with the entire office environment, comfort, and an assessment of the adequacy of the working environment for work tasks. A sample item is “In general, my work area provides a good setting in which to work.” The statement is assessed on a 7-point-scale ranging from “disagree strongly” to “agree strongly”. The environmental satisfaction scale was complemented with one item from Charles et al. (2003) that refers to satisfaction with the indoor environment at the individual workstation as a whole (overall environmental satisfaction) (“Indoor environment in your workstation as a whole” rated on a 7-point-scale ranging from “very poor” to “excellent”).

Organisational commitment was measured using a 9-item scale from J. Cook & Wall (1980). This scale represents three facets of commitment:

- Organisational identification refers to a feeling of pride to be a member of a specific organisation and to the internalisation of organisational goals and values (e.g. “I am quite proud to be able to tell people who it is I work for”).
- Organisational involvement refers to an organisation member’s willingness to invest personal effort for the sake of the organisation (e.g. “In my work I like to feel I am making some effort, not just for myself but for the organization as well”).
- Organisational loyalty describes the attachment to the organisation and a sense of belongingness that is manifested in a wish to stay in the organisation (e.g. “The offer of a bit more money with another employer would not seriously make me think of changing my job”).

The agreement with the statements is captured with a 7-point-scale ranging from “disagree strongly” to “agree strongly”.

Health symptoms were measured using a German scale developed by Mohr (1986, 1991, based on Fahrenberg, 1975). This scale asks for the frequency of a list of psychosomatic complaints (e.g. headache, backaches / lower back pain, neck / shoulder pain, dizziness). It is comparable to similar scales in English language used for the assessment of health and well-being (e.g. the Physical Symptoms Inventory, Spector & Jex, 1998). The list of symptoms refers to complaints that can be considered as psychological long-term stress responses. The frequency of the symptoms is indicated on a 5-point-scale ranging from “hardly ever / never” to “nearly every day”.

Individual performance was measured using a subjective performance assessment. This type of indirect and subjective performance assessment was chosen as the best alternative to removing performance from the research design. With information or knowledge work in offices, objective measures – that would be the preferred source of performance information – usually are not available. This does not suggest that subjective self-assessments of performance are interchangeable substitutes for objective performance measures but that in some cases they are the only option (Dess & Robinson Jr, 1984). Subjective performance assessments have the advantage of allowing comparisons between different jobs and businesses (Leaman & Bordass, 2000). Because not much experience with sensitivity and psychometric quality of subjective performance assessments in office work is available, three different individual performance assessment scales were employed:

- Self-assessed job performance (Oldham, 1988) consists of five items of self-rated performance (e.g. "I can accomplish a great deal each day.") on a 7-point-scale ranging from "strongly agree" to "strongly disagree".
- Satisfaction with subjective performance (Brennan et al., 2002): This scale consists of thirteen items rated on a 7-point-scale ranging from "strongly agree" to "strongly disagree". It focuses on feedbacks about one's own performance (e.g. "Peer feedback about my work is positive.") and includes items on the influence of the working environment on individual work outcomes (e.g. "It is easy to have a one-to-one conversation at my workspace."). Thus, the scale confounds different concepts, such as satisfaction, task performance, and appropriateness of the work environment. The scale, however, was included in the questionnaire because it was developed for similar research settings as the ones studied here and because the examination of the properties of the scale could be used for the further development of measures of perceived performance.
- Situational job performance (Lee & Brand, 2005) consists of three items that consist in comparisons of actual (situational) performance and typical performance. The three items cover the dimensions of quality, quantity, and creativity of work results. A sample item is "Compared to my typical work, right now I would rate the quality of my work as (Very good = 1; Very bad = 7)".

Outcomes on the inter-individual level were measured using two scales focusing on the social relations among colleagues at work:

- Work climate was measured using a scale from Rosenstiel & Bögel (1992) that consist of fourteen items describing perception and assessment of organisational climate with a focus on colleagues at work (e.g. "The atmosphere at work is impersonal."). The agreement to the statements is given on a 7-point-scale ranging from "very inaccurate" to "very accurate". Items were recoded to ensure that a higher score indicates a more positive climate.

9.2.5. Construct validity and internal consistency of scales

In this section the psychometric quality of the scales used in the first study is described. The analysis consists of three steps. The first step was to assess the dimensionality of the scales from a statistical viewpoint using principal component analyses (PCA). This procedure examines whether a number of questionnaire items represent a one-dimensional or a multi-dimensional construct. It serves to identify number and properties of dimensions contained in a construct measurement.
Scales that are reported to consist of several subscales in literature and scales with many items were analysed. Oblique rotations were used because it was assumed that subscales within the scales used are intercorrelated (as it is the case for most naturalistic data, especially if ratings are involved, Field, 2009). Oblique rotations usually are easier interpretable than orthogonal rotations. However, because of the intercorrelations the resulting solutions to some extend hold redundant information. This can limit data reduction, the central function of principal component analysis. The Kaiser-criterion was used to determine the number of factors. According to this criterion the number of components extracted is the number of components with an eigenvalue greater than 1 (cf. Stevens, 1996). Missing values were replaced with item means. This is a conservative approach since it constricts variance and thus reduces correlations between items (Cohen et al., 2003). The threshold for component loadings was set at 0.4. Thus variables share at least fifteen per cent of their variance with the construct (component) they were going to be used to help name (Stevens, 1996). Data from the pre-move survey were used for the PCA.

The second step consists in analysing the internal consistency of the scales used. Internal consistency measures to which degree a single item of a multi-item scale correlates with the whole of the rest of the items. It is considered as a reliability measure for scales because it determines the degree to which a group of items can be considered as a measurement of a single latent variable. The most common measure of internal consistency is coefficient Alpha (Cronbach, 1951). It represents the mean of the correlations between all of the different possible splits of the scale into two halves (Cohen et al., 2003). Coefficient Alpha usually provides a good estimate of reliability because sampling of content is usually the major source of measurement error (Nunnally & Bernstein, 1994). Furthermore, coefficient Alpha can be used as confirmatory measure of unidimensionality of a scale or as a measure of the strength of a dimension once the existence of a single factor has been determined by principal component analysis (Cortina, 1993).
Coefficient Alpha can reach a maximum value of +1 (perfect consistency). There are several recommendations about acceptable levels of coefficient Alpha. Nunnally & Bernstein (1994) consider values of 0.8 and higher as appropriate. Other authors consider cut-off points of 0.7 (Nunnally & Bernstein, 1994) or 0.65 (Aiken, 1996) as more appropriate, particularly when the scales are used for

comparisons between groups and not for individual tests or diagnoses. However, attention should be paid also the number of items (Cortina, 1993): Values of Alpha rise with increasing numbers of items. In scales with few items (less than 6) high values of Alpha represent high mean correlations (e.g. high internal consistency).

The third step in assessing the quality of the instruments used is a test-retest reliability analysis. The inclusion of a control group in the research design allows for an examination of test-retest reliability for the scales used. Test-retest reliability provides information about the stability of individual scores over time. Given no changes happen in the office design, respondents should score the same values on the measurement scales at two (or more) different points in time (Kline, 2000). Kline (2000) suggests a three-month gap between the measurements. Test-retest reliability is measured by a within-subjects correlation of the scores at the two points in time of measurement.

9.2.5.1. Construct validity

Screening of work task characteristics (KFZA)
Principal component analysis of KFZA (screening of work characteristics) data resulted in eight components. The original instrument (Prümper et al., 1995) contains 10 components which were extracted using a two-stage factor analytic procedure that was thought to better represent the components. A replication of the initial principal component analysis with the two-stage procedure applied by Prümper and colleagues (1995) resulted in the same component structure. Table 8 presents the pattern matrix from the initial PCA.
Differences compared to the original instrument are the following: the “holistic job” component (KFZA 7-8) could not be identified as a separate component. One of its items showed a cross-loading on two components (scope of action and co-operation). The “social support” subscale (KFZA9-11) forms a component together with two of three items of the co-operation construct (KFZA12-14). The item “Work requires close co-operation with other people in the organisation” (KFZA12) loads on a separate component that is used for data analyses instead of the co-operation multi-item construct proposed by Prümper et al. (1995). Furthermore according to the present analyses “information and participation” (KFZA21-22) and “benefits” (KFZA23-24) could be integrated as one component representing organisational climate.
The subscale “interruptions” (KFZA19-20) could not be replicated. Its two items loaded on the qualitative overload component (KFZA17-18). The subscale for interruptions was therefore excluded from further analyses. A second reason to exclude this scale is that interruptions in this research are not considered an attribute of job characteristics but of the work environment. Interruptions furthermore are included in the measures of privacy and distraction.

Table 8. Pattern matrix of the principal component analysis for KFZA items (time 1 data)

	Component							
	1	2	3	4	5	6	7	8
KFZA1	.767							
KFZA2	.792							
KFZA3	.785							
KFZA4						-.748		
KFZA5						-.703		
KFZA6						-.818		
KFZA7	.402							
KFZA8	.494							-.433
KFZA9				-.809				
KFZA10				-.766				
KFZA11				-.756				
KFZA12								.773
KFZA13				-.577				
KFZA14				-.736				
KFZA15							.904	
KFZA16							.796	
KFZA17		.838						
KFZA18		.770						
KFZA19		.409						
KFZA20		.767						
KFZA21			.805					
KFZA22			.753					
KFZA23			.816					
KFZA24			.773					
KFZA25					.859			
KFZA26					.870			

Note: factor loadings below .4 are omitted

Environmental features rating (EFR)

Results of PCA and internal consistency of the „Environmental Features Rating“ (EFR) scale (Charles et al., 2003) are comparable with the published figures. The PCA results in four latent dimensions that can be interpreted as regards content (Table 9). The first three components correspond to the factors reported by Veitch et al. (2007): the indoor climate scale could be replicated (component 2). In the main, the same is true for the lighting scale (component 3). However, in this scale the item “Your access to a view of outside from where you sit“ (EFR14) was dropped, because it did not load on this component. This item formed a separate factor in the analyses of Veitch and colleagues (2007) and was subsequently forced into the lighting scale in their research.

The factor privacy/acoustics could not be replicated. Instead, in this analysis two components emerged: the first can be named “task-related workplace appropriateness” (component 1) and is thus described less narrowly in content compared to Veitch et al. (2007). The second component identified is privacy (component 4).

Table 9. Pattern matrix of the principal component analysis for EFR items (time 1 data)

	Component			
	1	2	3	4
EFR1			-.956	
EFR2		.850		
EFR3		.884		
EFR4	.535			
EFR5				.940
EFR6				.903
EFR8	.690			
EFR9	.557			
EFR10			-.873	
EFR11			-.426	
EFR12		.791		
EFR13				
EFR14	.632			
EFR15	.848			
EFR16			-.836	
EFR17	.595			
EFR18	.698			

Note: factor loadings below .4 are omitted

Individual Performance

All items regarding subjective self-assessments of individual performance were entered in a PCA. The items originate from Brennan et al. (2002), Lee & Brand (2005), and Oldham (1988). The resulting components replicate the scales of Oldham (1988) (component 6) and Lee & Brand (2005) (component 3). The remaining items build four components, not all of which can easily be interpreted. The main component, however, is interpretable. It consists of all the items that contain subjective self-assessments of performance based on feedbacks from supervisors, peers, and clients (PR3, PR7, PR10, PR13). An analysis of the remainder of the items from Brennan et al. (2002) shows that they are focussing more on the fit between workplace environment and work tasks than on the assessment of individual performance. Therefore, these items were excluded for further analysis.

The PCA thus results in three interpretable components that delineate three facets of subjectively assessed performance: The component with the items from Oldham (1988) consists of subjective statements about quality and quantity of own work.

The component containing the items of Lee & Brand (2005) focuses situative performance („right now“) compared to typical performance. The third factor is composed of statements about own performance on the basis of feedback from various sources.

Table 10. Pattern matrix of the principal component analysis for self-assessed work performance items (time 1 data)

	Component					
	1	**2**	**3**	**4**	**5**	**6**
PR1					.611	
PR2				-.462		
PR3	.759					
PR4				-.648		
PR5				-.701		
PR6				-.603		
PR7	.777					
PR8		.764				
PR9		.543				
PR10	.806					
PR11		.697				
PR12					.819	
PR13	.660					
PR14						.685
PR15						.711
PR16	.491					.418
PR17						.699
PR18						.747
PR19			-.659			
PR20			-.856			
PR21			-.853			

Note: factor loadings below .4 are omitted

Privacy

A PCA was conducted for the privacy items from Oldham (1988), the item taken from Zalesny & Farace (1987), and the two items from Charles et al. (2003) (see above). The analysis results in two components that separate the two privacy items of the EFR scale from the rest (Table 11). Thus the two factors task privacy and communication privacy differentiated by Oldham (1988) cannot be replicated. The analysis of the internal consistency shows that values for coefficient Alpha are substantially higher when the items are integrated to compose one single privacy scale (Table 15). The resulting scale correlates moderately (r = .33) with the scale built of the two items taken from Charles et al. (2003).

Table 11. Pattern matrix of the principal component analysis for privacy items (time 1 data)

	Component	
	1	2
TP1	.710	
TP2	.601	
TP3	.666	
CP1	.658	
CP2	.693	
CP3	.661	
P1	-.775	
P2 / EFR5		.911
P3 / EFR6		.899
Note: factor loadings below .4 are omitted		

Work climate

The PCA for the work climate scale resulted in two components that can be interpreted as social support and psychological climate (Table 12). The components correlate very strongly (r = .64). Social support is based on trust and help of colleagues. Psychological climate is a description of perceived characteristics of social relations in the organisation (Rosenstiel & Bögel, 1992).

Table 12. Pattern matrix of the principal component analysis for work climate items (time 1 data)

	Component	
	1	2
BK1		-.587
BK2		-.851
BK3		-.740
BK4		-.858
BK5		-.780
BK6	.668	
BK8	.711	
BK9	.816	
BK10	.725	
BK11	.767	
BK12	.667	
BK13		
Note: factor loadings below .4 are omitted		

Organisational commitment

The three components of commitment proposed by J. Cook & Wall (1980) (organisational identification, organisational involvement, and organisational loyalty) could be replicated. The values of internal consistency for the components, however, are below an acceptable level. Therefore, organisational commitment was treated as a one-dimensional construct. The internal consistency of the commitment scale was satisfactory at 0.77 (pre-move) and 0.81 (post-move) respectively.

Table 13. Pattern matrix of the principal component analysis for organisational commitment items (time 1 data)

	Component		
	1	2	3
C1	.823		
C2			.504
C3		.721	
C4			.656
C5	.813		
C6		.691	
C7			.813
C8	.696		
C9		.750	
Note: factor loadings below .4 are omitted			

Social stress

Dimensionality analysis of the social stressors scale resulted in two components. The two components differ in the source of social stress. One component describes the social stressors as caused by colleagues' behaviour. The other component captures supervisors' behaviour as source of stress. Two items (ST4 and ST9) with loadings on both components were excluded from further analyses as they do not fit the distinction between the two sources of stress in terms of content either.

Table 14. Pattern matrix of the principal component analysis for social stress items (time 1 data)

	Component	
	1	2
ST1	.312	.705
ST2	.585	.310
ST3		.709
ST4	-.303	.490
ST5	.764	
ST6	.859	
ST7	.498	.414
ST8	.797	
ST9	.531	.324
ST10	.840	
Note: factor loadings below .4 are omitted		

9.2.5.2. Internal consistency

The internal consistency of the scales used is satisfactory, for most of the scales even good to excellent (Table 15). Some of the job analysis subscales did not reach satisfactory levels. However, some of the job analysis subscales consist only of two items (holistic job, cognitive demand at work, quantitative overload at work, interruptions, information and participation, benefits). For 2-item scales alpha values (which correspond to bivariate correlations in this case) of 0.5 are considered as satisfactory because this value on the one hand stands for a substantial correlation but on the other hand points out that two different facets of a construct are represented.

Table 15. Internal consistency (Coefficient Alpha) of measures at time 1 and time 2

Scale / construct (variable codes in brackets)	Subscales	Number of items	Internal consistency (Coefficient Alpha) as published in source of scale; comments	Internal consistency Pre-move survey (time 1)	Internal consistency Post-move survey (time 2)
General information (D1-D9)		9			
Job analysis (KFZA1-KFZA24)	Scope of action (KFZA1-KFZA3)	3	0.70	0.77; N = 303	0.70; N = 354
	Variety (KFZA4-KFZA6)	3	0.73	0.71; N = 276	0.75; N = 356
	Holistic job (KFZA7-KFZA8)	2	0.51	0.50; N = 274	0.54; N = 352
	Social support (KFZA9-KFZA11)	3	0.76	0.79; N =305	0.76; N = 353
	Co-operation (KFZA12-KFZA14)	3	0.64, excluded because of results of PCA (see text)	0.49; N = 306	0.61; N = 351
	Cognitive demand at work (KFZA15-KFZA16)	2	0.40	0.68; N = 284	0.69; N = 342
	Quantitative overload at work (KFZA17-KFZA18)	2	0.70	0.80; N = 285	0.83; N = 340
	Interruptions (KFZA19-KFZA20)	2	0.44, excluded because of results of PCA (see text)	0.37; N = 280	0.54; N = 343
	Information and participation (KFZA21-KFZA22)	2	0.70	0.74; N = 248	0.78; N = 335
	Benefits (KFZA23-	2	0.61	0.79; N =	0.77; N =

Scale / construct (variable codes in brackets)	Subscales	Number of items	Internal consistency (Coefficient Alpha) as published in source of scale; comments	Internal consistency Pre-move survey (time 1)	Internal consistency Post-move survey (time 2)
	KFZA24)			247	335
	Organisational climate (KFZA21-KFZA24)	4	New subscale	0.80; N = 334	0.82; N = 328
Job satisfaction (AZ0-AZ7)	Job satisfaction (AZ0, AZ1, AZ4, AZ5)	4	0.73	0.69; N = 532	0.73; N = 660
Work area satisfaction (AZU1-AZU3)		3	0.88	0.95; N = 320	0.97; N = 395
Environmental stressors (KFZA25-KFZA26)		2	0.60	0.71; N = 288	0.70; N = 396
Work and storage space (AZU4-AZU5)		2	0.76	0.95; N = 320	0.86; N = 396
Workspace quality (AU1-AU3)		3	0.85	0.86; N = 286	0.79; N = 390
Environmental Features Rating EFR1-EFR18; OES2; P2, P3)		17		0.90; N = 348	0.89; N = 297
	Assessment of lighting (EFR1, EFR10, EFR11, EFR16)	3	0.76 (incl. Item EFR14 „Your access to a view of outside from where you sit“ for comparison with published values)	0.85; N = 282	0.87; N = 315
	Assessment of indoor climate (EFR2, EFR3, EFR12)	3	0.82	0.85; N = 281	0.86; N = 320
	Assessment of task-related workplace appropriateness (EFR4, EFR8, EFR9, EFR13, EFR15,	7	Different components for this scale due to factor analysis, no comparison to published values possible	0.87; N = 265	0.86; N = 309

Scale / construct (variable codes in brackets)	Subscales	Number of items	Internal consistency (Coefficient Alpha) as published in source of scale; comments	Internal consistency Pre-move survey (time 1)	Internal consistency Post-move survey (time 2)
	EFR17, EFR18)				
	Privacy (P2, P3, correspond to EFR5, EFR6)	2		0.92; N = 501	0.94; N = 659
	Overall environmental satisfaction (OES2)	1			
Control (K1-K6)		6	0.71	0.83; N = 302	0.82; N = 358
Office noise (L1-L6)		6	Not specified	0.85; N = 214	0.77; N = 260
Distraction (AS1-AS3)		3	0.80	0.79; N = 311	0.86; N = 363
Crowding (CR1-CR4)		4	0.92	0.88; N = 277	0.83; N = 535
Preference for enclosed area (IA1, IA2)		2	0.77	0.81; N = 465	0.75; N = 708
Situational job performance (PR19-PR21)		3	0.76	0.74; N = 291	0.82; N = 332
Social climate (ST1-ST10)	Social stressors (ST1-ST10)	10	0.86	0.83; N = 262	0.85; N = 313
	Social stressors: colleagues (ST1, ST2, ST3, ST7)	4		0.78; N = 271	0.81; N = 327
	Social stressors: Supervisors (ST5, ST6, ST8, ST10)	4		0.84; N = 272	0.85; N = 323
Self-assessed job performance (PR1-PR18)	PR1-PR13 (Brennan et al., 2002)	13	0.89	0.83; N = 277	0.85; N = 307
	PR14-PR18 (Oldham, 1988)	5	0.76 to 0.78	0.82; N = 295	0.80; N = 330
	Self-assessed job performance based on feedbacks (PR3, PR7, PR10, PR13)	4		0.82; N = 284	0.84; N = 314

Scale / construct (variable codes in brackets)	Subscales	Number of items	Internal consistency (Coefficient Alpha) as published in source of scale; comments	Internal consistency Pre-move survey (time 1)	Internal consistency Post-move survey (time 2)
Privacy (TP1-TP3; CP1-CP3; P1)	Privacy (TP1-TP3 and CP1-CP3; P1)	7	New scale	0.84; N = 248	0.85; N = 338
	Task Privacy (TP1-TP3)	3	0.64 to 0.69	0.71; N = 252	0.79; N = 345
	Communication Privacy (CP1-CP3)	3	0.65 to 0.67	0.75; N = 253	0.67; N = 340
	Distraction through people (P1)	1			
Health symptoms (BF1-BF17)		16	Not specified	0.90; N = 235	0.89; N = 320
Commitment (C1-C9)	Commitment	9		0.81; N = 238	0.81; N = 303
	Organisational identification (C1, C5, C8)	3	0.74	0.76; N = 491	0.72; N = 636
	Organisational involvement (C3, C6, C9)	3	0.87	0.63; N = 242	0.53; N = 318
	Organisational Loyalty (C2, C4, C7)	3	0.82	0.52; N = 248	0.48; N = 308
Work climate (BK1-BK13)		13	Not specified	0.90; N = 259	0.88; N = 286
	Social support (BK1, BK2, BK3, BK4, BK5)	7	New subscale	0.82; N = 270	0.80; N = 297
	Psychological climate (BK6, BK8, BK9, BK 10, BK11, BK12)	6	New subscale	0.86; N = 265	0.87; N = 300

9.2.5.3. Reliability: Test-Retest

Test-retest reliability was calculated with data from the control group. The gap between the two points of measurement was 12 weeks. Test-retest reliability of the scales relating to office environment and job characteristics assessment are examined. Scales measuring more general attitudes considered as outcomes of office design and co-determined by many aspects of work experience are not included in this analysis because stability of these measures is not assumed.

Results of the test-retest reliability analysis for the job characteristic measures are presented in Table 16. Most values are around .70 and the stability of the measurements is therefore considered as very good. Test-retest reliability of two scales (holistic job and information and participation) is slightly lower (around .50) but still acceptable (Robinson, Shaver & Wrightsman, 1991). Reliability for the co-operation item is lowest with 0.43, indicating a low stability of the measurement or reflecting a real change in co-operation in this organisation.

The test-retest reliability values for measures of the office environment are presented in Table 17. The results of the reliability analyses can be considered as satisfying. However, there are two exceptions: First, the correlations between the two measurements for the workplace rating scale which includes questions about workplace appropriateness and furniture do not correlate significantly. There was no change in furniture or office design in the control group and open format comments from the questionnaires do not indicate any reasons for the absence of a correlation. The correlation was therefore controlled using a non-parametric procedure (Kendall's tau), an appropriate procedure for non-normally distributed data and small data sets with a large number of tied ranks. The non-parametric correlation coefficient is higher and statistically significant but still moderate in size.
A second measurement that has unsatisfactory test-retest reliability is the crowding scale adopted from May et al. (2005). Compared to the other test-retest correlations in Table 17 the value of 0.48 is low and indicates that the crowding measure is less stable over time. A value of this size, however, is acceptable for attitude measures (Robinson et al., 1991). The values for the remaining scales are moderate to very high. In sum, the measurements can be considered as stable and adequate. The exceptions discussed above may indicate that some of the constructs measured are more dynamic than assumed.

In summary, the measures are generally stable. Therefore changes in pre-post change comparisons in the experimental groups can be considered as effects of the changes in the office environments rather than incidental variability.

Table 16. Test-retest reliability values for job characteristics scales

Scale / construct (variable codes in brackets)	Test-retest reliability (correlation coefficients)
Scope of action (KFZA1-KFZA3)	r = 0.68***; N = 32
Variety (KFZA4-KFZA6)	r = 0.76***; N = 32
Holistic job (KFZA7-KFZA8)	r = 0.47**; N = 32
Social support (KFZA9-KFZA11)	r = 0.67***; N = 30
Co-operation (KFZA12)	r = 0.43***; N = 65
Cognitive demand at work (KFZA15-KFZA16)	r = 0.60***; N = 34
Quantitative overload at work (KFZA17-KFZA18)	r = 0.71***; N = 34
Information and participation (KFZA21-KFZA22)	r = 0.50**; N = 34
Benefits (KFZA23-KFZA24)	r = 0.69***; N = 32
*** p < 0.001; ** p < 0.01	

Table 17. Test-retest reliability values for scales relating to office environment assessment

Scale / construct (variable codes in brackets)	Subscales	Test-retest reliability (correlation coefficients)
Work area satisfaction (AZU1-AZU3)		r = 0.86***; N = 34
Environmental stressors (KFZA25-KFZA26)		r = 0.63***; N = 34
Satisfaction with work and storage space (AZU4-AZU5)		r = 0.71***; N = 34
Workspace quality (AU1-AU3)		r = 0.29 (n.s.); N = 34 (parametric correlation)
		τ = 0.38 (p < 0.01); N = 34 (non-parametric correlation)
Environmental Features Rating EFR1-EFR18; OES2; P2, P3)		
	Assessment of lighting (EFR1, EFR10, EFR11, EFR16)	r = 0.87***; N = 37
	Assessment of indoor climate (EFR2, EFR3, EFR12)	r = 0.89***; N = 37
	Assessment of task-related workplace appropriateness (EFR4, EFR8, EFR9, EFR13, EFR15, EFR17, EFR18)	r = 0.91***; N = 37
	Overall environmental satisfaction (OES2)	r = 0.74***; N = 37
Control (K1-K6)		r = 0.80***; N = 34
Sources of noise (L1-L6)		r = 0.76***; N = 34
Distraction (AS1-AS3)		r = 0.80***; N = 33
Crowding (CR1-CR4)		r = 0.48**; N = 33
Preference for enclosed area (IA1, IA2)		r = 0.66***; N = 70
Privacy (TP1-TP3; CP1-CP3; P1)	Privacy (TP1-TP3 and CP1-CP3; P1)	r = 0.73***; N = 37

*** p < 0.001; ** p < 0.01

9.2.5.4. Inter-rater Reliability

For the rating of job complexity, jobs were rated by two experienced work psychologists independently. Both items, task complexity and interaction complexity, were rated on a 4-point rating scale. Job complexity was assessed using the average of the two items. Both experts rated all jobs based on job titles and job descriptions. Inter-rater reliability was assessed using Cohen's Kappa (Cohen, 1960), a coefficient of agreement for nominal scales. Kappa for task

complexity was .68 and for interaction complexity .73. These values indicate a substantial agreement between the two ratings (Landis & Koch, 1977). The non-parametric correlation between the job complexity scores was $\tau = 0.82$ ($p < 0.001$, $N = 755$).
In summary, inter-rater reliability for the job complexity assessment is substantial.

9.2.6. Data screening and transformation

Initial analysis of the distribution of the variables led to a transformation of the social density variable. In order to reduce skewness and improve normality, social density (number of people in the office room) was changed using a logarithm transformation for the pre-change dataset and a square root transformation for the post-change dataset.
Visual and numerical inspection of the distributions revealed that most variables are negatively skewed to a moderate extent. According to Tabachnick & Fidell (2007), transformations lead only to marginal improvements of the statistical analyses if all variables are skewed to the same moderate extent.
Further problems with distributions were identified for cognitive demand at work and social stress caused by supervisors. Both variables show shapes that resemble exponential distributions with average values close to the maximal value. This leads to the conclusion that qualitative overload is a rare phenomenon in the sample. The same is true for social stress caused by supervisors. Qualitative overload was therefore merged with quantitative overload to form a general overload variable that is internally consistent (Cronbach's alpha .71 in pre-change and .78 in post-change data) and improves the normality of the distribution compared to the quantitative overload variable. Similarly, the social stress variables (social stress caused by colleagues / by supervisors) were merged. The internal consistency for the resulting variable is high (Cronbach's alpha .83 and .85) and the distribution similar to the other variables in the dataset. A log-transformation has been applied to health status data in order to improve normality of the distribution.

9.2.7. Verification of control group equivalence

The first study uses a non-equivalent comparison group quasi-experimental design, which is characterized by both a pre-test and a non-equivalent comparison group in a field setting. In order to ensure the validity of the research design, the characteristics of the control group are compared with the experimental groups. The non-equivalent comparison group quasi-experimental design is vulnerable to selection bias, i.e. to treatment effects that are confounded with characteristics of units correlated with outcome. The control group should therefore be as similar to the experimental groups as possible (Shadish & Cook, 2009).

In order to analyse the equivalence of the control and experimental groups a series of one-way analyses of variance (ANOVA) were performed on the pre-change data. In these analyses the demographic variables and job characteristics were compared between organisations. The Games-Howell procedure is used for post-hoc comparisons of the ANOVAs where sample sizes and population variances differ between groups (Field, 2009). In order to account for inhomogeneous variances, in these comparisons Welch F-ratios are used. The Welch F-ratio technique makes adjustments to the F-ratio and the residual degrees of freedom and thus combats the problems arising from violations of the assumption of homogeneity of variance. Also following Field's (2005) suggestions, for the comparison of the other post-hoc comparisons the Gabriel procedure are used because sample sizes are different. The results of the analyses for the complete sample are presented in Table 18 and those for the matched longitudinal sample are displayed in Table 19.

Table 18. Results of one-way ANOVAs for analysis of control group equivalence (total sample)

	df1	df2[18]	F	p	Post-Hoc Analyses: Significant differences between organisations
Age	4	142.84	4.05	<.01	A and Control, B and Control
Job tenure	5	123.98	7.19	<.001	A and B, A and C, A and F, B and F, C and E, Control and F, D and F
Highest completed education	5	559	5.98	<.001	A and B, A and D, A and F, C and D, C and F, Control and D, Control and F
Rate spent at the individual office workspace	5	563	5.70	n.s.	
Degree of employment	5	133.13	5.06	<.001	A and C, A and Control, A and D, B and Control, B and D
Scope of action	5	99.16	2.13	n.s.	
Variety	4	271	0.72	n.s.	
Holistic job	4	271	1.00	n.s.	
Social support	5	302	1.19	n.s.	
Overload at work	4	279	5.89	<.01	F and each of the others
Information and participation	3	104.45	5.87	<.01	A and Control, B and Control
Benefits	3	247	4.66	<.01	A and B
Organisational conditions (information, participation, and benefits)	3	110.10	4.88	<.01	A and B, A and Control

Post-hoc analyses for the complete sample indicate that the control group differs significantly from one experimental group in job tenure (organisation F). It differs significantly from two experimental groups on highest completed education

[18] The degrees of freedom are adjusted by the procedure for calculating the Welsh F-ratio

(organisations D and F), and on age and degree of employment (organisations A and B). Significant differences in job characteristics are found in quantitative overload (organisation F) but not on cognitive demand. Information and participation differs significantly between the control group and organisations A and B but there is no difference in benefits. There is a significant difference in environmental stressors between the organisation serving as a control group and organisation A. Furthermore there is a similar difference in organisational conditions (organisation A).

Table 19. Results of one-way ANOVAs for analysis of control group equivalence (matched longitudinal sample)

	df1	**df2**[19]	**F**	**P**	**Post-Hoc Analyses: Significant differences between organisations**
Age	3	102.39	3.60	< .05	No significant differences
Job tenure	4	252	2.67	< .05	C and D
Highest completed education	4	252	6.51	< .001	A and B, B and C, B and Control
Rate spent at the individual office workspace	4	254	0.70	n.s.	
Degree of employment	4	95.43	1.94	n.s.	
Scope of action	4	138	0.97	n.s.	
Variety	4	138	0.36	n.s.	
Holistic job	4	138	0.97	n.s.	
Social support	4	137	0.51	n.s.	
Overload at work	3	111	0.48	n.s.	
Information and participation	3	111	6.14	< .01	A and Control, B and Control
Benefits	3	111	3.89	< .05	A and Control
Organisational conditions (information, participation, and benefits)	3	111	5.18	< .01	A and Control, C and Control

Post-hoc analyses for the matched longitudinal sample reveal significant differences regarding the control group for highest completed education (significant difference between control group and organisation B), information and participation (organisations A and B), benefits (organisation A), and organisational conditions (organisations A and C).

In summary, the one-way ANOVAs show that the control group does not differ systematically from the experimental groups. There are not more differences between the control group and experimental groups than between experimental groups. The control group does not systematically differ from one or two specific

[19] The degrees of freedom are adjusted by the procedure for calculating the Welsh F-ratio

experimental groups. It can be concluded, therefore, that the control group may be considered as equivalent to the experimental groups in characteristics of employees and the jobs they perform.

A second set of equivalence comparisons was performed on the descriptive characteristics of groups defined by the version of questionnaire they received (see chapter 9.2.2). The result of these comparisons show that the two groups differ on education level ($t = 3.158$, $df = 475$, $p = 0.002$) with a slightly higher education level in the group that received version A of the questionnaire. All other dimensions (job complexity, age, tenure, degree of employment, percentage of work time spent in the office) were equal. This finding points to the importance of using education level as a covariate in the longitudinal analyses.

9.2.8. Attrition in longitudinal sample

Longitudinal research is associated with potential problems of subject attrition. If particular groups of people are lost in subsequent data collection, a biased sample or lack of generalizability may be the consequence. Study participants may select themselves out of subsequent waves of data collection due to the intervention that is studied or for other systematic reasons that may affect the results of the research (Goodman & Blum, 1996).
Data screening revealed that individual matching of data was not possible for all participants because subjects could refuse giving ID-information and because not all subjects participated in both waves of data collection.

Table 20. Overview over drop-out rates in the longitudinal sample

		Organisation					
		A	B	C	D	Control	Total
Stayers and leavers of longitudinal sample	Leaver	72	133	12	2	62	281
	Stayer	41	81	45	24	69	260
Total		113	214	57	26	131	541
Ratio Stayers/Total		64%	38%	79%	92%	61%	48%

In order to examine possible non-random sampling effects of participant attrition, a 4-step procedure proposed by Goodman & Blum (1996) was followed. The first step of this procedure consists in testing for the presence of non-random sampling by conduction a multiple logistic regression, a version of multiple regression in which the outcome is a categorical variable. The dependent variable for this procedure is a dichotomous variable that distinguishes between participants who responded at Time 1 (pre-change) and Time 2 (post-change) (stayers) and those who responded only at Time 1 (leavers of the sample). The independent variables of the multiple logistic regression model include all variables of interest measured as Time 1, including all variables that are used as predictor or criterion variables in the longitudinal data analyses.

Analyses suggest that participant attrition is not completely at random. Drop-out rates in the longitudinal sample are related to low social support, low satisfaction with work and storage spaces, and high crowding experience. Furthermore drop-out rates differ between organisations (Table 20). In order to assess the effects of non-random sampling, the steps 2-4 or Goodman and Blum's procedure are applied to the data. Goodman & Blum (1996) recommend assessing the effects of non-random sampling on means, variances, and correlations.

Table 21. Comparisons of means between stayers and leavers in longitudinal sample

	Stayers and leavers of longitudinal sample	N	Mean	Std. Error Mean	t	df	p	Effect size r
Social support	Leaver	133	3.82	.071	-2.031	273	.043	0.12
	Stayer	142	4.03	.072				
Work and storage space	Leaver	139	5.17	.144	-2.163	271.44*	.031	0.13
	Stayer	151	5.58	.118				
Preference for enclosed area	Leaver	234	3.06	.105	2.201	468	.028	0.10
	Stayer	236	2.75	.095				
Social stress	Leaver	131	5.23	.095	-2.227	276	.027	0.13
	Stayer	147	5.51	.081				
Gender	Leaver	280	.63	.029	-2.442	537.99*	.015	0.10
	Stayer	260	.72	.028				
Degree of employment (percentage)	Leaver	276	5.22	.096	-3.365	497.99*	.001	0.15
	Stayer	259	5.62	.071				
Highest completed education	Leaver	275	3.59	.071	-2.649	530	.008	0.11
	Stayer	257	3.84	.067				
Job Complexity	Leaver	201	2.38	.050	-2.800	423	.005	0.13
	Stayer	224	2.58	.048				

* degrees of freedom adjusted due to unequal variances

T-tests for independent samples were performed (step 2). The results of these comparisons of means are presented in Table 21. In the pre-change situation, the groups of leavers and stayers of the longitudinal sample differ as follows: employees experiencing higher social support, higher satisfaction with work and storage spaces, lower social stress, and a higher preference for open office environments are more likely to stay in the sample (i.e. to participate also in the post-change survey). Differences in perceived crowding stress do not reach statistical significance in this analysis of means. Additionally, stayers are more likely to be male, employed to a higher degree (i.e. less part-time workers), and have higher education and more complex jobs. Although all these differences are statistically significant, effect sizes are low. Therefore, the practical implications of these differences for the phenomena examined can be considered as low (Goodman & Blum, 1996).

Step 3 of Goodman and Blum's procedure consists in comparing the variances of main study variables between the whole pre-change sample and the sub-sample of stayers. These analyses show that the stayers are a more homogeneous group on the following study variables than the whole sample. Variance is restricted in the sub-sample of stayers on degree of employment, social density, and control over the office environment. These variance restrictions may lead to a downward bias for correlation coefficients involving these variables and therefore to an underestimation of relationships between variables (cf. R. A. Alexander, 1988).

Table 22. Description of final, matched longitudinal sample

			Organisation					
			A	**B**	**C**	**Control**	**D**	**Total**
Leavers	Questionnaire version	1	39	67	0	26	2	134
		2	33	66	0	36	0	135
		3	0	0	6	0	0	6
		4	0	0	6	0	0	6
		Total	72	133	12	62	2	281
Stayers	Questionnaire version	1	21	46	0	34	24	125
		2	20	35	0	35	0	90
		3	0	0	19	0	0	19
		4	0	0	26	0	0	26
		Total	41	81	45	69	24	260

To test for effects of non-random sampling on the structure of relationships among the independent variables, the fourth step of Goodman and Blum's procedure consists in multiple regression analyses. Regression models for the whole sample of the pre-change survey are compared to models including only those participants who responded to both data collections (i.e. the stayers). The regression models include all independent variables. T-tests on the differences between regression coefficients showed no differences between the whole pre-change sample and the sub-sample of stayers with the exception of one regression coefficient (social support) being significantly related to one out of three performance measures in the stayers group but not in the whole sample. Overall, the patterns of relationships are similar and do not indicate non-random sample attrition. The final, matched longitudinal sample is described in Table 22.

To summarise, Goodman and Blum's procedure reveals that non-random attrition occurred in the longitudinal sample. The group of stayers is more homogenous compared to the complete sample and is composed of employees experiencing higher social support, higher satisfaction with work and storage spaces, lower social stress, and a higher preference for open office environments. Additionally, stayers are more likely to be male, employed to a higher degree (i.e. less part-time workers), and have higher education and more complex jobs. Although all these differences are statistically significant, effect sizes are low. The homogeneity of the subsample of stayers is associated with variance restriction on a few variables (degree of employment, social density, and control over the office environment). This restriction in turn may lead to an underestimation of correlation coefficients involving the variables mentioned.

10. Results of Study 1

In this chapter the results of the first study are presented and discussed. First, descriptive results are presented in section 10.1. Second, results for longitudinal comparisons of means are presented in section 10.2, followed by the analyses of cross-sectional (section 10.4) and longitudinal regression models (section 10.6).

10.1. Descriptive results

Descriptive results are displayed in Table 23 to Table 27. Most bivariate Pearson correlation between control variables (age, tenure, gender, degree of employment, education level, and time at own workspace) and job characteristics are not significant. Where correlations are statistically significant, they are small to medium size. The same is true for correlations between control variables and characteristics of the office environments. With this class of variables, correlations at time 1 tend to be not significant while consistently negative correlations between tenure and time at own workspace at the one hand side and tenure and characteristics of the office environments on the other hand side can be found at time 2. The size of these correlations is of small to medium size, ranging from r=.076 to r=.213 (absolute values).

Correlations between characteristics of the office environments and job characteristics are small to medium size. The highest correlations are between quantitative work stress and distraction (r=.598) and qualitative work stress and distraction (r=.473) at time 1. However, these correlations are calculated from a subsample of 33 participants only and therefore may not be representative for the sample. Scope of action and control over the individual work environment correlate at r=.487 at time 1 and r=.398 at time 2.

The bivariate Pearson correlations among variables related to the perceived office environment are moderate to high in size (Table 24). The sizes of the correlations show that distinct aspects of perceived work environments are measured. However, some correlations are high (r >.5):

- Environmental stressors correlates highly with privacy (r=.405 at time 1 and r=.560 and r=.529 at time 2) and crowding (r=.519 at time 1 and r=.486 at time 2).
- Workplace appropriateness correlates highly with several other variables, namely lighting, distraction, office noise, privacy, and control. Some of the correlations are extremely high, notably workplace appropriateness and distraction (r=.510 at time 1 and r=.764 at time 2), workplace appropriateness and office noise (r=.521 at time 1 and r=.656 at time 2), workplace appropriateness and privacy (r=.691 and r=.722 at time 1 and r=.691 and r=.702 at time 2). These sizes show that the variables share up

to around 50 per cent of variance and therefore must be considered as conceptually similar.

- Office noise, distraction, and privacy correlate to a moderate to high degree. This indicates a partial conceptual overlap.

Table 23. Descriptive statistics for study variables at time 1 and time 2

	Time 1			Time 2		
	Mean	Std. Deviation	N	Mean	Std. Deviation	N
Age	5.26	2.18	546	6.00	2.21	678
Tenure	4.11	2.27	568	4.59	2.43	718
Gender	0.66	0.47	573	0.71	0.45	606
Degree of employment	5.39	1.44	568	5.57	1.20	713
Education level	3.75	1.14	565	3.91	1.11	713
Time spent at own office workspace	4.38	1.53	569	4.67	1.53	717
Job Complexity	2.58	0.72	764	2.58	0.72	764
Scope of action	3.60	0.84	309	3.46	0.81	359
Variety	3.85	0.75	276	3.67	0.80	359
Holistic job	3.58	0.83	276	3.56	0.87	356
Social support	3.91	0.84	308	3.85	0.83	355
Co-operation	4.05	0.88	508	3.53	1.10	632
Cognitive demand at work	4.03	0.93	284	3.90	0.96	341
Quantitative overload at work	3.01	1.05	284	3.05	1.12	343
Information and participation	3.08	0.96	253	2.91	1.02	343
Benefits	3.20	1.00	251	3.04	1.02	337
Social density	6.42	8.39	551	37.78	31.58	684
Environmental stressors	4.79	1.63	291	3.76	1.67	400
Lighting	5.22	1.27	283	4.78	1.44	326
Indoor climate	4.27	1.52	283	3.28	1.52	326
Workplace appropriateness	4.56	1.27	283	3.82	1.29	326
Work and storage space	5.39	1.59	323	4.97	1.63	399
Workspace quality	4.82	1.57	290	4.73	1.46	399
Distraction	4.89	1.27	312	3.91	1.46	365
Office Noise	4.36	1.46	282	4.22	1.25	370
Privacy	3.38	0.85	254	2.58	0.86	344
Privacy (2item measure)	2.96	1.35	503	1.94	1.24	664
Crowding	5.30	1.60	278	4.69	1.34	545
Control	4.46	1.34	315	3.65	1.33	370
Preference for enclosed area	2.90	1.54	470	2.61	1.49	708
Job satisfaction	4.43	1.17	560	4.11	1.21	698
Work area satisfaction	5.25	1.32	324	4.30	1.73	400
Overall environmental satisfaction	4.83	1.54	281	3.94	1.68	324
Commitment	5.01	1.03	250	4.66	1.10	334
Health symptoms	4.05	0.66	249	3.78	0.74	343
(Sqrt of) Self-assessed job performance	0.78	0.24	302	0.77	0.25	344
(Log of) Self-assessed job performance based on Feedbacks	0.46	0.14	302	0.43	0.16	343
(Sqrt of) Situational job performance	0.94	0.31	306	0.75	0.32	360

Correlations between control variables and outcomes are low in size (Table 25 and Table 26). Correlations between job characteristics and outcomes are of low to medium size (Table 25 and Table 26). The highest correlations can be found between job characteristics and job satisfaction and organisational commitment, respectively. Correlations between characteristics of the office environment and outcomes are low to moderate. The exceptions are the correlations between perceived office characteristics and environmental satisfaction. Notably workplace appropriateness correlates very strongly with work area satisfaction (r=.761 at time 1) and with overall environmental satisfaction (r=.819 at time 1 and r=.857 at time 2), indicating a large conceptual overlap.

Correlations among the outcomes (Table 27) show that outcomes remain relatively stable over time as indicated by high time 1 – time 2 correlations. This is mainly true for organisational commitment, health status, and job satisfaction. Autocorrelations for the individual work performance measures are smaller in size but still strong. Autocorrelations for environmental satisfaction are of moderate strength.

Job satisfaction and organisational commitment are highly correlated (r=.705 at time 1 and r=.626 at time 2). The correlation between the two measures for environmental satisfaction is high in size (r=.635). The intercorrelations among the performance measures are moderate. The measure of situational performance is more strongly related to other outcome measures than the two other measures of self-assessed performance. Generally, job satisfaction is more strongly correlated with the performance measures than the environmental satisfaction measures are.

Table 24. Correlation matrix (control variables and independent variables)

		Age	Tenure	Gender	Degree of employment	Education level	Time at own workspace	Job Complexity	Scope of action	Variety	Holistic job	Social support	Co-operation	Qualitative stress at work	Quantitative stress at work	Information and participation	Benefits	Social density	Environmental stressors	Lighting	Ventilation / temperature	Workplace appropriateness	Work and storage space	Workspace assessment	Distraction	Office noise	Privacy	Privacy 2item	Crowding	Control	Preference for enclosed area
Age	r	-	.603**	.083	.010	-.109**	.070	.095*	-.017	.000	.117*	-.203**	-.005	-.113*	.032	-.037	-.050	-.121**	-.058	.020	.068	-.084	.083	-.148**	-.123*	-.027	-.123*	-.043	-.041	-.036	-.137**
	N	-	669	557	665	666	669	494	321	321	318	317	588	331	333	333	327	639	361	316	316	316	360	360	326	331	334	617	506	331	660
Tenure	r	.518**	-	.026	-.057	-.207**	-.009	.063	-.003	.049	.065	-.176**	-.082*	-.122*	-.025	-.072	-.082	-.042	-.197**	-.014	.038	-.137*	-.041	-.162**	-.177**	-.135	-.200**	-.161**	-.148**	-.138**	-.220**
	N	541	-	598	709	708	711	529	355	355	352	351	623	336	338	338	332	676	396	321	321	321	395	395	361	365	340	656	538	365	700
Gender	r	.117**	.017	-	.346**	.204**	.005	.343**	-.003	.159**	.124*	.034	.156**	-.038	-.190**	-.026	-.069	.047	.025	.101	.164**	-.109	.037	-.020	-.106	.010	-.116	.030	-.052	-.075	-.056
	N	545	567	-	596	594	598	522	312	312	309	308	518	272	274	274	269	573	331	275	275	275	330	330	317	322	275	548	430	322	592
Degree of employment	r	.011	-.074	.288**	-	.108**	.238**	.246**	.044	.108*	.047	.040	.050	-.053	-.125*	-.076	-.013	.026	-.057	-.111*	-.041	-.051	.030	.015	.007	.060	-.094	.029	.023	-.031	.008
	N	541	564	568	-	704	708	528	354	354	351	350	621	333	335	335	330	673	392	320	320	320	391	391	359	363	337	652	534	363	696
Education level	r	-.006	-.055	.164**	.065	-	.055	.513**	-.084	-.014	.037	.098	-.091*	.054	-.033	.041	-.103	.183**	.014	-.034	-.047	-.107	-.041	.005	-.138**	.034	-.149**	-.051	.041	-.055	-.058
	N	538	560	565	563	-	707	526	353	353	350	349	622	337	339	339	333	672	390	322	322	322	389	389	357	360	340	654	535	360	696
Time at own workspace	r	-.055	-.073	-.035	.230**	-.087*	-	.005	-.159**	-.066	.017	.022	-.178**	-.070	.019	-.250**	-.223**	.076*	-.213**	-.009	-.113*	-.125*	-.128*	-.198**	-.133*	-.033	-.129*	-.120**	-.095*	-.190**	-.162**
	N	542	565	569	566	564	-	530	356	356	353	352	623	335	337	337	332	677	395	321	321	321	394	394	361	365	339	657	539	365	699
Job Complexity	r	.218**	.167**	.240**	.169**	.474**	-.159**	-	.033	.091	-.038	-.005	-.064	-.121	-.175**	.088	-.045	.144**	-.094	-.048	.020	-.060	-.007	-.110	-.191**	.050	-.104	-.039	-.017	-.061	-.089*
	N	426	449	452	450	448	451	-	271	271	269	268	466	247	248	248	243	519	293	243	243	243	292	292	275	278	250	493	396	278	524
Scope of action	r	.155**	.099	.096	.193**	.082	-.090	.253**	-	.447**	.398**	.261**	.340**					-.020	.097	.149*	.187*	.358**	.018	.172*	.215**	.173**		.196**	.144**	.398**	.171**
	N	283	304	309	306	305	307	248	-	359	356	355	354	0	0	0	0	337	174	185	185	185	174	174	359	359	0	315	359	359	357
Variety	r	.112	.085	.086	.160**	-.085	-.115	.157*	.403**	-	.406**	.343**	.339**					-.040	.152*	.073	.231**	.219**	.067	.197**	.103	.133*		.148**	.073	.251**	.078
	N	250	271	276	273	272	274	221	276	-	356	355	354	0	0	0	0	337	174	185	185	185	174	174	359	359	0	315	359	359	357
Holistic job	r	.183**	.168**	.116	.076	-.042	-.059	.066	.444**	.334**	-	.156**	.192**					-.031	.074	.149*	.171*	.170*	.009	.185*	.054	.100		.132*	.051	.198**	.101
	N	250	271	276	273	272	274	221	276	276	-	354	353	0	0	0	0	335	172	184	184	184	172	172	356	356	0	314	356	356	354
Social support	r	.003	-.102	.084	.095	-.059	.024	.041	.282**	.310**	.358**	-	.292**					.022	.124	.238**	.187*	.313**	.157*	.151*	.213**	.196**		.201**	.218**	.305**	.161**
	N	282	303	308	305	304	306	247	308	275	275	-	353	0	0	0	0	335	171	184	184	184	171	171	355	355	0	313	355	355	353
Co-operation	r	.090*	.028	.101*	.120**	.082	-.016	.166**	.188**	.237**	.093	.189**	-	.019	-.085	.134*	.278**	-.047	.246**	.270**	.321**	.328**	.198**	.321**	.206**	.150**	.255**	.304**	.155**	.433**	.249**
	N	481	503	507	503	500	504	404	308	275	275	307	-	276	277	278	273	598	380	251	251	251	379	379	354	354	274	587	530	354	627
Qualitative stress at work	r	-.165**	-.205**	-.032	-.037	.077	.001	.109	.102			.172	-.044	-	.487**	.156**	.159**	-.046	.147*	.116	.067	.136	.193**	.180**			.218**	.155**	.260**		.074
	N	283	284	283	282	280	282	226	33	0	0	33	230	-	341	340	334	322	210	130	130	130	209	209	0	0	337	337	177	0	337
Quantitative stress at work	r	-.125*	-.257**	-.079	-.101	-.199**	.122*	-.291**	.090			.510**	-.185**	.345**	-	.155**	.084	-.143*	.132	.136	.104	.292**	.105	.164*			.221**	.131*	.246**		.049
	N	283	284	283	282	280	282	226	33	0	0	33	230	284	-	342	336	324	211	131	131	131	210	210	0	0	339	339	178	0	339
Information and participation	r	-.031	-.064	-.098	.072	.017	-.035	.049					.221**	.063	.023	-	.555**	.047	.250**	.207*	.180*	.318**	.166*	.328**			.326**	.289**	.371**		.215**
	N	252	253	252	251	249	251	199	0	0	0	0	200	250	250	-	337	324	210	132	132	132	209	209	0	0	339	339	177	0	339
Benefits	r	.071	.006	-.110	.183**	-.172**	-.115	.016					.241**	-.012	.008	.522**	-	.083	.250**	.116	.157	.263**	.197**	.300**			.291**	.286**	.177*		.248**
	N	250	251	250	249	247	249	198	0	0	0	0	198	249	249	251	-	319	207	129	129	129	206	206	0	0	333	334	174	0	333
Social density	r	-.146**	.001	-.022	-.089*	-.131**	.062	-.158**	-.309**	-.063	-.090	-.027	-.111*	.003	.037	-.051	-.124	-	-.263**	-.033	-.251**	-.211**	-.153**	-.002	-.275**	-.133*	-.185**	-.261**	-.223**	-.192**	.033
	N	526	546	551	548	546	550	439	295	262	262	294	486	276	276	245	243	-	373	310	310	310	372	372	342	345	326	633	514	345	668
Environmental stressors	r	.040	-.049	-.069	-.026	-.013	.014	.003	.177**	.110	.070	.197**	.013	.054	.193	.144	.165	-.262**	-				.368**	.439**	.490**	.442**	.560**	.529**	.486**	.388**	.378**
	N	265	288	291	289	286	289	236	253	253	253	252	283	32	32	31	31	281	-	0	0	0	399	399	178	182	211	348	358	182	389
Lighting	r	.089	-.049	.059	-.015	.105	-.027	.227**	-.006	.152	.088	.212	.201**	.139*	.139*	.333**	.313**	-.187**		-	.362**	.378**			.463**	.443**	.129	.246**	.298**	.345**	.150**
	N	281	280	282	279	279	280	216	56	23	23	56	225	252	252	222	220	270	0	-	326	326	0	0	187	188	133	316	187	188	319
Ventilation / temperature	r	.096	.013	.015	-.001	.152*	-.108	.224**	.138	.135	.006	.098	.125	-.054	.058	.212**	.260**	-.232**		.489**	-	.497**			.326**	.309**	.471**	.427**	.230**	.484**	.174**
	N	281	280	282	279	279	280	216	56	23	23	56	225	252	252	222	220	270	0	283	-	326	0	0	187	188	133	316	187	188	319
Workplace appropriatenes	r	.012	-.051	-.030	.117	.021	-.012	.146*	.089	.431*	.327	.377**	.095	.073	.174**	.323**	.283**	-.364**		.557**	.502**	-			.764**	.656**	.691**	.702**	.552**	.689**	.439**
	N	281	280	282	279	279	280	216	56	23	23	56	225	252	252	222	220	270	0	283	283	-	0	0	187	188	133	316	187	188	319
Work and storage space	r	-.020	.016	-.036	.025	.054	-.022	.123*	.328**	.145*	.151*	.186**	.069	.185	.099	.143	.204	-.270**	.357**	.348*	.439*	.623**	-	.437**	.426**	.396**	.269**	.347**	.454**	.537**	.227**
	N	297	320	323	321	318	321	262	285	252	252	284	315	65	65	31	31	313	290	33	33	33	-	399	178	182	211	348	358	182	389
Workspace assessment	r	.109	.048	-.013	-.012	-.002	-.022	.050	.250**	.126*	.190**	.179**	.018	-.004	-.057	.305	.196	-.174**	.369**				.473**	-	.337**	.322**	.477**	.484**	.416**	.413**	.355**
	N	264	287	290	288	285	288	235	253	253	253	252	283	31	31	31	31	280	290	0	0	0	289	-	178	182	211	348	358	182	389
Distraction	r	.081	-.047	.009	.007	-.161**	-.048	.015	.261**	.228**	.189**	.339**	.064	.473**	.598**			-.240**	.455**	.127	.039	.510**	.368**	.330**	-	.565**		.596**	.451**	.500**	.450**
	N	286	307	312	309	308	310	250	309	276	276	308	308	33	33	0	0	298	256	56	56	56	288	256	-	365	0	315	365	365	363
Office noise	r	.077	.022	.215**	.180**	.071	-.001	.164*	.079	.068	.077	.058						-.015	.097	.258	.062	.521**	.171**	.010	.234**	-		.555**	.397**	.402**	.274**
	N	255	276	282	278	277	279	224	275	275	275	274	274	0	0	0	0	267	258	24	24	24	257	258	278	-	0	315	365	370	363
Privacy	r	.012	-.007	-.160*	-.023	-.004	-.040	.082					.043	.132*	.276**	.225**	.189**	-.381**	.154	.437**	.345**	.691**	.214	.233			-	.663**	.558**		.363**
	N	253	254	253	252	250	252	199	0	0	0	0	200	250	250	253	251	246	31	223	223	223	31	31	0	0	-	342	179	0	342
Privacy 2item	r	.045	-.072	-.052	.095*	-.047	-.072	.095	.296**	.109	.145*	.215**	.097*	.068	.163**	.271**	.222**	-.360**	.405**	.433**	.352**	.722**	.319**	.263**	.544**	.442**	.735**	-	.456**	.568**	.386**
	N	476	499	502	498	495	500	398	249	216	216	248	446	281	281	251	249	481	223	280	280	280	255	223	249	216	252	-	494	315	656
Crowding	r	-.032	-.211**	-.081	.047	.027	-.055	.072	.196**	.135*	.054	.240**	.046					-.357**	.519**	-.151	-.334	.009	.467**	.351**	.432**	.077		.504**	-	.401**	.303**
	N	252	273	278	275	274	276	222	275	275	275	274	274	0	0	0	0	264	255	23	23	23	254	255	278	277	0	215	-	365	542
Control	r	.065	.001	.028	.089	-.044	-.040	.054	.487**	.290**	.276**	.328**	.035	.407*	.276			-.334**	.351**	.064	-.057	.436**	.491**	.472**	.461**	.108		.452**	.498**	-	.386**
	N	288	309	315	311	310	312	251	309	276	276	308	308	33	33	0	0	300	258	57	57	57	290	258	312	281	0	249	278	-	363
Preference for enclosed area	r	-.051	-.029	-.030	-.037	.030	-.015	-.042	-.082	.014	.010	.110	.061	.075	.036	.134*	.131*	.160**	-.084	-.006	-.002	-.001	.001	.041	-.001	.029	-.043	-.071	-.126	-.033	-
	N	443	466	469	465	462	467	373	213	213	213	212	412	250	250	253	251	449	225	245	245	245	224	225	216	216	254	465	215	216	-

*p<.05; **p<.01; Time 1 below diagonal, time 2 above diagonal

Table 25. Correlations IV-DV time 1

		Job satisfaction	Work area satisfaction	Overall environmental satisfaction	Commitment	Health symptoms	Self-assessed job performance	Self-assessed job performance based on Feedbacks	Situational job performance
Age	r	.171**	.045	.040	.258**	-.049	.133*	.091	.108
	N	533	298	279	249	248	276	276	280
Tenure	r	.050	-.027	-.043	.134*	-.063	.124*	.148*	.143*
	N	555	321	278	250	249	298	298	302
Gender	r	-.074	-.013	-.084	-.005	.017	-.092	.015	.061
	N	559	324	280	249	248	302	302	306
Degree of employment	r	.016	.019	.093	.191**	.090	.164**	.024	.112
	N	555	322	277	248	247	299	299	303
Education level	r	-.164**	-.025	.001	-.074	.144*	-.129*	-.008	-.102
	N	552	319	277	246	245	298	298	302
Time at own workspace	r	-.059	-.038	-.072	-.090	.074	.074	.017	.064
	N	556	322	278	248	247	300	300	304
Job Complexity	r	-.017	.092	.136*	.036	.110	.038	.093	.047
	N	446	263	214	197	197	243	243	246
Scope of action	r	.345**	.285**	.142	.	.	.294**	.284**	.329**
	N	307	286	55	0	0	302	302	303
Variety	r	.347**	.274**	.240	.	.	.393**	.252**	.379**
	N	274	253	23	0	0	269	269	270
Holistic job	r	.367**	.154*	.053	.	.	.307**	.335**	.334**
	N	274	253	23	0	0	269	269	270
Social support	r	.450**	.326**	.236	.	.	.229**	.332**	.294**
	N	306	285	55	0	0	301	301	302
Co-operation	r	.134**	.117*	.070	.289**	.078	.069	.055	.138*
	N	505	316	223	196	195	301	301	302
Cognitive demand at work	r	.037	.134	.029	.012	.182**	.183	.357*	.268
	N	283	65	250	248	248	33	33	33
Quantitative overload at work	r	.116	.217	.083	-.021	.169**	-.081	-.080	.142
	N	283	65	250	248	248	33	33	33
Information and participation	r	.381**	.355	.275**	.447**	.192**	.	.	.
	N	252	31	221	249	248	0	0	0
Benefits	r	.414**	.102	.285**	.433**	.195**	.	.	.
	N	250	31	219	247	247	0	0	0
Social density	r	-.176**	-.264**	-.381**	-.201**	-.263**	-.020	-.057	-.103
	N	538	314	268	242	241	289	289	293
Environmental stressors	r	.239**	.534**	.	.050	.168	.153*	.119	.172**
	N	283	291	0	31	32	246	246	252
Lighting	r	.219**	.299	.510**	.311**	.266**	-.089	.143	.158
	N	277	33	281	219	217	56	56	54
Indoor climate	r	.259**	.533**	.493**	.201**	.276**	-.164	.109	.323*
	N	277	33	281	219	217	56	56	54
Workplace appropriateness	r	.315**	.761**	.819**	.267**	.384**	.022	.177	.337*
	N	277	33	281	219	217	56	56	54
Work and storage space	r	.323**	.573**	.479**	.104	.084	.150*	.166**	.228**
	N	315	323	32	31	32	278	278	284
Workspace quality	r	.314**	.544**	.	.252	.171	.203**	.204**	.157*
	N	282	290	0	30	31	246	246	252
Distraction	r	.400**	.525**	.462**	.	.	.249**	.255**	.377**
	N	307	289	55	0	0	302	302	306
Office noise	r	.023	.239**	.502*	.	.	.034	.079	.169**
	N	273	258	24	0	0	268	268	272
Privacy	r	.308**	.505**	.584**	.233**	.378**	.	.	.
	N	252	31	222	249	248	0	0	0
Privacy 2	r	.275**	.446**	.622**	.237**	.286**	.101	.141*	.252**
	N	497	256	278	247	246	242	243	244
Crowding	r	.286**	.558**	.129	.	.	.114	.181**	.193**
	N	273	255	23	0	0	268	268	272
Control	r	.427**	.519**	.309*	.	.	.268**	.245**	.314**
	N	307	291	56	0	0	302	302	306
Preference for enclosed area	r	.114*	.010	-.013	.172**	.127*	.041	.021	-.003
	N	463	225	244	249	248	206	207	213

*p<.05; **p<.01

Table 26. Correlation IV-DV time 2

		Job satisfaction time 2	Work area satisfaction time 2	Overall environmental satisfaction time 2	Commitment time 2	Health symptoms time 2	Self-assessed job performance time 2	Self-assessed job performance based on Feedbacks time 2	Situational job performance time 2
Age time 2	r	-.023	-.183**	-.051	.033	-.114*	.048	-.129*	-.028
	N	652	361	314	325	333	309	308	321
Tenure time 2	r	-.106**	-.296**	-.100	-.042	-.078	-.018	-.085	-.011
	N	691	396	319	331	339	339	338	356
Gender time 2	r	-.023	.015	-.050	.050	.115	-.041	-.045	-.057
	N	585	331	273	270	276	299	299	312
Degree of employment time 2	r	-.004	.004	.005	.087	.023	.000	-.005	-.010
	N	686	392	318	328	336	338	336	354
Education level time 2	r	-.079*	-.042	-.050	-.081	.041	.007	.072	-.151**
	N	689	390	320	332	339	336	335	352
Time at own workspace time 2	r	-.168**	-.262**	-.128*	-.241**	-.144**	.013	.018	-.097
	N	689	395	319	330	338	340	338	356
Job Complexity time 2	r	-.089*	-.116*	-.050	-.036	-.049	-.007	.034	-.125*
	N	517	293	241	242	250	260	260	272
Scope of action time 2	r	.329**	.144	.316**	.	.	.310**	.300**	.289**
	N	355	174	185	0	0	341	341	354
Variety time 2	r	.502**	.166*	.261**	.	.	.298**	.343**	.230**
	N	355	174	185	0	0	341	341	354
Holistic job time 2	r	.360**	.076	.175*	.	.	.348**	.200**	.261**
	N	353	172	184	0	0	341	341	352
Social support time 2	r	.440**	.222**	.363**	.	.	.170**	.387**	.257**
	N	352	171	184	0	0	340	339	351
Co-operation time 2	r	.313**	.354**	.306**	.322**	.175**	.238**	.283**	.206**
	N	628	380	251	269	275	338	338	350
Cognitive demand at work time 2	r	.111*	.182**	.078	.186**	.340**	.	.	.
	N	338	210	130	331	339	0	0	0
Quantitative overload at work time 2	r	.113*	.117	.156	.083	.207**	.	.	.
	N	340	211	131	333	341	0	0	0
Information and time 2articipation time 2	r	.436**	.407**	.264**	.455**	.238**	.	.	.
	N	341	210	132	334	340	0	0	0
Benefits time 2	r	.472**	.336**	.207*	.510**	.213**	.	.	.
	N	335	207	129	330	334	0	0	0
Social density time 2	r	-.079*	-.163**	-.208**	.070	-.021	.013	.037	-.216**
	N	657	373	308	317	326	321	321	338
Environmental stressors time 2	r	.463**	.588**	.	.347**	.428**	.132	.036	.260**
	N	382	400	0	203	211	165	165	175
Lighting time 2	r	.177**	.	.334**	.115	.271**	.232**	.120	.320**
	N	316	0	324	131	132	177	177	185
Indoor climate time 2	r	.302**	.	.518**	.026	.293**	.235**	.208**	.290**
	N	316	0	324	131	132	177	177	185
Workplace appropriateness time 2	r	.452**	.	.857**	.213*	.338**	.209**	.206**	.618**
	N	316	0	324	131	132	177	177	185
Work and storage space time 2	r	.279**	.484**	.	.308**	.309**	.257**	.160*	.322**
	N	381	399	0	202	210	165	165	175
Workspace quality time 2	r	.438**	.626**	.	.415**	.417**	.308**	.185*	.236**
	N	381	399	0	202	210	165	165	175
Distraction time 2	r	.367**	.546**	.708**	.	.	.104	.059	.438**
	N	356	178	187	0	0	342	342	360
Office noise time 2	r	.325**	.514**	.582**	.	.	.118*	.096	.290**
	N	356	182	188	0	0	342	342	360
Privacy time 2	r	.396**	.650**	.586**	.294**	.322**	.	.	.
	N	339	211	133	331	340	0	0	0
Privacy 2 time 2	r	.394**	.619**	.640**	.327**	.302**	.127*	.174**	.389**
	N	654	348	316	332	340	301	302	312
Crowding time 2	r	.400**	.549**	.542**	.373**	.418**	.137*	.147**	.302**
	N	532	358	187	170	178	342	342	360
Control time 2	r	.446**	.563**	.692**	.	.	.282**	.211**	.434**
	N	356	182	188	0	0	342	342	360
Preference for enclosed area time 2	r	.373**	.451**	.389**	.255**	.281**	.126*	.110*	.356**
	N	693	389	319	331	340	340	340	358

*p<.05; **p<.01

Table 27. DV correlation matrix (Time 1 below diagonal, time 2 above diagonal, diagonal = time 1 – time 2 correlation)

			1.	2.	3.	4.	5.	6.	7.	8.
1.	Job satisfaction	r	.675**	.212**	.214*	.626**	.271**	.346**	.369**	.254**
		N	256	150	109	114	114	137	136	140
2.	Work area satisfaction	r	.432**	.364**	.	.066	.040	.120	.128	-.017
		N	316	151	0	26	26	119	118	122
3.	Overall environmental satisfaction	r	.348**	.635**	.267**	.251*	.302**	.043	.241	.352
		N	275	32	109	88	88	19	19	19
4.	Commitment	r	.705**	.345	.289**	.764**	.225*	.	.	.
		N	249	31	218	112	112	0	0	0
5.	(Log of) health status	r	.301**	.281	.350**	.238**	.682**	.	.	.
		N	249	32	216	246	113	0	0	0
6.	(Sqrt of) Self-assessed job performance	r	.300**	.200**	.003	.	.	.592**	.408**	.181*
		N	302	279	55	0	0	135	134	137
7.	(Log of) Self-assessed job performance based on Feedbacks	r	.315**	.206**	.171	.	.	.606**	.508**	.201*
		N	302	279	55	0	0	301	135	138
8.	(Sqrt of) Situational job performance	r	.382**	.324**	.454**	.	.	.421**	.432**	.409**
		N	301	285	53	0	0	297	297	138

*p<.05; **p<.01

10.2. Longitudinal comparison of means

The study design of the first study includes a control group that allows the comparison of the experimental groups with a non-treatment group. The longitudinal comparisons of means refer to hypotheses 1a – 1d, 2a – 2e, and 3 (chapter 9.1).
In order to check the treatment, perceived social density was compared between organisations (Figure 27).

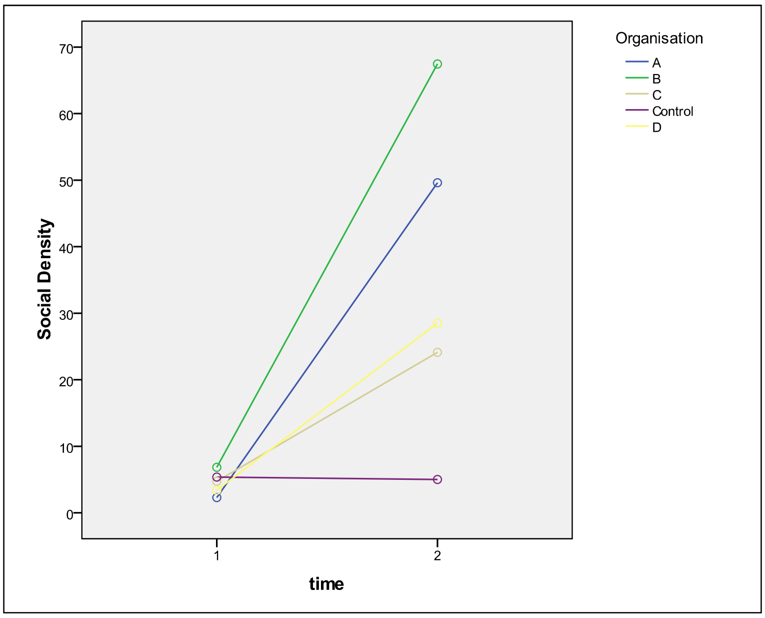


Figure 27. Perceived social density for the matched longitudinal sample at the two time points

This check describes the different intensity of changes in the different organisations studied. As can be seen from Figure 27 the magnitude of the changes regarding social density in organisations A and B is considerably higher than for organisations C and D. The results of the longitudinal comparisons of means are described in the following sections.

10.2.1. Longitudinal changes in perceived office environment

Characteristics of the office environment are expected to differ between the experimental and control groups. Table 28 presents the mean values at the two points of time for both, the experimental group and the control group[20].

Table 28. Means, standard deviations, and within-group tests for experimental and control groups at each point in time for characteristics of the office environment in the longitudinal sample

	Longitudinal sample	
Office environment characteristics	**Experimental group Mean (SD)**	**Control group Mean (SD)**
Environmental stressors 1	4.78 (1.68)	4.68 (1.77)
Environmental stressors 2	4.25** (1.62)	4.28 (1.69)
Lighting 1	5.38 (1.28)	4.82 (1.64)
Lighting 2	4.75** (1.41)	4.86 (1.63)
Indoor climate 1	4.13 (1.57)	4.57 (1.55)
Indoor climate 2	3.28** (1.59)	4.37 (1.67)
Workplace appropriateness 1	4.61 (1.16)	4.43 (1.43)
Workplace appropriateness 2	3.88*** (1.10)	4.49 (1.44)
Work and storage space 1	5.62 (1.47)	5.44 (1.39)
Work and storage space 2	4.99** (1.80)	5.43 (1.33)
Workspace quality 1	4.87 (1.35)	4.52 (1.69)
Workspace quality 2	5.30*** (1.17)	4.74 (1.64)
Distractions 1	4.92 (1.14)	4.96 (1.16)
Distractions 2	3.77*** (1.44)	5.12 (1.22)
Office noise 1	4.47 (1.35)	4.73 (1.22)
Office noise 2	4.27 (1.30)	4.59 (1.36)
Privacy 1	3.48 (0.86)	3.12 (0.84)
Privacy 2	2.64*** (0.78)	3.07 (0.75)
2-item Privacy 1	3.13 (1.35)	2.78 (1.33)
2-item Privacy 2	2.00*** (1.14)	2.78 (1.40)
Crowding 1	5.61 (1.46)	5.01 (1.60)
Crowding 2	4.83*** (1.45)	5.08 (1.20)
Control 1	4.76 (1.06)	4.31 (1.35)
Control 2	4.13*** (1.26)	4.25 (1.25)
Preference for enclosed area 1	2.69 (1.38)	2.90 (1.63)
Preference for enclosed area 2	2.98** (1.51)	3.05 (1.52)

(*p<.05; **p<.01; ***p<.001 for differences across time within group)

In the first study a control group was employed in order to determine causation in changes of the physical office environments in the experimental groups. Based on

[20] High values represent positive assessments or experiences.

the logic of using a control group in the quasi-experimental research design, no differences between the two points of measurement in time in the control group should occur. This assumption is formulated in Hypothesis 1b which is confirmed by the repeated measures t-tests presented in Table 28.

Table 29. ANCOVA results for the effects of time and organisation on environmental stressors

Predictor	F	df	partial η^2
Covariates			
Education	.173	1, 140	.00
Tenure	.529	1, 140	.00
Gender	1.987	1, 140	.01
Main effects			
Organisation	7.855***	4,140	.18
Time	.031	1,140	.00
Interaction effects			
Time X Education	.363	1,140	.00
Time X Tenure	2.353	1,140	.02
Time X Gender	2.206	1,140	.02
Time X Organisation	5.720***	4,140	.14
n			148

* p < .05, ** p < .01, *** p < .001

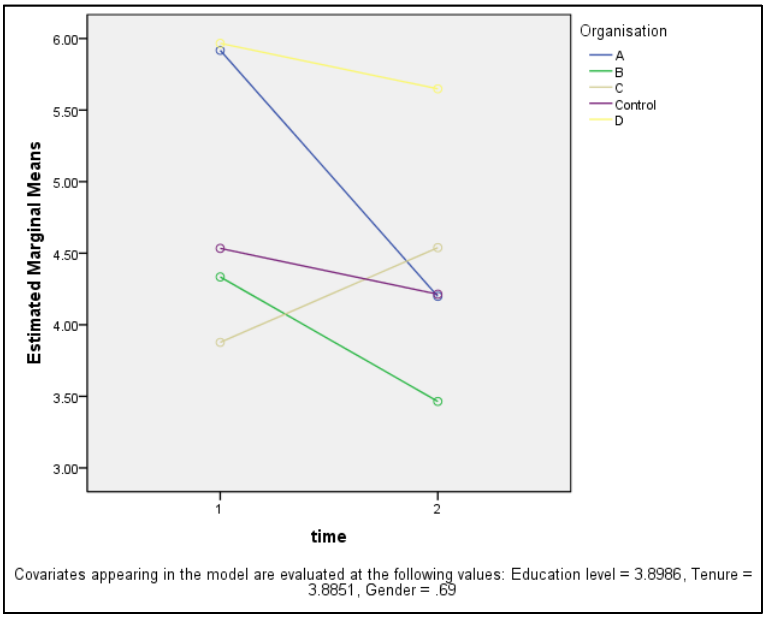


Figure 28. Organisation X Time interaction in the analysis of perceived environmental stressors[21]

In order to test the effect of office change on perceptions and assessments of the office environments, a series of repeated measures analyses of variance for each office environment characteristic was performed. Organisation was the between-subjects variable, and time was the within-subjects variable. Covariates included

[21] Estimated marginal means represent adjusted group means, i.e. group means that are adjusted for the effect of the covariates.

were tenure / age[22], gender, and education level, as previous research indicates that these variables may affect well-being (Warr, 1990) and work performance (T. W. H. Ng & Feldman, 2008, 2010).

Generally, in the repeated measures ANCOVAs for office environment characteristics no main effects of organisation or time are expected. Rather, an organisation-x-time interaction is expected indicating that there are no changes in the control group but in the experimental groups.

Table 30. ANCOVA results for the effects of time and organisation on perceived lighting conditions

Predictor	F	df	partial η^2
Covariates			
Education	.493	1, 98	.01
Age	3.926	1, 98	.04
Gender	8.425**	1, 98	.08
Main effects			
Organisation	2.076	3,98	.06
Time	.359	1,98	.00
Interaction effects			
Time X Education	1.179	1,98	.01
Time X Age	.957	1,98	.01
Time X Gender	.358	1,98	.00
Time X Organisation	3.345*	3,98	.09
n			107

* p < .05, ** p < .01, *** p < .001

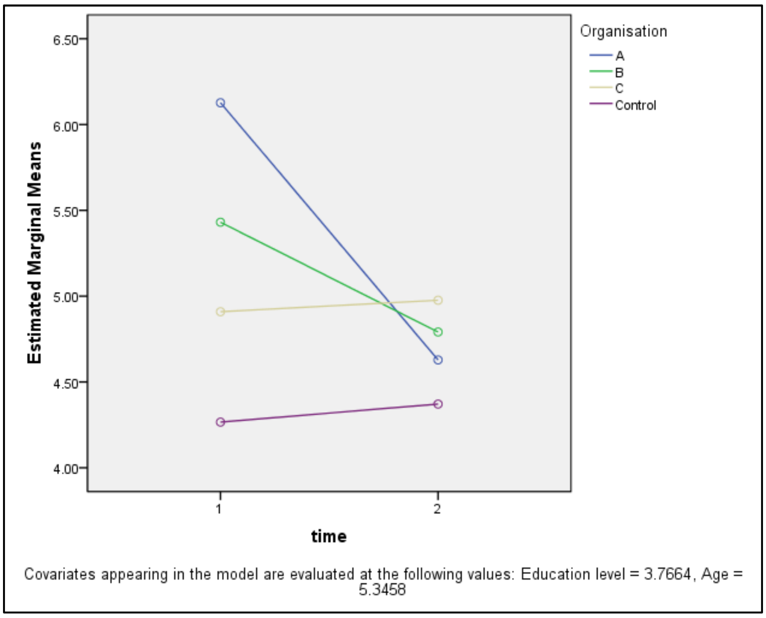


Figure 29. Organisation X Time interaction in the analysis of perceived lighting conditions

There was no significant main effect of time on environmental stressors (Table 29). However, the effect of organisation on environmental stressors was highly significant and of medium to large size. There was a significant interaction effect between organisation and time on environmental stressors. This indicates that participants'

[22] Data on age could not be collected in organisation D due to confidentiality requirements of that organisation. For analyses where data from organisation D are available, tenure instead of age is entered into the repeated measures ANCOVAs as a covariate.

perceptions of environmental stress in relation to changes in the office environment were affected differently in different organisations (Figure 28).

There was no significant main effect of time or organisation on perceived lighting quality (Table 30). There was a significant interaction effect between organisation and time on perceived lighting quality. This interaction is presented in Figure 29. Furthermore, gender (covariate) had a significant effect. Specifically, men reported higher satisfaction with lighting conditions (M = 5.32, SE = 0.16) than women (M = 4.43, SE = 0.29).

There was no significant main effect of time on perceived indoor climate (Table 31). There was a significant main effect of organisation and a significant interaction of time and organisation (Figure 30).

Table 31. ANCOVA results for the effects of time and organisation on perceived indoor climate

Predictor	F	df	partial η^2
Covariates			
Education	.143	1, 100	.02
Age	3.812	1, 100	.04
Gender	.303	1, 100	.08
Main effects			
Organisation	4.087**	3,100	.11
Time	.032	1,100	.00
Interaction effects			
Time X Education	.904	1,100	.01
Time X Age	.197	1,100	.00
Time X Gender	.027	1,100	.00
Time X Organisation	8.829***	3,100	.21
n			107

* p < .05, ** p < .01, *** p < .001

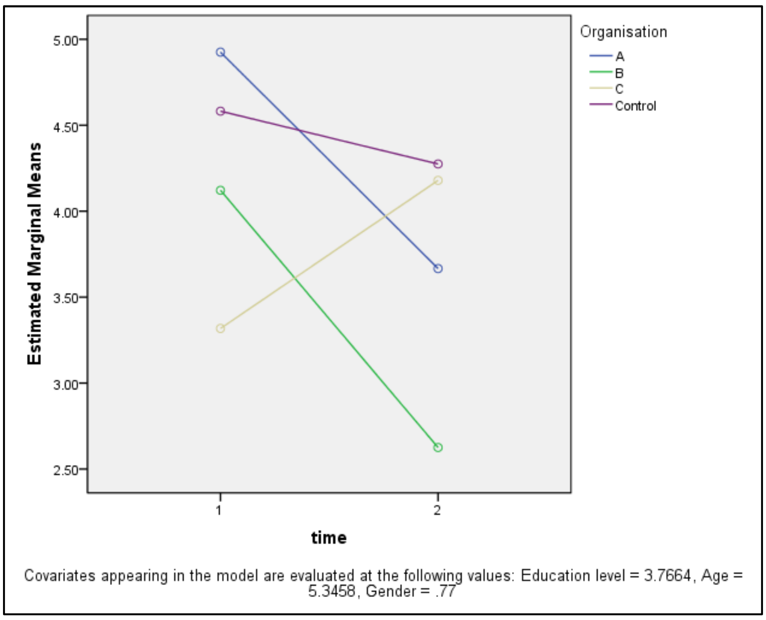


Figure 30. Interaction of time and organisation in the longitudinal analysis of perceived indoor climate

There was no significant main effect of time on workplace appropriateness (Table 32). Neither was there a main effect of organisation. There was a significant interaction of time-x-organisation (Figure 31). Furthermore, there was a significant interaction between gender and time ($F(1,100) = 5.90$, $p < .05$, partial $\eta^2 = .06$) and a significant effect of age (covariate) ($F(1,100) = 4.33$, $p < .05$, partial $\eta^2 = .04$) (positive association between age and perceived workplace appropriateness). The gender-x-time interaction indicates that men reacted stronger to the change and rated the appropriateness of their workplace more negatively than women (Figure 32).

Table 32. ANCOVA results for the effects of time and organisation on perceived workplace appropriateness

Predictor	F	df	partial η^2
Covariates			
Education	.820	1, 100	.00
Age	4.334*	1, 100	.04
Gender	.051	1, 100	.00
Main effects			
Organisation	2.306	3,100	.07
Time	3.017	1,100	.03
Interaction effects			
Time X Education	.945	1,100	.01
Time X Age	3.217	1,100	.03
Time X Gender	5.899*	1,100	.06
Time X Organisation	10.391***	3,100	.24
n			107

* p < .05, ** p < .01, *** p < .001

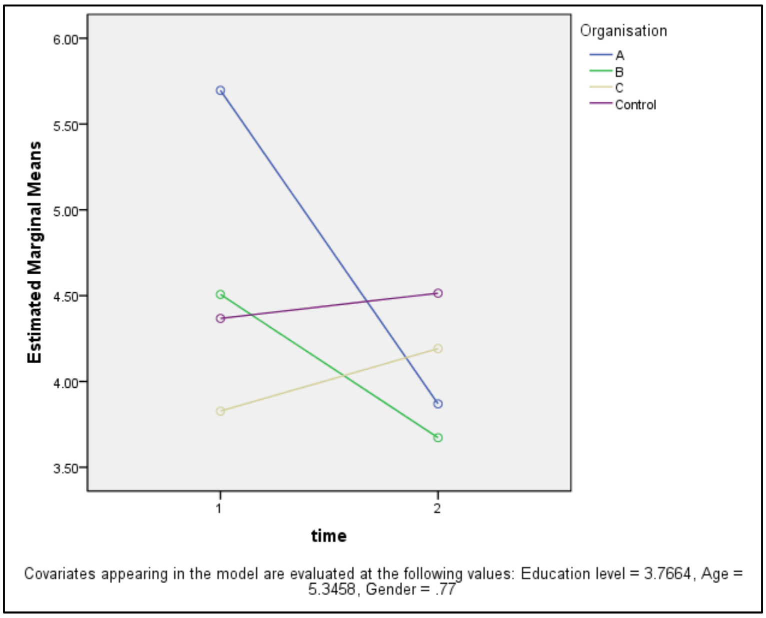


Figure 31. Interaction of time and organisation in the longitudinal analysis of workplace appropriateness

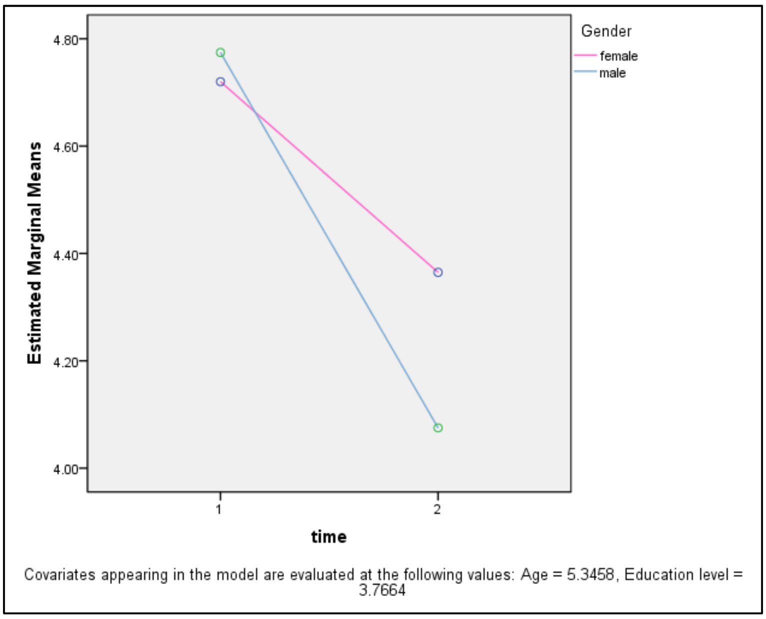


Figure 32. Interaction of time and gender in the longitudinal analysis of workplace appropriateness

For work and storage space assessment there was no statistically significant main effect of time (Table 33). There was a significant main effect of organisation and a significant time-x-organisation interaction (Figure 33).

Table 33. ANCOVA results for the effects of time and organisation on assessment of work and storage spaces

Predictor	F	df	partial η^2
Covariates			
Education	.853	1, 139	.01
Tenure	.511	1, 139	.01
Gender	.045	1, 139	.00
Main effects			
Organisation	7.634***	4, 139	.18
Time	2.765	1, 139	.02
Interaction effects			
Time X Education	1.819	1, 139	.01
Time X Tenure	2.261	1, 139	.02
Time X Gender	2.613	1, 139	.02
Time X Organisation	6.848***	4, 139	.17
n			147

* p < .05, ** p < .01, *** p < .001

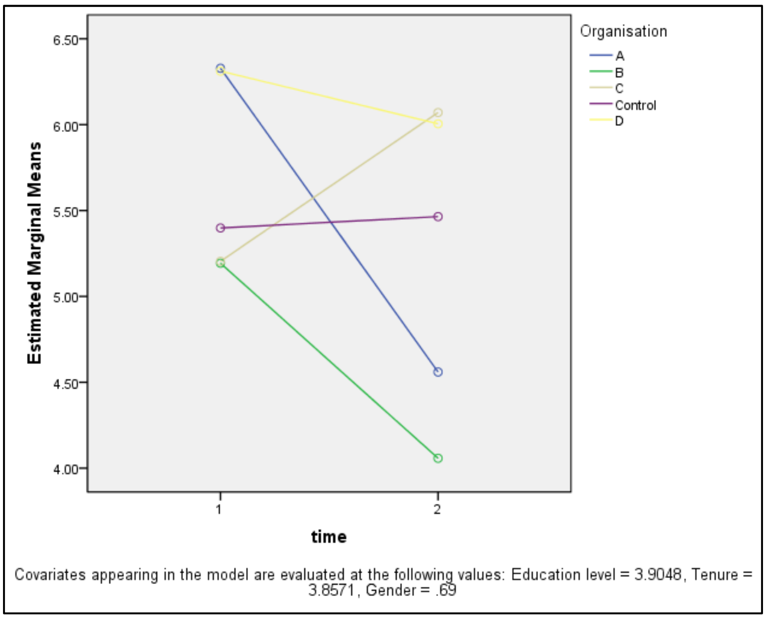


Figure 33. Time-x-organisation interaction in the analysis of work and storage space assessment

There were significant main effects for time and organisation (Table 34) on workspace quality. The interaction of time and organisation was statistically significant (Figure 34) as was the interaction between time and education.

Table 34. ANCOVA results for the effects of time and organisation on assessment of workspace quality

Predictor	F	df	partial η^2
Covariates			
Education	.431	1, 139	.00
Tenure	.016	1, 139	.00
Gender	.053	1, 139	.00
Main effects			
Organisation	3.293*	4, 139	.09
Time	15.480***	1, 139	.10
Interaction effects			
Time X Education	7.006**	1, 139	.05
Time X Tenure	3.649	1, 139	.03
Time X Gender	2.746	1, 139	.02
Time X Organisation	2.962*	4, 139	.08
n			147

* p < .05, ** p < .01, *** p < .001

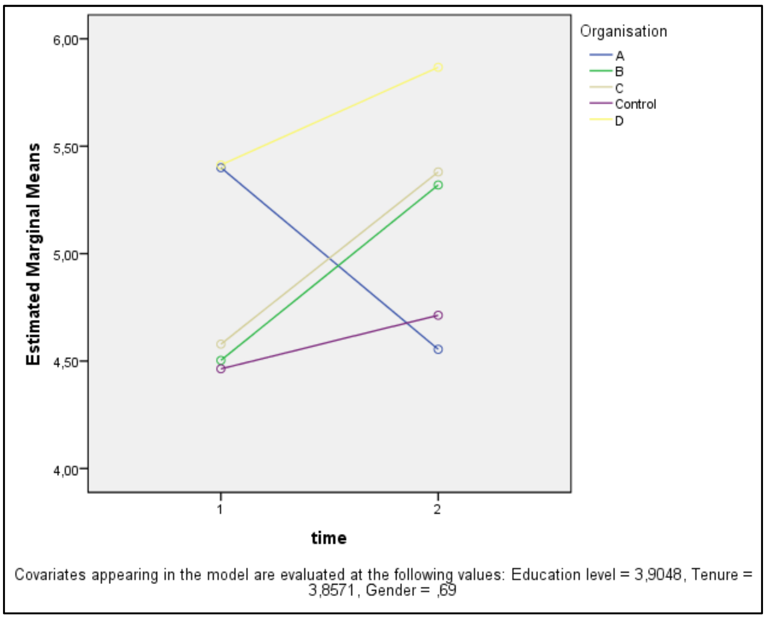


Figure 34. Interaction of time and organisation in the longitudinal analysis of workspace quality

There was no significant main effect for time on distractions (Table 35). The main effect for organisation was highly significant as was the interaction of time and organisation (Figure 35).

Furthermore, there was a significant effect of education level (covariate) and a significant interaction between time and tenure indicating a stronger increase in perceived distractions for employees with higher tenure between the two points in time. Education level is negatively related to distractions after change.

Table 35. ANCOVA results for the effects of time and organisation on assessment of distractions

Predictor	F	df	partial η^2
Covariates			
Education	4.831*	1, 130	.04
Tenure	1.956	1, 130	.02
Gender	.732	1, 130	.01
Main effects			
Organisation	5.572***	4, 130	.15
Time	.071	1, 130	.00
Interaction effects			
Time X Education	.417	1, 130	.00
Time X Tenure	6.404*	1, 130	.05
Time X Gender	.611	1, 130	.01
Time X Organisation	8.401***	4, 130	.21
n			138

* p < .05, ** p < .01, *** p < .001

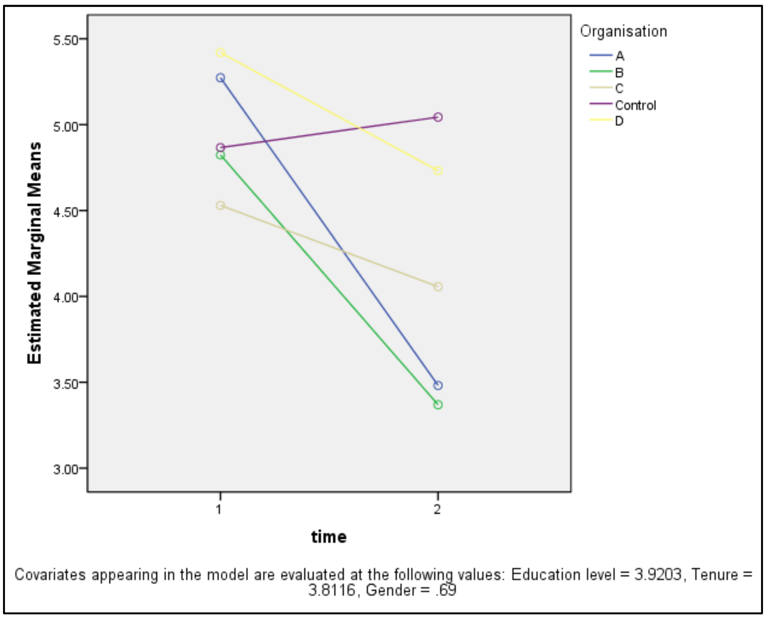


Figure 35. Interaction of time and organisation in the longitudinal analysis of distractions

There was no significant main effect for time on perceived noise (Table 36). There was a significant main effect of organisation on perceived noise. The interaction between time and organisation was significant (Figure 36). Furthermore, there was a significant effect of gender (covariate) indicating higher perceived noise levels for women. Additionally, a significant interaction between time and education level was found.

Table 36. ANCOVA results for the effects of time and organisation on perceived office noise

Predictor	F	df	partial η^2
Covariates			
Education	.622	1, 130	.01
Tenure	.157	1, 130	.00
Gender	4.475*	1, 130	.03
Main effects			
Organisation	16.161***	4, 130	.33
Time	2.317	1, 130	.02
Interaction effects			
Time X Education	4.755*	1, 130	.04
Time X Tenure	1.662	1, 130	.01
Time X Gender	.028	1, 130	.00
Time X Organisation	6.681***	4, 130	.17
n			138

* $p < .05$, ** $p < .01$, *** $p < .001$

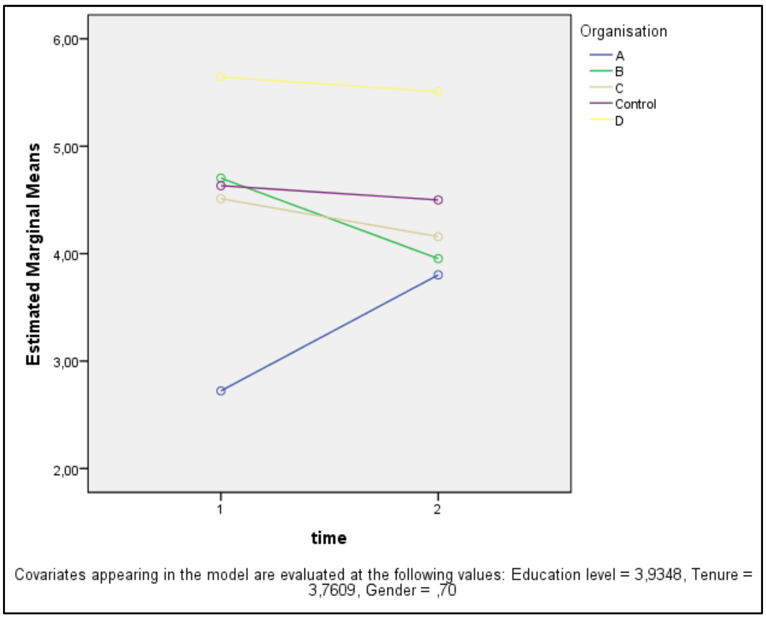


Figure 36. Interaction of time and organisation in the longitudinal analysis of perceived office noise

There was no significant main effect for time on privacy (Table 37). There was a significant main effect for organisation on privacy. The interaction of time and organisation was significant (Figure 37).

Table 37. ANCOVA results for the effects of time and organisation on perceived privacy

Predictor	F	df	partial η^2
Covariates			
Education	.677	1, 106	.01
Age	.466	1, 106	.00
Gender	1.421	1, 106	.01
Main effects			
Organisation	4.260**	3, 106	.11
Time	.304	1, 106	.00
Interaction effects			
Time X Education	.011	1, 106	.00
Time X Age	.901	1, 106	.01
Time X Gender	1.065	1, 106	.01
Time X Organisation	7.791***	3, 106	.18
n			113

* p < .05, ** p < .01, *** p < .001

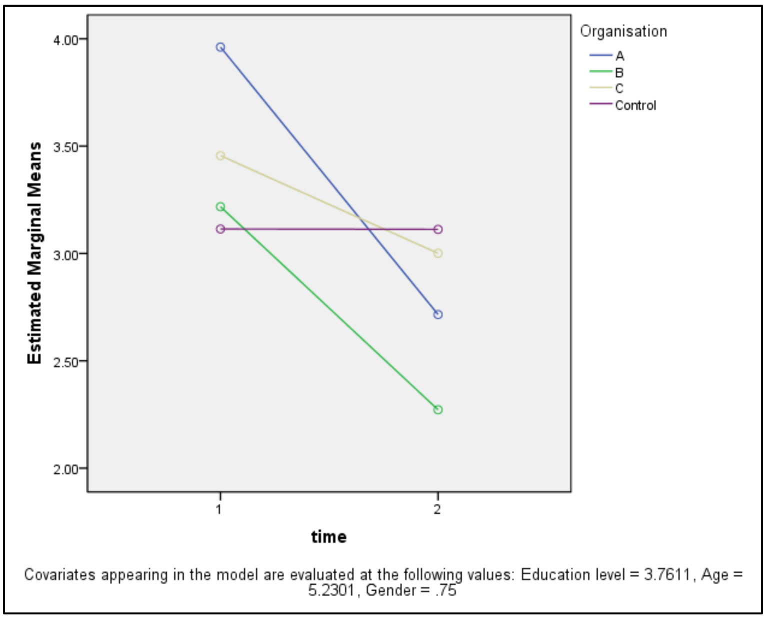


Figure 37. Interaction of time and organisation in the longitudinal analysis of perceived privacy

There was no significant main effect for time on crowding (Table 38). There was a significant main effect for organisation on crowding. The interaction of time and organisation was significant (Figure 38). In addition, there was a significant effect of gender (covariate) indicating higher crowding stress for women.

Table 38. ANCOVA results for the effects of time and organisation on crowding

Predictor	F	df	partial η^2
Covariates			
Education	.216	1, 130	.00
Tenure	1.390	1, 130	.01
Gender	3.933*	1, 130	.03
Main effects			
Organisation	8.266***	4, 130	.20
Time	.029	1, 130	.00
Interaction effects			
Time X Education	.775	1, 130	.01
Time X Tenure	.683	1, 130	.01
Time X Gender	.009	1, 130	.00
Time X Organisation	7.914***	4, 130	.20
n			138

* p < .05, ** p < .01, *** p < .001

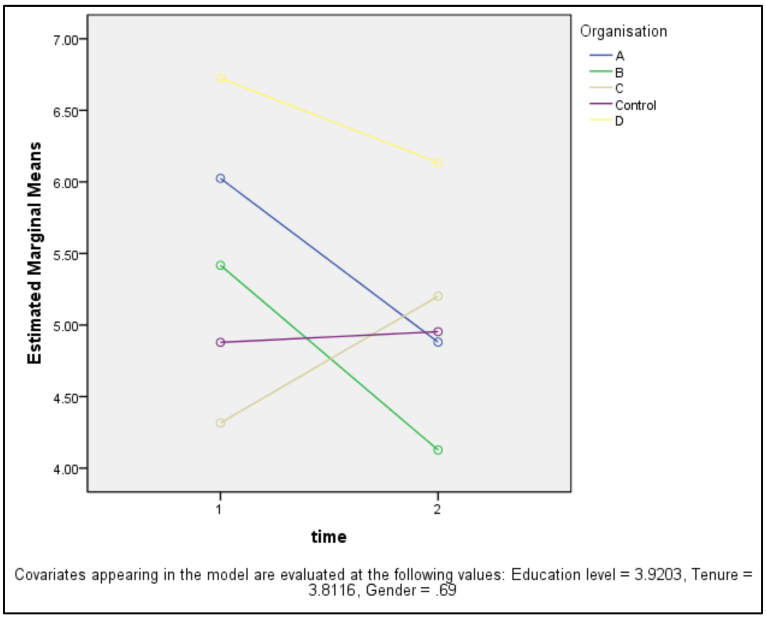


Figure 38. Interaction of time and organisation in the longitudinal analysis of crowding

There was no significant main effect for time on control over the environment (Table 39). There was a significant main effect for organisation on control. The interaction of time and organisation was significant (Figure 39). In addition, there was a significant interaction of time and tenure, indicating that higher-tenure employees assess control more negatively after the change.

Table 39. ANCOVA results for the effects of time and organisation on perceived control over the work environment

Predictor	F	df	partial η^2
Covariates			
Education	.002	1, 131	.00
Tenure	.080	1, 131	.00
Gender	.086	1, 131	.00
Main effects			
Organisation	2.679*	4, 131	.08
Time	3.467	1, 131	.03
Interaction effects			
Time X Education	2.011	1, 131	.02
Time X Tenure	13.067***	1, 131	.09
Time X Gender	.681	1, 131	.01
Time X Organisation	5.430***	4, 131	.14
n			139

* p < .05, ** p < .01, *** p < .001

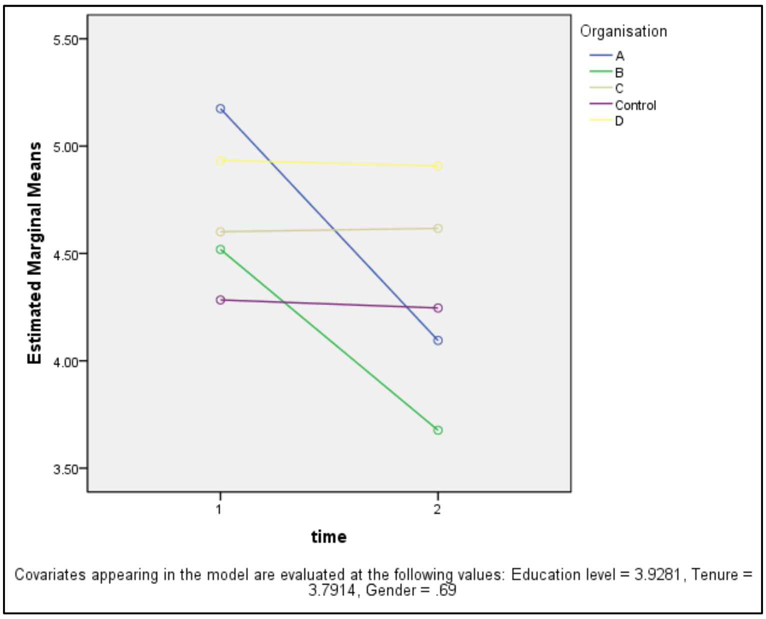


Figure 39. Interaction of time and organisation in the longitudinal analysis of control

There were no significant main effects for time (Table 40) and organisation on preference for enclosed area. The interaction of time and organisation was not significant either.

Table 40. ANCOVA results for the effects of time and organisation on individual preferences for enclosed areas

Predictor	F	df	partial η^2
Covariates			
Education	.772	1, 221	.00
Tenure	1.377	1, 221	.01
Gender	2.547	1, 221	.01
Main effects			
Organisation	2.331	4, 221	.04
Time	1.277	1, 221	.01
Interaction effects			
Time X Education	.003	1, 221	.00
Time X Tenure	.677	1, 221	.00
Time X Gender	.049	1, 221	.00
Time X Organisation	1.385	4, 221	.02
n			229

* p < .05, ** p < .01, *** p < .001

In summary, the longitudinal changes in office environment variables occurred as expected and formulated in hypothesis 1a. A significant interaction effect of time-x-organisation can be observed on all office environment variables except on workspace quality (where there are two separate main effects of time and organisation) and preference for enclosed area. With these two exceptions, hypothesis 1a is confirmed. While perceptions of the office environment change between time 1 (before intervention) and time 2 (after intervention), preferences

remain stable. Changes in the perception of the office environments therefore seem not to be reflections of changes in preferences.
The interaction effects show that effects of change are not the same for each organisation. Measurements in the control group are stable and differences in pre- and post-change measurements are small, especially when compared to the experimental groups. These results suggest that there were no events that affected the perceptions of the office environment in the control group. Consequently, it can be suggested that the differences between experimental groups are related to objective changes in the work environment that led to changes in employee's subjective experience of the workplace.
Furthermore, the direction of change differs in the experimental groups. Organisations A and B show a very similar pattern of change (with the exception of workspace quality). A similar, although less consistent, pattern can also be observed for organisations C and D. In most analyses, organisation D is the organisation with the highest assessment while organisation C usually is the organisation with the lowest assessment at time 1. At time 2, organisations C and D move toward each other in some cases (perceived environmental stressors, work and storage space assessment, crowding) or show a parallel increase (workspace quality) or decrease (distractions), or horizontal pattern (perceived office noise, control) in assessments, respectively.

10.2.2. Longitudinal changes in job characteristics

Job characteristics are expected to remain unchanged by the changes of the office environments (cf. hypotheses 1c and 1d). Table 41 shows the descriptive statistics of the job characteristics variables at the two points of time. High values represent positive assessments or experiences. The differences between time 1 and time 2 are small for both, the experimental group and the control group. As formulated in hypothesis 1d, no change is expected in the control group. This hypothesis is largely confirmed by the results displayed in Table 41. The confirmation of hypothesis 1d is not complete, however, because there is a statistically significant difference in co-operation over time for the control group.
In order to test the effect of office change on job characteristics, I conducted a series of repeated measures analyses of variance for job characteristics. Organisation was the between-subjects variable, and time was the within-subjects variable. Four covariates were included: job complexity, tenure, gender, and education level.

There was no significant main effect of time for scope of action (Table 42). There was no significant main effect of organisation either. The time-x-organisation interaction was not significant. These results indicate that there was neither a difference between the two points in time nor between the organisations.
Similar results were found for variety (Table 43), holistic job (Table 44), social support (Table 45), co-operation (Table 46), cognitive demand at work (Table 47), and benefits (Table 50).

Table 41. Means, standard deviations, and within-group tests for experimental and control groups at each point in time for job characteristics in the longitudinal sample

	Longitudinal sample	
Job characteristic	**Experimental group Mean (SD)**	**Control group Mean (SD)**
Scope of action 1	3.65 (0.73)	3.41 (0.84)
Scope of action 2	3.59 (0.74)	3.60 (0.64)
Variety 1	3.89 (0.79)	3.89 (0.78)
Variety 2	3.81 (0.76)	3.85 (0.64)
Holistic job 1	3.52 (0.86)	3.65 (0.82)
Holistic job 2	3.51 (0.86)	3.77 (0.82)
Social support 1	4.06 (0.87)	3.91 (0.82)
Social support 2	4.03 (0.78)	3.96 (0.74)
Co-operation 1	4.08 (0.84)	4.07 (0.86)
Co-operation 2	4.01 (0.87)	4.32* (0.81)
Cognitive demand at work 1	4.13 (1.00)	4.06 (0.88)
Cognitive demand at work 2	4.06 (0.77)	4.07 (0.73)
Quantitative overload at work 1	2.94 (0.96)	3.17 (1.10)
Quantitative overload at work 2	2.95 (0.97)	3.07 (1.11)
Information and participation 1	3.21 (0.87)	2.43 (1.06)
Information and participation 2	2.97** (0.99)	2.72 (1.11)
Benefits 1	3.23 (0.93)	2.76 (1.07)
Benefits 2	3.34 (0.91)	3.03 (1.21)

*p<.05; **p<.01 for differences across time within group

Table 42. ANCOVA results for the effects of time and organisation on scope of action

Predictor	F	df	partial η^2
Covariates			
Job Complexity	.999	1, 109	.01
Education	.090	1, 109	.00
Tenure	.227	1, 109	.00
Gender	.773	1, 109	.01
Main effects			
Organisation	.409	4, 109	.02
Time	2.096	1, 109	.02
Interaction effects			
Time X Job Complexity	.042	1, 109	.00
Time X Education	.076	1, 109	.00
Time X Tenure	8.958**	1, 109	.08
Time X Gender	1.181	1, 109	.01
Time X Organisation	1.900	4, 109	.07
n			118

* p < .05, ** p < .01, *** p < .001

Table 43. ANCOVA results for the effects of time and organisation on variety

Predictor	F	df	partial η^2
Covariates			
Job Complexity	.240	1, 109	.00
Education	1.627	1, 109	.02
Tenure	.047	1, 109	.00
Gender	6.379*	1, 109	.06
Main effects			
Organisation	.631	4, 109	.02
Time	2.707	1, 109	.02
Interaction effects			
Time X Job Complexity	3.085	1, 109	.03
Time X Education	.003	1, 109	.00
Time X Tenure	2.666	1, 109	.02
Time X Gender	.007	1, 109	.00
Time X Organisation	1.252	4, 109	.04
n			118

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 44. ANCOVA results for the effects of time and organisation on holistic job

Predictor	F	df	partial η^2
Covariates			
Job Complexity	.463	1, 109	.00
Education	.228	1, 109	.00
Tenure	2.297	1, 109	.02
Gender	.457	1, 109	.00
Main effects			
Organisation	.392	4, 109	.01
Time	1.831	1, 109	.02
Interaction effects			
Time X Job Complexity	.468	1, 109	.00
Time X Education	.023	1, 109	.00
Time X Tenure	9.208**	1, 109	.08
Time X Gender	.080	1, 109	.00
Time X Organisation	.950	4, 109	.03
n			118

* $p < .05$, ** $p < .01$, *** $p < .001$

There was a significant main effect for time on quantitative overload (Table 48). There was no significant time-x-organisation interaction. The main effect of time has its roots in a significant interaction of time-x-tenure and the pairwise comparison between the two time points is not significant. The significant time-x-tenure interaction shows that high-tenure employees experienced an increase in quantitative overload while low-tenure employees report no change.

Table 45. ANCOVA results for the effects of time and organisation on social support

Predictor	F	df	partial η^2
Covariates			
Job Complexity	2.698	1, 107	.03
Education	.226	1, 107	.00
Tenure	.589	1, 107	.01
Gender	8.635**	1, 107	.08
Main effects			
Organisation	1.779	4, 107	.06
Time	3.289	1, 107	.03
Interaction effects			
Time X Job Complexity	1.436	1, 107	.01
Time X Education	.200	1, 107	.00
Time X Tenure	1.081	1, 107	.01
Time X Gender	7.432**	1, 107	.07
Time X Organisation	1.090	4, 107	.04
n			116

* p < .05, ** p < .01, *** p < .001

Table 46. ANCOVA results for the effects of time and organisation on co-operation

Predictor	F	df	partial η^2
Covariates			
Job Complexity	4.695*	1, 172	.03
Education	.584	1, 172	.00
Tenure	2.812	1, 172	.02
Gender	.216	1, 172	.00
Main effects			
Organisation	2.292	4, 172	.05
Time	.223	1, 172	.00
Interaction effects			
Time X Job Complexity	3.188	1, 172	.02
Time X Education	.095	1, 172	.00
Time X Tenure	.022	1, 172	.00
Time X Gender	1.730	1, 172	.01
Time X Organisation	1.599	4, 172	.04
n			181

* p < .05, ** p < .01, *** p < .001

Table 47. ANCOVA results for the effects of time and organisation on cognitive demand

Predictor	F	df	partial η^2
Covariates			
Job Complexity	.517	1, 89	.01
Education	1.167	1, 89	.01
Tenure	8.855**	1, 89	.02
Gender	1.592	1, 89	.02
Main effects			
Organisation	.454	3, 89	.02
Time	.007	1, 89	.00
Interaction effects			
Time X Job Complexity	1.430	1, 89	.02
Time X Education	.123	1, 89	.00
Time X Tenure	3.491	1, 89	.04
Time X Gender	.213	1, 89	.00
Time X Organisation	.633	3, 89	.02
n			97

* p < .05, ** p < .01, *** p < .001

Table 48. ANCOVA results for the effects of time and organisation on quantitative overload

Predictor	F	df	partial η^2
Covariates			
Job Complexity	.046	1, 89	.00
Education	.000	1, 89	.00
Tenure	2.511	1, 89	.03
Gender	7.155**	1, 89	.07
Main effects			
Organisation	1.102	3, 89	.04
Time	6.086*	1, 89	.06
Interaction effects			
Time X Job Complexity	2.320	1, 89	.03
Time X Education	.112	1, 89	.00
Time X Tenure	8.882**	1, 89	.09
Time X Gender	1.597	1, 89	.02
Time X Organisation	.401	3, 89	.01
n			97

* p < .05, ** p < .01, *** p < .001

Table 49. ANCOVA results for the effects of time and organisation on information and participation

Predictor	F	df	partial η^2
Covariates			
Job Complexity	.199	1, 90	.00
Education	.117	1, 90	.00
Tenure	.321	1, 90	.00
Gender	.408	1, 90	.01
Main effects			
Organisation	2.476	3, 90	.08
Time	2.289	1, 90	.03
Interaction effects			
Time X Job Complexity	3.976*	1, 90	.04
Time X Education	.820	1, 90	.01
Time X Tenure	.176	1, 90	.00
Time X Gender	.344	1, 90	.00
Time X Organisation	2.782*	3, 90	.09
n			98

* p < .05, ** p < .01, *** p < .001

Table 50. ANCOVA results for the effects of time and organisation on benefits

Predictor	F	df	partial η^2
Covariates			
Job Complexity	.854	1, 88	.01
Education	.006	1, 88	.00
Tenure	1.664	1, 88	.02
Gender	2.627	1, 88	.03
Main effects			
Organisation	1.736	3, 88	.06
Time	.309	1, 88	.00
Interaction effects			
Time X Job Complexity	.261	1, 88	.00
Time X Education	4.745*	1, 88	.05
Time X Tenure	.584	1, 88	.01
Time X Gender	1.263	1, 88	.01
Time X Organisation	.561	3, 88	.02
n			96

* p < .05, ** p < .01, *** p < .001

There was a significant interaction effect of time-x-organisation in information and participation (Table 49). There were no corresponding main effects. This effect indicates that perceived information and participation decreased in three experimental groups, but not in the control group (Figure 40).

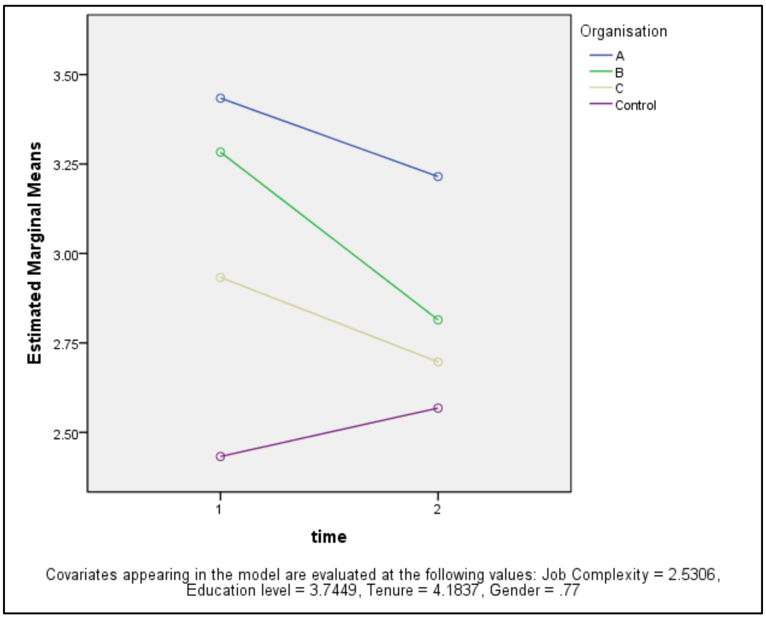


Figure 40. Interaction of time and organisation in the analysis of perceived information and participation

In summary, there were no main effects of time or organisation on job characteristics. There was a significant interaction effect of time-x-organisation on perceived information and participation suggesting a decrease in the experimental groups that may be attributable to the change in office design and/or the corresponding change management process because it is not paralleled by a corresponding change in the control organisation. With the exception of perceived information and participation in the experimental groups and co-operation in the control group, hypotheses 1c and 1d are confirmed.

10.2.3. Longitudinal changes in outcomes

To test the effect of office change on selected outcomes, a third series of repeated measures analyses of variance for each outcome was performed. Organisation was the between-subjects variable, and time was the within-subjects variable. Covariates included were: tenure / age[23], gender, and education level.

There was no significant main effect for time on job satisfaction (Table 51). There was no significant main effect for organisation on job satisfaction. The interaction of

[23] Data on age could not be collected in organisation D due to confidentiality requirements of that organisation. For analyses where data from organisation D are available, tenure instead of age is entered into the repeated measures ANCOVAs as a covariate.

time and organisation was significant (Figure 41). This result confirms hypothesis 2a. In addition, there was a significant interaction of time and tenure. Finally, there was a significant effect of level of education (covariate) indicating a negative relationship between level of education and job satisfaction.

Table 51. ANCOVA results for the effects of time and organisation on job satisfaction

Predictor	F	df	partial η^2
Covariates			
Education	5.535*	1, 242	.02
Tenure	.283	1, 242	.00
Gender	.055	1, 242	.00
Main effects			
Organisation	1.997	4, 242	.03
Time	1.836	1, 242	.01
Interaction effects			
Time X Education	.709	1, 242	.00
Time X Tenure	4.294*	1, 242	.02
Time X Gender	.075	1, 242	.00
Time X Organisation	5.502***	4, 242	.08
n			250

* p < .05, ** p < .01, *** p < .001

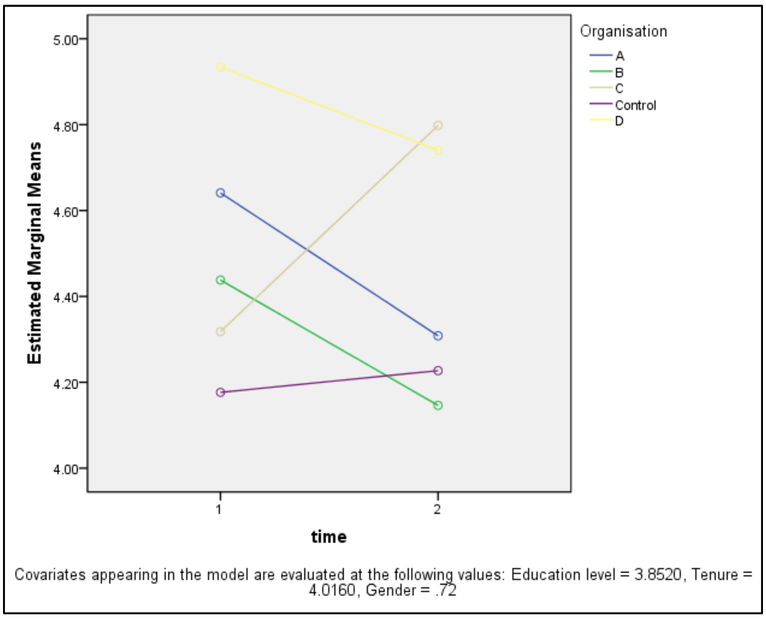


Figure 41. Interaction of time and organisation in the longitudinal analysis of job satisfaction

There was no significant main effect for time on work area satisfaction (Table 52). There was a significant main effect for organisation on work area satisfaction. The interaction of time and organisation was significant (Figure 42) which confirms hypothesis 2b. There was a significant effect of tenure (covariate) indicating a negative relationship between tenure and work area satisfaction. In addition, there was a significant interaction of time and tenure, indicating that higher-tenure employees' satisfaction with the work area is reduced stronger compared to low-tenure employees at time 2 than at time 1.

Table 52. ANCOVA results for the effects of time and organisation on work area satisfaction

Predictor	F	df	partial η^2
Covariates			
Education	.017	1, 140	.00
Tenure	4.926*	1, 140	.03
Gender	.434	1, 140	.00
Main effects			
Organisation	5.182**	4, 140	.13
Time	.936	1, 140	.01
Interaction effects			
Time X Education	.720	1, 140	.01
Time X Tenure	6.192*	1, 140	.04
Time X Gender	.039	1, 140	.00
Time X Organisation	5.482***	4, 140	.14
n			148

* p < .05, ** p < .01, *** p < .001

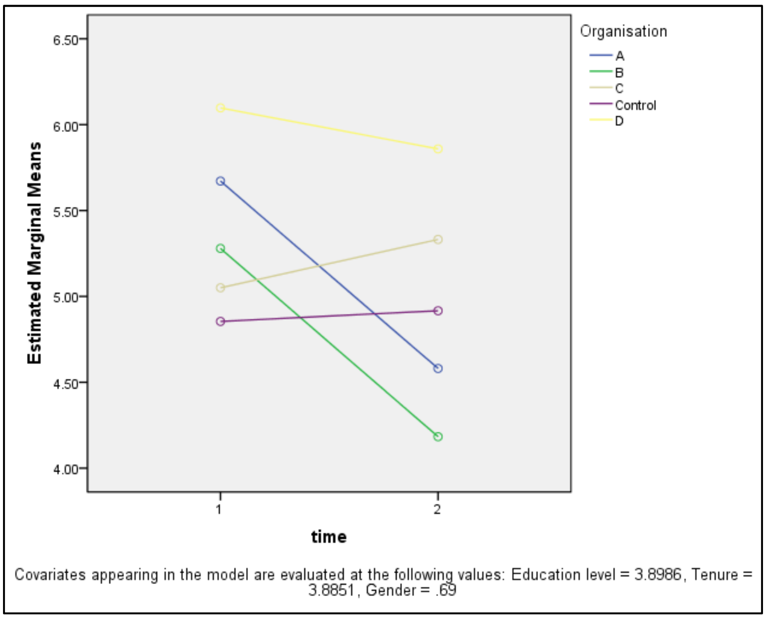


Figure 42. Interaction of time and organisation in the longitudinal analysis of work area satisfaction

The main effects of time and organisation on overall environmental satisfaction were not significant (Table 53). There was a significant interaction between time and organisation (Figure 43). This result confirms the analysis of the effects on work area satisfaction and also confirms hypothesis 2b.

Table 53. ANCOVA results for the effects of time and organisation on overall environmental satisfaction

Predictor	F	df	partial η^2
Covariates			
Education	.000	1, 100	.00
Age	3.806	1, 100	.04
Gender	.003	1, 100	.00
Main effects			
Organisation	2.106	3, 100	.06
Time	1.274	1, 100	.01
Interaction effects			
Time X Education	.415	1, 100	.00
Time X Age	1.722	1, 100	.02
Time X Gender	1.743	1, 100	.02
Time X Organisation	4.828**	3, 100	.13
n			107

* p < .05, ** p < .01, *** p < .001

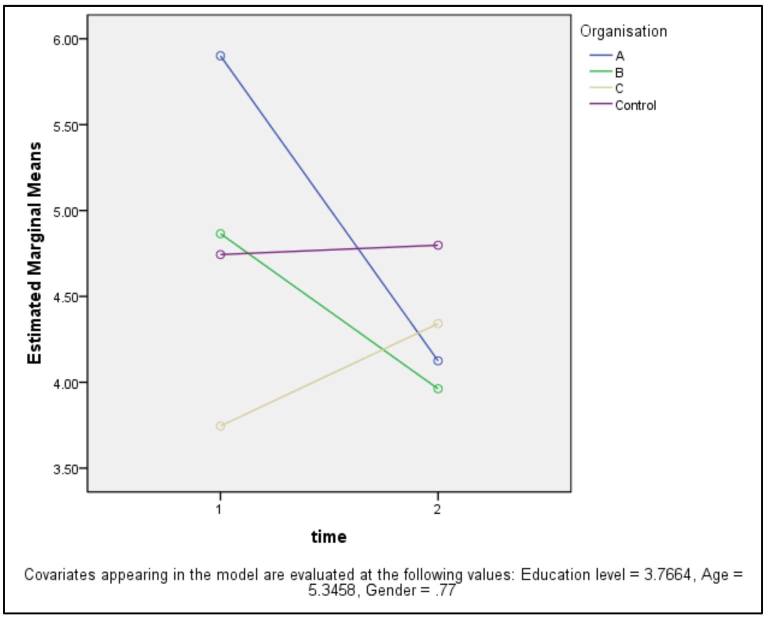


Figure 43. Interaction of time and organisation in the longitudinal analysis of overall environmental satisfaction

There was no significant main effect of time on organisational commitment and there was no significant main effect of organisation on organisational commitment (Table 54). There was no significant interaction between time and organisation. There was a significant effect of age on organisational commitment indicating a positive relationship between age and organisational commitment. Hypothesis 2c therefore has to be rejected.

There was no significant main effect of time on health symptoms and there was no significant main effect of organisation on health symptoms (Table 55). There was no significant interaction between time and organisation. Therefore also hypothesis 2d has to be rejected.

Table 54. ANCOVA results for the effects of time and organisation on organisational commitment

Predictor	F	df	partial η^2
Covariates			
Education	.721	1, 104	.01
Age	10.517**	1, 104	.09
Gender	.026	1, 104	.00
Main effects			
Organisation	1.653	3, 104	.05
Time	.074	1, 104	.00
Interaction effects			
Time X Education	.124	1, 104	.00
Time X Age	.275	1, 104	.00
Time X Gender	1.210	1, 104	.01
Time X Organisation	.271	3, 104	.01
n			111

* p < .05, ** p < .01, *** p < .001

Table 55. ANCOVA results for the effects of time and organisation on health symptoms

Predictor	F	df	partial η^2
Covariates			
Education	.651	1, 104	.01
Age	.104	1, 104	.00
Gender	.096	1, 104	.00
Main effects			
Organisation	2.239	3, 104	.06
Time	.665	1, 104	.01
Interaction effects			
Time X Education	.040	1, 104	.00
Time X Age	.044	1, 104	.00
Time X Gender	.598	1, 104	.01
Time X Organisation	2.370	3, 104	.06
n			111

* p < .05, ** p < .01, *** p < .001

There was no significant main effect of time on self-assessed job performance and there was no significant main effect of organisation on self-assessed job performance (Table 56). There was no significant interaction between time and organisation. There was no significant main effect of time on self-assessed job performance based on feedbacks and there was no significant main effect of organisation on self-assessed job performance based on feedbacks (Table 57). There was no significant interaction between time and organisation. There was a significant interaction between time and tenure, indicating that high-tenure employees assess their performance higher than low-tenure employees at time 1 but lower at time 2.

There was no significant main effect of time on situational job performance (Table 58). There was a significant main effect of organisation on situational job performance. There was a significant interaction between time and organisation

(Figure 44). Furthermore, there was a significant interaction between time and tenure. There was also an effect of level of education on situational job performance, indicating a negative relationship between level of education and situational job performance.

Table 56. ANCOVA results for the effects of time and organisation on self-assessed job performance

Predictor	F	df	partial η^2
Covariates			
Education	.553	1, 122	.01
Tenure	.016	1, 122	.00
Gender	.098	1, 122	.00
Main effects			
Organisation	.383	4, 122	.01
Time	.004	1, 122	.00
Interaction effects			
Time X Education	.316	1, 122	.00
Time X Tenure	3.184	1, 122	.03
Time X Gender	1.006	1, 122	.01
Time X Organisation	1.260	4, 122	.04
n			130

* p < .05, ** p < .01, *** p < .001

Table 57. ANCOVA results for the effects of time and organisation on self-assessed job performance

Predictor	F	df	partial η^2
Covariates			
Education	.030	1, 122	.00
Tenure	.035	1, 122	.00
Gender	.006	1, 122	.00
Main effects			
Organisation	1.013	4, 122	.03
Time	2.316	1, 122	.02
Interaction effects			
Time X Education	.003	1, 122	.00
Time X Tenure	7.191**	1, 122	.06
Time X Gender	1.219	1, 122	.01
Time X Organisation	.153	4, 122	.01
n			130

* p < .05, ** p < .01, *** p < .001

Taken together, the results on job performance are equivocal. Hypothesis 2e is confirmed for situational job performance and has to be rejected for the other two measures of self-assessed job performance.

Table 58. ANCOVA results for the effects of time and organisation on self-assessed job performance

Predictor	F	df	partial η^2
Covariates			
Education	5.246*	1, 125	.04
Tenure	.109	1, 125	.00
Gender	3.832	1, 125	.03
Main effects			
Organisation	3.323*	4, 125	.10
Time	1.050	1, 125	.01
Interaction effects			
Time X Education	.576	1, 125	.01
Time X Tenure	7.425**	1, 125	.06
Time X Gender	.638	1, 125	.01
Time X Organisation	4.718**	4, 125	.13
n			133

* p < .05, ** p < .01, *** p < .001

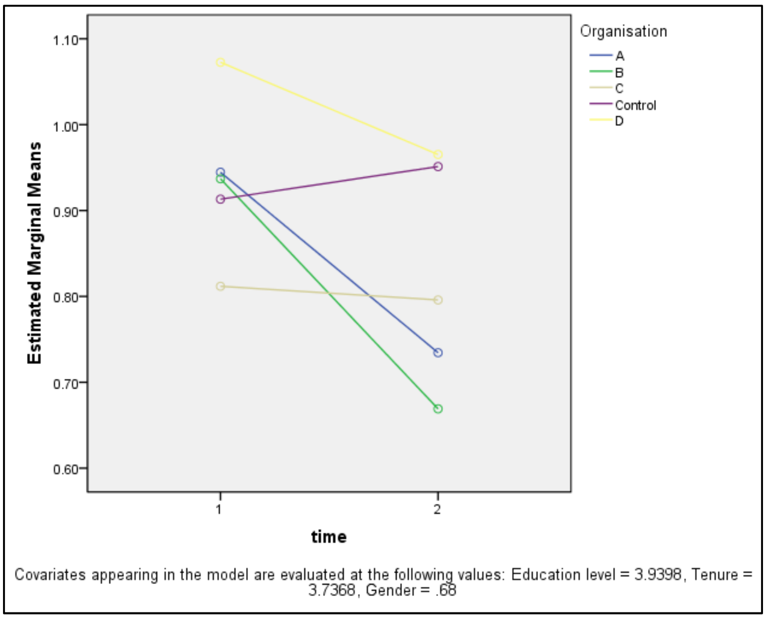


Figure 44. Interaction of time and organisation in the longitudinal analysis of situational job performance

There was no significant main effect of time on social support as an element of social climate (Table 59) and there was no significant main effect of organisation on social support. There was no significant interaction between time and organisation.

Table 59. ANCOVA results for the effects of time and organisation on social support as part of social climate

Predictor	F	df	partial η^2
Covariates			
Education	2.152	1, 99	.02
Age	.151	1, 99	.00
Gender	1.469	1, 99	.02
Main effects			
Organisation	.642	3, 99	.01
Time	.600	1, 99	.01
Interaction effects			
Time X Education	.523	1, 99	.01
Time X Age	1.045	1, 99	.01
Time X Gender	.410	1, 99	.00
Time X Organisation	1.151	3, 99	.03
n			106

* p < .05, ** p < .01, *** p < .001

There was no significant main effect of time on psychological climate (Table 60) and there was no significant main effect of organisation on social support. There was no significant interaction between time and organisation. There was a significant interaction between time and education (covariate) indicating a decline in psychological climate for the group with the highest education and an increase in psychological climate for the group with the lowest education.

Table 60. ANCOVA results for the effects of time and organisation on psychological climate as part of social climate

Predictor	F	df	partial η^2
Covariates			
Education	1.053	1, 98	.01
Age	1.557	1, 98	.02
Gender	.064	1, 98	.00
Main effects			
Organisation	2.095	3, 98	.06
Time	2.940	1, 98	.03
Interaction effects			
Time X Education	5.120*	1, 98	.05
Time X Age	.201	1, 98	.00
Time X Gender	.019	1, 98	.00
Time X Organisation	.672	3, 98	.02
n			105

* p < .05, ** p < .01, *** p < .001

There was no significant main effect of time on social stress caused by colleagues (Table 61) and there was no significant main effect of organisation on social stress caused by colleagues. There was no significant interaction between time and organisation. There was a significant interaction between time and tenure (covariate) indicating an increase in perceived social stress caused by colleagues for employees with higher tenure. Furthermore, there was a significant effect of gender. Women experienced higher stress after the change of the office environment while men did not.

There was no significant main effect of time on social stress caused by supervisors and there was no significant main effect of organisation on social stress caused by supervisors (Table 61). There was no significant interaction between time and organisation.

The results on the perceived social environment indicate that there is no change over time in the experimental group that could be related to the intervention or the changes in perceptions of the office environment between time 1 and time 2. These findings disconfirm Hypothesis 3.

Table 61. ANCOVA results for the effects of time and organisation on social stress caused by colleagues

Predictor	F	df	partial η^2
Covariates			
Education	1.955	1, 131	.02
Tenure	1.143	1, 131	.01
Gender	6.249*	1, 131	.05
Main effects			
Organisation	1.135	4, 131	.03
Time	.673	1, 131	.01
Interaction effects			
Time X Education	1.286	1, 131	.01
Time X Tenure	5.723*	1, 131	.04
Time X Gender	1.169	1, 131	.01
Time X Organisation	.779	4, 131	.02
n			139

* p < .05, ** p < .01, *** p < .001

Table 62. ANCOVA results for the effects of time and organisation on social stress caused by supervisors

Predictor	F	df	partial η^2
Covariates			
Education	.343	1, 130	.00
Tenure	.975	1, 130	.01
Gender	.864	1, 130	.01
Main effects			
Organisation	1.326	4, 130	.04
Time	3.758	1, 130	.03
Interaction effects			
Time X Education	.213	1, 130	.00
Time X Tenure	4.049*	1, 130	.03
Time X Gender	3.472	1, 130	.03
Time X Organisation	1.577	4, 130	.05
n			138

* p < .05, ** p < .01, *** p < .001

In summary, there are few effects for the outcome variables. Significant time-x-organisation interactions can be observed for job satisfaction, work area satisfaction, overall environmental satisfaction, and situational job performance. These results confirm hypotheses 2a and 2b but disconfirm hypotheses 2c and 2d. The pattern of

these interactions is very similar to the one for the office environment characteristics (see above). The measurements in the control group are stable and the direction of change differs between experimental groups. Similar to the results for the office environment variables, the pattern on the outcome variables is similar for organisations A and B and – to a lesser degree – for C and D.
Social environment outcomes (social stress and work climate) remain largely unaffected by changes in the office environment. This result disconfirms hypothesis 3. Only employees with highest education or high tenure seem to experience slightly more stress caused by colleagues or a slightly more negative psychological climate, respectively, after changes in the office environment.

10.3. Summary of longitudinal comparisons

Changes in office users' perceptions and reactions are examined in a longitudinal sample that includes data from both, before and after change points in time. Four office change projects are analysed and set in relation to a control group.
First, a series of repeated-measures analyses of variance were performed for office environment variables. As expected, changes in perceptions and assessments of the office environment were found. A significant interaction effect of time-x-organisation can be observed on all office environment variables except on workspace quality (where there are two separate main effects of time and organisation) and preference for enclosed area. Employees' preferences for enclosed or open environments therefore are not influenced by changes in their office environments.

In a second series of comparisons of means, longitudinal changes in job characteristics were examined. Conforming to expectations, job characteristics did not change as a function of changes in the office environment and there was neither a main effect of time nor of organisation. However, there was a significant interaction effect of time-x-organisation on perceived information and participation suggesting a decrease in the experimental groups that may be attributable to the change in office design or the corresponding change management process because it is not paralleled by a corresponding change in the control organisation.

The time-x-organisation interactions indicate that longitudinal differences are a function of point in time and organisation in combination. Changes over time vary in intensity and direction in different organisations. Differences over time in the control group are small, particularly when compared to the experimental groups. From these results I conclude that between the two measurements no events occurred that had an impact on the variables measured in the control group. Consequently, the differences in the longitudinal measurements observed in the experimental groups can causally be related to the interventions in the organisations (i.e. relocations, changes in office environments).
The direction of change differs in the experimental groups. Organisations A and B show a very similar pattern of change (with the exception of workspace quality and office noise) which consists of a decrease of assessments of the office environment

and reductions in job satisfaction, work area satisfaction, overall environmental satisfaction, and situational job performance.
A similar, although less consistent, pattern can also be observed for organisations C and D. In these organisations perceptions of workplace quality were more positive after the change, distraction was assessed more negatively, and perceived noise and control remained unchanged. There were differences in the assessments of environmental stressors, work and storage spaces, crowding and three outcome variables (job satisfaction, work area / overall environmental satisfaction, and situational job performance).
The similarity of the patterns for organisations A and B may be attributable to the magnitude of change of the office environment in terms of social density which is about double the size of the change in organisations C and D (Figure 27).
In addition to time-x-organisation interactions, significant main effects of organisation can be observed for noise, distraction, privacy, crowding, and control over the environment. These effects indicate that there are differences between organisations. Pairwise comparisons show that these main effects are mainly due to a significant difference of organisation D to all other participating organisations or to a significant difference between organisations B and D (with more positive ratings in organisation D). For variables noise and privacy, there are significant differences between organisations A and B (more positive ratings in organisation A). Differences between organisations may be due to their businesses, organisational culture, size, or other factors. Organisation D is the smallest of all participating organisations and the more positive ratings on socio-spatial aspects may be due to higher familiarity among employees and an organisational culture that values human relations.

Further results from the longitudinal analysis of office environment variables consist in small to medium main effects of gender. Women assessed crowding, lighting, and noise in their office environments more negatively. Furthermore, there are two gender-x-time interactions indicating that women's' ratings of improvements in workplace appropriateness and workspace quality over time were slightly more pronounced.
There were two time-x-tenure interaction effects. Employees with higher tenure perceived a stronger increase of distractions and a stronger reduction of control over the own office environment over time.

Changes in characteristics of the office environment are mirrored to a limited degree by changes in the outcomes. Significant time-x-organisation interactions can be observed for job satisfaction, work area satisfaction, overall environmental satisfaction, and situational job performance. The pattern of these interactions is very similar to the one for the office environment characteristics (see above). The measurements in the control group are stable and the direction of change differs between experimental groups. As for the office environment variables, the pattern on the outcome variables is similar for organisations A and B and – to a lesser degree – for C and D. Organisation D is the smallest of the units studied and the assessment of the office environment is consistently higher than in the other organisations. Repeated measures ANCOVAs were therefore repeated without organisation D in order to check whether significant organisation-x-time interactions are produced by this unit. The exclusion of organisation D reduces the number of significant main effects of organisation (in the analysis of environmental stressors, workspace quality, crowding, control, work area satisfaction, and situational job performance) and does not change the results for work and storage space assessment, distractions, perceived office noise, and job satisfaction). However, the organisation-x-time interactions, which are in the focus of the study, remain statistically significant.

Social environment variables are almost not affected by changes in the office environment. Therefore, social stress is dealt with as an organisational construct that is considered independent of the design of office environments.

10.4. Cross-sectional regression models

The analyses of the relationships among variables are based on data collected with different versions of the questionnaire. Due to limits for the length of the questionnaire set by the participating organisations, different versions of the questionnaire were employed in order to fully benefit of the surveys for exploratory analyses (see chapter 9.2). The regression analyses therefore differ in the size of the dataset and all analyses do not include data from all participating organisations. Each analysis using time 1 data (pre-change) can be cross-validated by a similar analysis using time 2 data (post-change). However, regression models based on questionnaire version D can be calculated with time 2 data only because it relies on data from organisation E where no pre-change data are available.

Generally, variables pertaining to the office environment are entered into the regressions models first. Job characteristics and variables of the social environment are entered in subsequent blocks. This procedure allows the estimation of independent effects of the office environment and the examination of mediation effects of the impact of the office environment on outcomes through job characteristics.

10.4.1. Job satisfaction

Based on the review of literature (chapters 6 and 7), the influences of job characteristics on job satisfaction can be considered as well supported: The job characteristics described in chapter 7 have received consistent empirical support regarding the influence on job satisfaction. Additionally, there is evidence for the important role of social support and cooperation for job satisfaction (chapter 7.4). Social stressors have been shown to negatively impact job satisfaction (chapter 7.4). Office environment characteristics have been shown to have an impact on job satisfaction. Specifically there is evidence for influences of office noise, daylight, control, and office openness (see chapters 6.2 and 6.3). Furthermore there is inconclusive evidence about the influence of privacy, distractions, and social density (see chapters 6.3 and 6.4) on job satisfaction.

In this section the relationships between these variables and job satisfaction are examined using data collected with different versions of the questionnaire.
The first regression analysis uses data from questionnaire version A. The first block entered into the model contains office characteristics. The second block is built of job characteristics. The third block contains social stressors. The final model (Table 63) includes four significant predictors, two job characteristics (variety and holistic jobs), social stress, and distraction.

Table 63. Hierarchical regression results (beta-values) of job and environmental characteristics on job satisfaction (questionnaire version A, time 1, N=177)

Step	Predictor	Step 1	Step 2	Step 3
1	Control	.181*	.023	.038
	Office noise	-.075	-.032	-.062
	Privacy	.063	.103	.084
	(LOG10 of) social density	.049	.017	.006
	Distraction	.393***	.221*	.222*
	Environmental stressors	-.005	.001	.011
	Work and storage space	.016	.047	.018
	Workspace quality	.062	.040	.047
	Crowding	.031	.005	.002
2	Scope of action		-.015	-.015
	Variety		.215**	.210**
	Holistic job		.230**	.179**
	Social support		.235***	.088
3	Social stress			.288***
	ΔR^2 at each step	.28***	.19***	.05***

* p < .05, ** p < .01, *** p < .001

A second analysis with the same regression approach and the same variables with post-change data results in a similar but not equal model (Table 64). In this analysis the two job characteristics variety and holistic job are accompanied by social support (instead of social stress) and crowding (instead of distraction). Crowding reaches statistical significance only after job characteristics are entered into the model in step 2, indicating a suppressor effect. Total variance explanation is high and almost the same for both models (R^2=.52 for the time 1 model and R^2=.53 for the time 2 model).
A further model was analysed using data from Version C of the questionnaire. In this version workspace variables were replaced by variables regarding ambient factors of the office environment.

Table 64. Hierarchical regression results (beta-values) of job and environmental characteristics on job satisfaction (questionnaire version A, time 2, N=119)

Step	Predictor	Step 1	Step 2	Step 3
1	Control	.082	-.002	.029
	Office noise	.139	.054	.037
	Privacy	.080	.064	.079
	(LOG10 of) social density	-.008	-.011	-.021
	Distraction	-.013	-.011	.001
	Environmental stressors	.125	.154	.127
	Work and storage space	.009	.013	-.017
	Workspace quality	.165	.030	.032
	Crowding	.134	.218*	.223*
2	Scope of action		-.008	-.023
	Variety		.306***	.300***
	Holistic job		.218*	.204*
	Social support		.174*	.085
3	Social stress			.155
	ΔR^2 at each step	.30***	.23***	.01

* p < .05, ** p < .01, *** p < .001

Table 65. Hierarchical regression results (beta-values) of job and environmental characteristics on job satisfaction (questionnaire version C, time 2, N=177)

Step	Predictor	Step 1	Step 2
1	Office noise	-.042	-.064
	Control	.193	.072
	Lighting	-.011	-.030
	Indoor climate	.176*	.138*
	Workplace appropriateness	.322*	.287*
	(LOG10 of) social density	-.117	-.014
	Distraction	.010	.026
	Privacy	.036	.039
	Crowding	.193*	.167*
2	Scope of action		-.077
	Variety		.287***
	Holistic job		.137*
	Social support		.169**
	ΔR^2 at each step	37***	15***

* p < .05, ** p < .01, *** p < .001

Similar to the previous analysis, the first block entered into the model contains office characteristics. The second block is built of the job characteristics. This model could only be calculated with time 2 data because it uses data from organisation E where no pre-change data are available.

The resulting model (Table 65) explains 52 per cent of variance in job satisfaction. Like the previous models, it includes the job characteristics variety and holistic job. Additionally, it includes social support and three characteristics of the office environment: indoor climate, workplace appropriateness, and crowding.

The fourth regression model for job satisfaction was calculated using data from version B of the questionnaire. This version of the questionnaire contains only overload at work as a job characteristic. Office characteristics were entered in the first block and overload at work was entered in the second block.

In this analysis 13 per cent of the variance in job satisfaction was explained by the model but no predictor was statistically significant (Table 66). The cross-validation of this result with post-change data is displayed in Table 67. In this analysis workplace appropriateness appears as the only significant predictor of job satisfaction. The model explains 12 per cent of variance in job satisfaction.

Table 66. Hierarchical regression results (beta-values) of job and environmental characteristics on job satisfaction (questionnaire version B, time 1, N=211)

Step	Predictor	Step 1	Step 2
1	Privacy	.185	.180
	Lighting	.078	.076
	(LOG10 of) social density	-.090	-.092
	Indoor climate	.060	.060
	Workplace appropriateness	.048	.049
2	Overload at work		.012
	ΔR^2 at each step	.13***	.0

* p < .05, ** p < .01, *** p < .001

Table 67. Hierarchical regression results (beta-values) of job and environmental characteristics on job satisfaction (questionnaire version B, time 2, N=121)

Step	Predictor	Step 1	Step 2
1	Privacy	-.043	-.021
	Lighting	-.058	-.041
	(LOG10 of) social density	.086	.072
	Indoor climate	.038	.015
	Workplace appropriateness	.375**	.389**
2	Overload at work		-.101
	ΔR^2 at each step	.12*	.0

* p < .05, ** p < .01, *** p < .001

Data collected with version D of the questionnaire was used for an additional regression model on job satisfaction. A hierarchical regression with office characteristics in the first block and social stress in the second block was performed. The resulting model (Table 68) includes privacy, workspace quality, and social stress as significant predictors and explains 38 per cent of variance in job satisfaction.

Table 68. Hierarchical regression results (beta-values) of environmental characteristics and social stress on job satisfaction (questionnaire version D, time 2, N=172)

Step	Predictor	Step 1	Step 2
1	Privacy	.173*	.211*
	Environmental stressors	.116	.069
	Work and storage space	.030	.020
	Workspace quality	.232**	.198*
	crowding	.164	.089
2	Social stress		.292***
	ΔR^2 at each step	.31***	.07***

* p < .05, ** p < .01, *** p < .001

To summarise, the six statistical regression models show that there are different predictors for job satisfaction. The job characteristics variety and holistic job are complemented with social support and social stress respectively as well as with characteristics of the office environment such as distractions, privacy, crowding, indoor climate, and workplace appropriateness. The increase in explained variance attributable to the integration of office characteristic variables ranges from seven per cent up to a maximum of seventeen per cent. Total variance explained by the models ranges from nine to fifty-two per cent.

Table 69. Overview of results from cross-sectional regression analyses regarding hypotheses for job satisfaction

Hypothesis	Variable	Total number of models where predictor is significant (number of models including this predictor)	Time 1	Time 2
4a	Office noise	0 (3)	0 (1)	0 (2)
6b	Lighting	0 (3)	0 (1)	0 (2)
7a	Control	0 (3)	0 (1)	0 (2)
8a	Social density	0 (5)	0 (2)	0 (3)
9a	Privacy	1 (6)	0 (2)	1 (4)
10a	Distraction	1 (3)	1 (1)	0 (2)
11a	Crowding	2 (4)	0 (1)	2 (3)
12a	Workplace appropriateness	2 (3)	0 (1)	2 (2)
13a	Workspace quality	1 (3)	0 (1)	1 (2)

With regard to the hypotheses, these results disconfirm most the predicted relationships between characteristics of the office environment and job satisfaction (Table 69). In a subset of regression models, variables relating to the socio-spatial environment appear as significant predictors. The hypotheses on the influence of privacy and distraction are confirmed by trend. Crowding is a significant predictor in two models. Workplace appropriateness, a variable that describes the task-related appropriateness of the office environment, is a predictor for job satisfaction and this confirms the prediction derived from the Job Demands-Resources framework. However, the majority of hypothesised relationships cannot be confirmed. While at time 1 only distraction appear as a significant predictor, more variables are significant predictors in time 2 models (privacy, crowding, workplace appropriateness, and workspace quality).

10.4.2. Environmental satisfaction

In the literature reviewed in chapter 6, evidence is summarised on the factors influencing environmental satisfaction. Satisfaction with the physical work environment has been shown to be influenced by privacy (chapter 6.4.2), office noise (chapter 6.2.1), thermal comfort (chapter 6.2.2), and lighting (chapter 6.2.3). In addition, there is inconclusive evidence for influences of control over the own office environment (chapter 6.2.4), storage space and workspace quality (only one study, chapter 6.3.1), social density (chapter 6.3.2), distraction (chapter 6.4.2), and crowding (chapter 6.4.3). There is no theoretical or empirical basis to assume that job characteristics should influence environmental satisfaction.
In the questionnaires for the first study two measures for environmental satisfaction have been employed, a three-item scale measuring work area satisfaction, and a single item measure measuring overall environmental satisfaction. The two measurements correlate very strongly (r=.635 in a subsample of 32 subjects where both measurements were used for cross-validation).

Table 70. Hierarchical regression results (beta-values) of environmental characteristics and job characteristics on environmental satisfaction (questionnaire version A, time 1, N=181)

Step	Predictor	Step 1	Step 2	Step 3
1	Privacy	.295***	.028	.045
	Office Noise	.397***	.150*	.157*
2	Control		-.002	.021
	Work and storage space		.175**	.199**
	(LOG10 of) social density		-.029	-.051
	Distraction		.163*	.128
	Crowding		.262***	.232***
	Workspace quality		.267***	.261***
3	Scope of action			-.118
	Variety			.124*
	Holistic job			-.025
	Social support			.060
	ΔR^2 at each step	.35***	.27***	.02

* p < .05, ** p < .01, *** p < .001

Workplace appropriateness was not included in the models due to the very high correlations with environmental satisfaction (Table 25 and Table 26). Thus, hypothesis 12b cannot be tested.

The first regression model uses data from version A of the questionnaire. Based on available evidence privacy and office noise were entered as first block. The second block consists of control, work and storage space, social density, distraction, crowding and workspace quality. In the third block job characteristics were entered. The last block did not contribute to an increase in explained variance (Table 70). The same model was analysed with post-change data (Table 71). In both models office noise, work and storage space, and workspace quality appear as significant predictors. Job characteristics did not contribute to explained variance in environmental satisfaction in both models. The model using pre-change data contains distraction and crowding that do not appear as significant predictors in the post-change model. Variance explained by these models range is 62 per cent (time 1) and 65 per cent (time 2).

Table 71. Hierarchical regression results (beta-values) of environmental characteristics and job characteristics on environmental satisfaction (questionnaire version A, time 2, N=122)

Step	Predictor	Step 1	Step 2	Step 3
1	Privacy	.247**	.011	.007
	Office Noise	.547***	.258**	.249**
2	Control		.092	.086
	Work and storage space		.297***	.299**
	(LOG10 of) social density		-.014	-.018
	Distraction		.131	.129
	Crowding		.107	.106
	Workspace quality		.149*	.147*
3	Scope of action			.019
	Variety			.031
	Holistic job			-.039
	Social support			.048
	ΔR^2 at each step	.51***	.14***	.004

* p < .05, ** p < .01, *** p < .001

A regression model using the data from version D of the questionnaire consisted of three blocks. The first block contains privacy; the second block includes work and storage space, workspace quality, and crowding. The third block enters overload at work and social stressors. The third block did not add to explained variance (Table 72). The analysis shows that privacy, workspace quality, and crowding are important predictors for environmental satisfaction. Compared to the models based on version A of the questionnaire, privacy appears as an additional predictor.

Table 72. Hierarchical regression results (beta-values) of environmental characteristics, overload, and social stress on environmental satisfaction (questionnaire version D, time 2, N=172)

Step	Predictor	Step 1	Step 2	Step 3
1	Privacy	.651***	.372***	.385***
2	Work and storage space		.072	.075
	Workspace quality		.315***	.307***
	Crowding		.205**	.208**
3	Overload			-.071
	Social stress			.036
	ΔR^2 at each step	.42***	.16***	.008

* p < .05, ** p < .01, *** p < .001

Data from version B of the questionnaire was used for a regression analysis of overall environmental satisfaction. Privacy, indoor climate, and lighting compose the first block[24]. The second block consists in social density and overload (Table 73). The same analysis was performed using the post-change data (Table 74). The results indicate that all predictors contribute to overall environmental satisfaction in the pre-change sample. In the time 2 analysis only privacy and indoor climate emerge as significant predictors.

Table 73. Hierarchical regression results (beta-values) of environmental characteristics and overload at work on overall environmental satisfaction (questionnaire version B, time 1, N=211)

Step	Predictor	Step 1	Step 2
1	Privacy	.322***	.361***
	Indoor climate	.160**	.156**
	Lighting	.260***	.269***
	(LOG10 of) social density	-.199**	-.176**
2	overload		-.115*
	ΔR^2 at each step	.51***	.01*

* p < .05, ** p < .01, *** p < .001

Table 74. Hierarchical regression results (beta-values) of environmental characteristics and overload at work on overall environmental satisfaction (questionnaire version B, time 2, N=121)

Step	Predictor	Step 1	Step 2
1	Privacy	.401***	.403***
	Indoor climate	.368***	.366***
	Lighting	-.075	-.074
	(LOG10 of) social density	-.038	-.039
2	overload		-.008
	ΔR^2 at each step	.42***	.001

* p < .05, ** p < .01, *** p < .001

[24] Data on workplace appropriateness are available from version B of the questionnaire. Due to the very strong correlation between workplace appropriateness and overall environmental satisfaction (Table 24), however, these data are not included in the regression analysis.

Data from version C of the questionnaire were used for a regression model for overall environmental satisfaction. This regression model is an extension of the one based on version B. It includes additional variables of the office environment (office noise, control, distractions, and crowding) and the job characteristics. The first block consists of privacy, lighting, ventilation and temperature, and office noise. The second block includes control, social density, distraction, and crowding. Job characteristics were entered in the third block (Table 75). In this regression analysis, control and distraction are the strongest predictors. Other significant beta-values are found for privacy, lighting, and crowding. Job characteristics are not significantly related to overall environmental satisfaction in this analysis.

Table 75. Hierarchical regression results (beta-values) of office environmental characteristics and job characteristics on overall environmental satisfaction (questionnaire version C, time 2, N=177)

Step	Predictor	Step 1	Step 2	Step 3
1	Privacy	.341***	.123*	.132*
	Lighting	.177**	.110*	.103*
	Indoor climate	.177**	.075	.072
	Office noise	.295***	-.002	-.009
2	Control		.332***	.296***
	(SQRT of) social density		.000	-.005
	Distraction		.305***	.309***
	Crowding		.167**	.156**
3	Scope of action			.008
	Variety			.039
	Holistic job			-.011
	Social support			.093
	ΔR^2 at each step	.55***	.15***	.01

* p < .05, ** p < .01, *** p < .001

In summary, a variety of characteristics of the office environment influence environmental satisfaction. Job characteristics do not appear as predictors in the analyses.
Variables from different classes of office environment aspects contribute to overall environmental satisfaction: socio-spatial variables (privacy, crowding, and distraction), functional aspects (workplace appropriateness), office design variables (workspace quality, work and storage spaces), and office environment conditions (noise, lighting, climate, and control). Variance explanation in the different regression models range from 42 to 70 per cent.

The results confirm most of the hypotheses concerning the relationship between perceived characteristics of the office environment and environmental satisfaction

(Table 76). Hypothesis 8b, however, is disconfirmed: social density is not a predictor of environmental satisfaction.

Time 1 and time 2 models are similar and the same variables appear as significant predictors.

Table 76. Overview of results from cross-sectional regression analyses regarding hypotheses for environmental satisfaction

Hypothesis	**Variable**	**Total number of models where predictor is significant (number of models including this predictor)**	**Time 1**	**Time 2**
4b	Office noise	2 (3)	1 (1)	1 (2)
5a	Indoor climate	2 (3)	1 (1)	1 (2)
6a	Lighting	2 (3)	1 (1)	1 (2)
8b	Social density	1 (5)	1 (2)	0 (3)
9b	Privacy	4 (6)	1 (2)	3 (4)
10b	Distraction	2 (3)	1 (1)	1 (2)
11b	Crowding	3 (4)	1 (1)	2 (3)
13b	Workspace quality	3 (3)	1 (1)	2 (2)

10.4.3. Organisational commitment

Evidence regarding the relationship between office environmental characteristics and organisational commitment is inconclusive or lacking (see chapter 5.3). Regression analyses with organisational commitment as outcome variable are carried out in two steps in order to analyse the impacts of job or social stress at the one hand side and effects of the work environment on the other hand side.

Table 77. Regression results (beta-values) of environmental factors and overload at work on organisational commitment (questionnaire version B, time 1, N=210)

Step	**Predictor**	**Step 1**	**Step 2**
1	Lighting	.240**	.249**
	Indoor climate	.010	.009
	Workplace appropriateness	-.047	-.057
	Privacy	.128	.157
	(LOG10 of) social density	-.104	-.091
2	Overload at work		-.073
	ΔR2 at each step	.12***	.0

* p < .05, ** p < .01, *** p < .001

The first model for organisational commitment uses data from version B of the questionnaire. This version contains overload as the only job characteristic. The following variables were entered: lighting, indoor climate, workplace appropriateness, privacy, social density, and overload at work. The analysis was performed with both, pre-change (Table 77) and post-change data (**Fehler! Ungültiger Eigenverweis auf Textmarke.**). Lighting is the only predictor for organisational commitment in the Time 1 analysis. However, the ratio of explained variance is modest. The analysis of Time 2 data results in a different picture. In this analysis the significant predictors are workplace appropriateness and work overload. Variance explanation is higher with 26 per cent.

Table 78. Regression results (beta-values) of environmental factors and overload at work on organisational commitment (questionnaire version B, time 2, N=82)

Step	Predictor	Step 1	Step 2
1	Lighting	.019	.061
	Indoor climate	-.068	-.152
	Workplace appropriateness	.513***	.586***
	Privacy	-.116	-.045
	(LOG10 of) social density	.200	.168
2	Overload at work		-.318**
	ΔR2 at each step	.17*	.09**

* p < .05, ** p < .01, *** p < .001

A third hierarchical regression analysis on organisational commitment was performed using data from version D of the questionnaire. Here, different predictors were entered: social density, crowding, environmental stressors, work and storage space, and workspace quality were entered in the first block. Overload at work and social stress were entered into the model in subsequent blocks. This analysis produces social stress and workspace quality as significant predictors of organisational commitment (Table 79).

Table 79. Regression results (beta-values) of environmental factors and stressors from different sources on organisational commitment (questionnaire version D, time 2, N=162)

Step	Predictor	Step 1	Step 2	Step 3
1	(SQRT of) social density	.135	.145	.063
	Crowding	.103	.079	.045
	Environmental stressors	.195*	.190*	.142
	Work and storage space	.038	.035	.040
	Workspace quality	.284**	.284**	.252**
2	Overload at work		.112	.031
3	Social stress			.261**
	ΔR^2 at each step	.23***	.01	.05**

* p < .05, ** p < .01, *** p < .001

The three regression models analysed for organisational commitment provide a heterogeneous picture and the results on the relationship between characteristics of the office environment and organisational commitment are inconclusive. Due to the lack of prior research on the relationship between office design and organisational commitment, no hypotheses had been formulated. However, the analyses show that environmental characteristics are predictors of organisational commitment, notably workplace appropriateness, workspace quality, and lighting. Social stress and work overload are elements of the social and job design environment that influence organisational commitment.

10.4.4. Health

Health status was measured by a list of symptoms that are considered typical for psychosomatic illness. The experience of stress is an important factor in reducing health (see chapter 5.4). The review of the literature shows that noise (chapter 6.2.1), climate and air quality (chapter 6.2.2), and lighting (chapter 6.2.3) are important factors of the office environment for employees' health. The evidence for control (chapter 6.2.4), social density (chapter 6.3.2), and crowding (6.4.3) is equivocal but all of these factors may contribute to experience of stress and are therefore worth analysing in relation to health.

Table 80. Hierarchical regression results (beta-values) of environmental factors and work overload on health (questionnaire version B, time 1, N=209)

Step	Predictor	Step 1	Step 2	Step 3
1	Lighting	.187*	.028	.008
	Indoor climate	.202**	.110	.112
2	Workplace appropriateness		.161	.185
	Privacy		.214*	.146
	(SQRT of) social density		-.050	-.081
3	Work overload			.173**
	ΔR^2 at each step	.11***	.09***	.03**

* p < .05, ** p < .01, *** p < .001

The first regression analysis for health uses data from questionnaire version B. Ambient characteristics (lighting and Indoor climate) are entered in the first block. Workplace appropriateness, privacy, and social density are entered in the second block. Work overload was entered last. The results are presented in Table 80 (time 1) and Table 81 (time 2). Work overload appears as significant predictor in the time 1 analysis, workplace appropriateness is the only statistically significant predictor in the time 2 regression model.

The second regression model for health uses data from questionnaire version D (time 2 only). In this regression model, stressors from different sources, namely work overload, environmental stressors, and social stress are entered in the first block. The second block contains characteristics of the office environment: privacy, social density, workspace quality, and work and storage spaces. The results of this regression model are presented in Table 82. Workspace quality, environmental stressors, and social stress are the significant predictors of health status in this model.

Table 81. Hierarchical regression results (beta-values) of environmental factors and work overload on health (questionnaire version B, time 2, N=121)

Step	Predictor	Step 1	Step 2	Step 3
1	Lighting	.148	.116	.099
	Indoor climate	.222*	.160	.182
2	Workplace appropriateness		.271*	.260*
	Privacy		.001	-.020
	(SQRT of) social density		.162	.179
3	Work overload			.091
	ΔR^2 at each step	.09**	.07*	.01

* p < .05, ** p < .01, *** p < .001

Table 82. Hierarchical regression results (beta-values) of stressors from different sources and environmental characteristics on health (questionnaire version D, time 2, N=195)

Step	Predictor	Step 1	Step 2	Step 3	Step 4
1	Privacy	.126	-.024	-.045	-.022
	(SQRT of) social density	-.037	.025	.030	-.030
	Work and storage space	.111	.034	.021	.028
	Workspace quality	.292***	.247**	.238**	.203**
2	Environmental stressors		.356***	.345***	.276**
3	Work overload			.192**	.117
4	Social stress				.253***
	ΔR^2 at each step	.19***	.07***	.04**	.05***

* p < .05, ** p < .01, *** p < .001

Together, the three regression models for health show that workplace appropriateness and workspace quality characteristics of the office environment are important factors for health. The results disconfirm hypothesis 5b that postulates a relationship between indoor climate and health and hypothesis 6c that relates perceived lighting quality to health. Indoor climate and lighting are not statistically significant anymore when socio-spatial and functional aspects of the office environment are entered into the regression models in step 2.
Variance explanation for models including job and environmental aspects ranges from sixteen to thirty-five per cent. Notably workplace appropriateness, environmental stressors, and workspace quality add to variance explained by social stress and work overload.

10.4.5. Individual work performance

Literature on the relationship between office work environments and individual work performance identifies noise and distraction (chapters 6.2.1 and 6.4.2), thermal comfort and air quality (chapter 6.2.2), control (chapter 6.2.4), job characteristics (chapter 7.1), and social stress (chapter 7.4) as important factors of the environment on performance. There is inconclusive evidence for lighting (chapter 6.2.3) and social density (chapter 6.3.2). The relationship between job characteristics and work performance is well established by empirical research (chapter 7).

The first set of regression models for individual work performance used all three performance scales as dependent variables and data from questionnaire versions A and C. For analyses using data from questionnaire version A, office characteristics were entered in the first block. The second block contains job characteristics and the third block contains social stress.
The results of the analyses for self-assessed job performance are presented in Table 83 and Table 84. Distraction and social density appear as significant predictors in the time 1 regression model, accounting for 15 per cent of variance. Control, however, disappears as a significant predictor when job characteristics are added to the model. In the final model, distraction and social density appear as significant predictors related to the office environment. Variety and holistic job are strong predictors in the pre-change model. In the post-change model, none of the predictors is statistically significant except for work and storage space that becomes significant after job characteristics have been entered in the model.
The regression models using self-assessed job performance based on feedbacks as outcome measure are presented in Table 85 and Table 86. Both models include social stress as a strong significant predictor. No features of the office environment appear as statistically significant predictors.

Table 83. Hierarchical regression results (beta-values) of job characteristics, social, and environmental factors on individual job performance (questionnaire version A, time 1, self-assessed job performance, N=232)

Step	Predictor	Step 1	Step 2	Step 3
1	Distraction	.236**	.191*	.177*
	Office noise	-.018	-.037	-.025
	Control	.258**	.147	.145
	Crowding	-.079	-.051	-.054
	Environmental stress	.022	.038	.032
	Work and storage space	.019	.021	.015
	Workspace quality	.070	.060	.066
	(LOG10 of) social density	.150	.168*	.169*
2	Scope of action		.024	.026
	Variety		.271***	.267***
	Holistic job		.170*	.159*

	Social support		-.022	-.081
3	Social stress			.121
	ΔR^2 at each step	.15***	.12***	.01

* p < .05, ** p < .01, *** p < .001

Table 84. Hierarchical regression results (beta-values) of job characteristics, social, and environmental factors on individual job performance (questionnaire version A, time 2, self-assessed job performance, N=147)

Step	Predictor	Step 1	Step 2	Step 3
1	Distraction	-.131	-.162	-.154
	Office noise	.061	.025	.032
	Control	.145	.031	.065
	Crowding	-.010	.008	.008
	Environmental stress	.026	.021	-.013
	Work and storage space	.147	.221*	.192
	Workspace quality	.192	.104	.103
	(LOG10 of) social density	.028	-.010	-.026
2	Scope of action		.144	.118
	Variety		.145	.140
	Holistic job		.135	.125
	Social support		.132	.050
3	Social stress			.151
	ΔR^2 at each step	.14**	.13***	.01

* p < .05, ** p < .01, *** p < .001

Table 85. Hierarchical regression results (beta-values) of job characteristics, social, and environmental factors on individual job performance (questionnaire version A, time 1, Self-assessed job performance based on Feedbacks, N=232)

Step	Predictor	Step 1	Step 2	Step 3
1	Distraction	.233**	.164*	.135
	Office noise	.035	.033	.058
	Control	.183*	.055	.051
	Crowding	.112	.107	.098
	Environmental stress	-.095	-.079	-.093
	Work and storage space	-.010	-.007	-.020
	Workspace quality	.110	.088	.102
	(LOG10 of) social density	.144	.115	.118
2	Scope of action		.039	.044
	Variety		.057	.051
	Holistic job		.167*	.145*
	Social support		.221**	.100
3	Social stress			.245**

	ΔR^2 at each step	.16***	.10***	.04**

* p < .05, ** p < .01, *** p < .001

Table 86. Hierarchical regression results (beta-values) of job characteristics, social, and environmental factors on individual job performance (questionnaire version A, time 2, Self-assessed job performance based on Feedbacks, N=147)

Step	Predictor	Step 1	Step 2	Step 3
1	Distraction	-.103	-.177	-.157
	Office noise	.050	.015	.031
	Control	-.100	-.232*	-.143
	Crowding	.094	.102	.100
	Environmental stress	.001	-.017	-.101
	Work and storage space	.188	.236*	.163
	Workspace quality	.116	.062	.065
	(LOG10 of) social density	.058	-.030	-.072
2	Scope of action		.091	.024
	Variety		.106	.084
	Holistic job		.093	.069
	Social support		.414***	.200*
3	Social stress			.393***
	ΔR^2 at each step	.07	.24***	.08***

* p < .05, ** p < .01, *** p < .001

The regression models using data from version A of the questionnaire and situational job performance as a measure show that distraction and control are significant predictors of job performance (Table 87 and Table 88).

Table 87. Hierarchical regression results (beta-values) of job characteristics, social, and environmental factors on individual job performance (questionnaire version A, time 1, Situational job performance, N=233)

Step	Predictor	Step 1	Step 2	Step 3
1	Distraction	.317***	.249**	.252**
	Office noise	.067	.050	.048
	Control	.189*	.051	.051
	Crowding	-.014	.017	.018
	Environmental stress	-.022	.004	.005
	Work and storage space	.067	.065	.066
	Workspace quality	-.033	-.049	-.050
	(LOG10 of) social density	.054	.062	.062
2	Scope of action		.053	.053
	Variety		.240***	.241***
	Holistic job		.163*	.165*
	Social support		.063	.074

3	Social stress			-.022
	ΔR^2 at each step	.19***	.12***	.0

* p < .05, ** p < .01, *** p < .001

Table 88. Hierarchical regression results (beta-values) of job characteristics, social, and environmental factors on individual job performance (questionnaire version A, time 2, Situational job performance, N=150)

Step	Predictor	Step 1	Step 2	Step 3
1	Distraction	.204*	.187*	.187*
	Office noise	-.046	-.074	-.074
	Control	.154	.108	.108
	Crowding	.008	.027	.027
	Environmental stress	.025	.014	.015
	Work and storage space	.119	.139	.139
	Workspace quality	.103	.059	.059
	(LOG10 of) social density	-.110	-.132	-.131
2	Scope of action		-.039	-.039
	Variety		.098	.098
	Holistic job		.153	.154
	Social support		.153	.154
3	Social stress			-.003
	ΔR^2 at each step	.24***	.07*	.0

* p < .05, ** p < .01, *** p < .001

Table 89. Hierarchical regression results (beta-values) of job characteristics and environmental factors on individual job performance (questionnaire version C, time 2, Self-assessed job performance, N=171)

Step	Predictor	Step 1	Step 2
1	Distraction	-.143	-.157
	Office noise	-.059	.047
	Control	.207	.128
	Crowding	.001	.002
	Lighting	.173*	.158
	Indoor climate	.090	.068
	Workplace appropriateness	.100	.058
	(SQRT of) social density	.110	.176*
2	Scope of action		.084
	Variety		.088
	Holistic job		.299***
	Social support		-.109
	ΔR^2 at each step	.12*	.13***

* p < .05, ** p < .01, *** p < .001

Three additional models for job performance were performed using data from questionnaire version C. This version differs from version A in the environmental variables. While version A covers socio-spatial and office design aspects, version C focuses on ambient conditions. Due to the very small size of the before-change sample, these analyses were only performed using post-change data.
Office characteristics were entered in the first block and job characteristics in the second block of the regression model. The results are presented in Table 89 to Table 91, each showing the results for a different performance measure.

Table 90. Hierarchical regression results (beta-values) of job characteristics and environmental factors on individual job performance (questionnaire version C, time 2, Self-assessed job performance based on feedbacks, N=171)

Step	Predictor	Step 1	Step 2
1	Distraction	-.041	-.049
	Office noise	-.184	-.118
	Control	.123	-.004
	Crowding	.034	.013
	Lighting	.039	.028
	Indoor climate	.102	.095
	Workplace appropriateness	.240	.170
	(SQRT of) social density	.068	.088
2	Scope of action		.153
	Variety		.151
	Holistic job		.027
	Social support		.194*
	ΔR^2 at each step	.09	.12***

* p < .05, ** p < .01, *** p < .001

Table 91. Hierarchical regression results (beta-values) of job characteristics and environmental factors on individual job performance (questionnaire version C, time 2, Situational job performance, N=176)

Step	Predictor	Step 1	Step 2
1	Distraction	-.124	-.128
	Office noise	.068	.128
	Control	.208*	.178*
	Crowding	.011	-.001
	Lighting	.043	.026
	Indoor climate	-.016	-.024
	Workplace appropriateness	.456***	.422***
	(SQRT of) social density	-.076	-.047
2	Scope of action		.055
	Variety		-.004
	Holistic job		.178*
	Social support		-.025
	ΔR^2 at each step	.41***	.04*

* p < .05, ** p < .01, *** p < .001

The model using self-assessed performance as the outcome measure shows that social density is positively related to work performance. A second significant predictor is holistic job. For the model with self-assessed performance based on feedbacks social support is the only significant predictor.
Finally, the model with situational performance shows a substantial increase of 41 per cent in explained variance due to the inclusion of control and workplace appropriateness. Holistic job, a job characteristic, explains additional four per cent of variance.

In summary, the regression analyses for individual job performance show only moderate effects of office environment variables. However, the situational job performance measure seems to be more sensitive towards environmental conditions. This is evident in the higher increases in explained variance when environmental variables are entered in the regression models.
The most important aspects of the office environment for individual job performance from these analyses are control over the environment and distractions. Entering office environment characteristics add between zero and twenty-nine per cent in variance explanation (in addition to job characteristics). Total variance explanation ranges between seventeen and forty-five per cent.

Table 92. Overview of results from cross-sectional regression analyses regarding hypotheses for individual work performance

Hypothesis	Variable	Total number of models where predictor is significant (number of models including this predictor)	Time 1	Time 2
4c	Office noise	0 (9)	0 (3)	0 (6)
5c	Indoor climate	0 (3)	0 (0)	0 (3)
6d	Lighting	0 (3)	0 (0)	0 (3)
7b	Control	1 (9)	0 (3)	1 (6)
8c	Social density	2 (9)	1 (3)	1 (6)
10c	Distraction	3 (9)	2 (3)	1 (6)
11d	Crowding	0 (9)	0 (3)	0 (6)
12d	Workplace appropriateness	1 (3)	0 (0)	1 (3)
13d	Workspace quality	0 (6)	0 (3)	0 (3)

With regard to the research hypotheses (summarised in Table 92), the models disconfirm the predicted relationships with the exception of hypothesis 11 that postulates no relationship between crowding and work performance. Distraction appears as significant predictor in three out of nine regression analyses. In the time 1 models, distraction and social density are the only significant predictor while several variables are significant in one of the six time 2 analyses. The variables associated with the socio-spatial environment seem to play a more important role than the ones related to the ambient environment. The hypothesised relationships of office noise, indoor climate, lighting, and social density with individual work performance are not confirmed.

10.5. Summary of cross-sectional regression models

The cross-sectional analysis of effects of the work environment on job satisfaction, environmental satisfaction, organisational commitment, health, and individual work performance shows that aspects of the perceived office environment can contribute significantly to variance explanation in these outcomes. The results of the regressions models for different samples are summarised in Table 93. Sample sizes in the cross-sectional analyses range from 120 to 230 and allow the detection of medium effects (as opposed to the sample sizes sufficient for large effects in the longitudinal analyses) (Miles & Shevlin, 2001).

Table 93 Summary of statistically significant predictors in cross-sectional regression models in relation to total number of models containing the predictor

	Outcome						
Predictor	Job satisfaction	Environmental satisfaction	Organisational commitment	Health	Self-assessed job performance	Self-assessed job performance based on feedbacks	Situational job performance
Environmental stressors	0(3)		0(1)	1(1)	0(2)	0(2)	0(2)
Lighting	0(3)	2(3)	1(2)	0(2)	0(1)	0(1)	0(1)
Indoor climate	1(3)	2(3)	0(2)	0(2)	0(1)	0(1)	0(1)
Office noise	0(3)	2(3)			0(3)	0(3)	0(3)
Control	0(3)	1(3)			0(3)	0(3)	1(3)
Workplace appropriateness	2(3)		1(2)	1(2)	0(1)	0(1)	1(1)
Work and storage space	0(3)	2(3)	0(1)	0(1)	1(2)	0(2)	0(2)
Workspace quality	1(3)	3(3)	1(1)	1(1)	0(2)	0(2)	0(2)
Social density	0(5)	1(5)	0(3)	0(3)	2(3)	0(3)	0(3)
Distractions	1(3)	2(3)			1(3)	0(3)	2(3)
Privacy	1(6)	4(6)	0(2)	0(2)			
Crowding	2(4)	3(4)	0(2)		0(3)	0(3)	0(3)
Scope of action	0(3)	0(3)			0(3)	0(3)	0(3)
Variety	3(3)	0(3)			1(3)	0(3)	1(3)
Holistic job	3(3)	0(3)			2(3)	1(3)	2(3)
Social support	1(3)	0(3)			0(3)	2(3)	0(3)
Social stress	2(3)	0(1)	1(1)	1(1)	0(2)	2(2)	0(2)
Overload	0(2)	1(3)	1(3)	1(3)			

Cross-sectional regressions on job satisfaction show that job characteristics are consistent predictors of job satisfaction. Variety and holistic job emerge as significant predictors in all regression models where they were included as independent variables. Similarly, social stress or social support appear to be significant predictors in all regression models. Different variables relating to the office environment emerge as significant predictors (Table 93). Significant predictors relating to the office environment are not the same for all regression models. However, socio-spatial aspects (privacy, crowding, and distraction) consistently emerge as significant predictors while ambient environment variables do not. Variance in job satisfaction explained by office environmental factors ranges from twelve to thirty-seven per cent.

The analyses for environmental satisfaction identify different aspects of the office environment as significant predictors for environmental satisfaction. Functional aspects (workplace appropriateness), socio-spatial variables (privacy, crowding, and distraction), office design variables (workspace quality, work and storage spaces), and office environment conditions (noise, lighting, climate, and control) have influences on overall environmental satisfaction and explain 42 to 70 per cent of the variance in this construct.

The analyses indicate that lighting, workplace appropriateness, and workspace quality are predictors of organisational commitment, together with social stress and overload at work. The relationship between aspects of the office environment and organisational commitment may be context specific. Different predictors were found in the pre- and post-change situations and variance explanation in the post-change situations was higher with 26 to 28 per cent compared to 12 per cent in the pre-change situation.
Thus, changes in the office environment may increase employees' commitment to the organisation by rendering visible employee appreciation in the work environment. Providing appropriate work environments (the strongest predictor in the analyses) may be a central element in social exchange between employees and organisations and symbolize the socio-spatial contract (Vischer, 2005). This effect, however, may be closely associated to the change in the environment that increases the saliency of the physical workplace and the persistence of this effect over time remains to be investigated.

Cross-sectional regression analyses show associations between health and workplace appropriateness, environmental stressors, and workspace quality. These facets of the physical environment predict health status in combination with work overload and social stress. The total variance explanation for two models including work overload and environmental factors is 16 to 23 per cent and for a model including also social stress 35 per cent.

Results from the cross-sectional regression analyses show that individual work performance was influenced by control, distraction, social density, work and storage space, and workplace appropriateness in some models. In some regression models, however, no predictor related to the office environment was statistically significant. Variance explanation for the different measures of individual performance was stronger by job characteristics than by office characteristics. Environmental characteristics explain up to 41 per cent of explained variance although in most models where environmental variables were significant predictors variance explained was between 12 and 16 per cent. Distraction is the most consistent predictor related to the office environment for performance across different models.

Where regressions models could be cross-validated over time (i.e. data collected with the same version of the questionnaire and in the same organisations), there was limited agreement in the results insofar as the same predictors appeared in both, the time 1 and the time 2 analyses. The partial disagreement between the analyses for both points in time indicates that influence factors could be dependent on specific aspects of the situations and therefore are not generalizable over different office design solutions. The dependency of the causal relationships on the specific office design is analysed in the longitudinal regression analyses (chapter 10.6).

Although statistical relationships between characteristics of the office environment and outcomes can be established by the cross-sectional regression models most of the hypotheses are disconfirmed. There is evidence for the influence for some of the hypothesised relationships between variables relating to the office environment to outcomes in some of the statistical models. Furthermore, office design variables relating to the material environment (work and storage spaces, workplace appropriateness, and workspace quality) appear as important variables for the outcomes studied. No hypotheses had been formulated for these variables based on theoretical considerations and previous research.
An examination of the steps in the hierarchical regression analyses indicates that the effects of some environmental characteristics are mediated by other variables, i.e. predictors become statistically insignificant when other variables are added to the model. These mediation effects concern the relationship of control with job satisfaction and performance, privacy with environmental satisfaction and health, distraction with environmental satisfaction and performance, climate with environmental satisfaction and health, and lighting with health and performance. Moreover, there are indicators for suppressor effects in the hierarchical regression models, i.e. some variables become only significant after more variables are entered into the models in steps two or three.

The predictive relationship between changes in the office environment and changes in outcomes is analysed in longitudinal regression models. These analyses are described in the following chapter.

10.6. Longitudinal regression models

10.6.1. Job satisfaction

The regression model for job satisfaction used data from questionnaire versions A and B. In the model using data from version A control, office noise, privacy, social density, distraction, social stressors, environmental stressors, workspace quality, work and storage spaces, and crowding were entered as predictors. Job characteristics are entered into the model in step 2 as control variables. The regression analysis is summarised in Table 94. It shows that privacy, control, and office noise are important predictors for job satisfaction and that there are lagged effects of control and privacy at time 1.

Table 94. Hierarchical longitudinal regression results (beta-values) of job and environmental characteristics on job satisfaction (questionnaire version A; N = 57)

Step	Predictor	Step 1	Step 2	Step 3	Step 4
1	Job satisfaction time 1	.659***	.564***	.454**	.437**
2	Job Complexity		-.126	-.066	-.227
	Age		-.029	.008	-.007
	Gender		.046	.028	.223
	Scope of action time 2		-.039	-.033	-.010
	Variety time 2		.108	.057	.244
	Holistic job time 2		.237	.372*	.208
	Social support time 2		.094	.143	.067
3	Control time 1			-.290*	-.612**
	Office Noise time 1			-.187	-.188
	Privacy 2 time 1			-.023	.309*
	(LOG10 of) social density time 1			-.094	.339
	Distraction time 1			.249	.276
	Social stress time 1			.117	-.049
	Environmental stressors time 1			.138	-.334
	Work and storage space time 1			-.017	.215
	Workspace quality time 1			.057	.111
	Crowding time 1			-.075	-.058
4	Control time 2				.330
	Office Noise time 2				.413*
	Privacy 2 time 2				-.467*
	(SQRT of) social density time 2				-.205
	Distraction time 2				-.339
	Social stress time 2				.151
	Environmental stressors time 2				.286
	Work and storage space time 2				.099
	Workspace quality time 2				-.005
	Crowding time 2				.262
	ΔR^2 at each step	.43***	.13	.10	.17*

* p < .05, ** p < .01, *** p < .001

A second model with job satisfaction as a dependent variable and social density, privacy, lighting, Indoor climate, and workplace appropriateness, did not show significant additional variance explanation (Table 95); only job satisfaction at time 1 was a significant predictor for job satisfaction at time 2 in all four steps of the regression analysis. This model fails to confirm the importance of privacy as an important predictor for job satisfaction.

Table 95. Hierarchical longitudinal regression results (beta-values) of job and environmental characteristics on job satisfaction (questionnaire version B; N = 74)

Step	Predictor	Step 1	Step 2	Step 3	Step 4
1	Job satisfaction time 1	.730***	.719***	.698***	.715***
2	Job Complexity		-.107	-.113	-.071
	Age		-.028	-.044	-.053
	Gender		-.051	-.025	-.088
	Stress (qualitative and quantitative overload)		-.104	-.062	-.081
3	(LOG10 of) social density time 1			-.210*	-.153
	Privacy time 1			-.222	-.164
	Lighting time 1			-.054	-.038
	Indoor climate time 1			-.051	-.050
	Workplace appropriateness time 1			.216	.272
4	(SQRT of) social density time 2				-.142
	Privacy time 2				-.086
	Lighting time 2				-.054
	Indoor climate time 2				.100
	Workplace appropriateness time 2				-.082
	ΔR^2 at each step	.53***	.02	.04	.02

* p < .05, ** p < .01, *** p < .001

10.6.2. Environmental satisfaction

The regression model for environmental satisfaction used the same data as the model for job satisfaction (see above). This model is summarised in Table 96. Although the increment in variance explanation in step 4 is substantial and highly significant none of the predictors is statistically significant. This result may be due to the sample size which is small in relation to the number of variables.

A second model using data from questionnaire version B employed overall environmental satisfaction as dependent variable and social density, privacy, lighting, and indoor climate as independent variables. Workplace appropriateness was available for this model but was not entered into the regression model because it is extremely highly correlated with overall environmental satisfaction (see Table 25 and Table 26). The results of this analysis are displayed in Table 97. Privacy and indoor climate appear as significant predictors of environmental satisfaction in this model.

Table 96. Hierarchical longitudinal regression results (beta-values) on environmental satisfaction (questionnaire version A; N = 57)

Step	Predictor	Step 1	Step 2	Step 3	Step 4
1	Work area satisfaction time 1	.362**	.420**	.272	.172
2	Job Complexity		-.023	.072	.101
	Age		.052	.011	-.048
	Gender		.066	.036	.020
	Scope of action time 2		-.103	-.085	-.076
	Variety time 2		-.174	-.184	.227
	Holistic job time 2		.239	.306	.040
	Social support time 2		.098	.102	-.105
3	Control time 1			-.059	.011
	Office noise time 1			-.120	-.096
	Privacy 2 time 1			-.228	-.026
	(LOG10 of) social density time 1			-.161	.208
	Distraction time 1			.130	-.171
	Social stress time 1			.088	.043
	Environmental stressors time 1			.428	.226
	Work and storage space time 1			-.015	.077
	Workspace quality time 1			-.218	-.293
	Crowding time 1			-.124	-.078
4	Control time 2				.240
	Office noise time 2				.412
	Privacy 2 time 2				.079

	(SQRT of) social density time 2				-.043
	Distraction time 2				.062
	Social stress time 2				.020
	Environmental stressors time 2				-.007
	Work and storage space time 2				.073
	Workspace quality time 2				.026
	Crowding time 2				.238
	ΔR^2 at each step	.13**	.06	.16	.45***

* p < .05, ** p < .01, *** p < .001

Table 97. Hierarchical longitudinal regression results (beta-values) on environmental satisfaction (questionnaire version B; N = 74)

Step	Predictor	Step 1	Step 2	Step 3	Step 4
1	Overall environmental satisfaction time 1	.328**	.327**	.405**	.338*
2	Job Complexity		-.084	-.051	-.001
	Age		.091	.109	.100
	Gender		.004	-.023	-.088
	Stress (qualitative and quantitative overload) time 2		.182	.187	.185
3	(LOG10 of) social density time 1			.073	.102
	Privacy time 1			-.009	-.083
	Lighting time 1			-.319*	-.047
	Indoor climate time 1			.343*	.107
4	(SQRT of) social density time 2				-.093
	Privacy time 2				.281*
	Lighting time 2				-.093
	Indoor climate time 2				.301*
	ΔR^2 at each step	.11**	.04	.11	.20**

* p < .05, ** p < .01, *** p < .001

10.6.3. Organisational commitment

Organisational commitment was included in questionnaire version B. A longitudinal regression model for organisational commitment included social density, privacy, lighting, Indoor climate, and workplace appropriateness as independent variables. The analysis showed that organisational commitment at time 1 was the only significant predictor for organisational commitment at time 2 (Table 98).

Table 98. Hierarchical longitudinal regression results (beta-values) on organisational commitment (questionnaire version B; N = 72)

Step	Predictor	Step 1	Step 2	Step 3	Step 4
1	Organisational commitment time 1	.804***	.792***	.820***	.828***
2	Job Complexity		-.054	-.046	-.038
	Age		.041	.036	.062
	Gender		.016	.040	.036
	Stress (qualitative and quantitative overload) time 2		-.018	-.002	.057
3	(LOG10 of) social density time 1			-.049	-.065
	Privacy time 1			.015	.057
	Lighting time 1			.003	-.083
	Indoor climate time 1			-.029	-.032
	Workplace appropriateness time 1			-.080	-.081
4	(SQRT of) social density time 2				.125
	Privacy time 2				-.126
	Lighting time 2				.045
	Indoor climate time 2				.120
	Workplace appropriateness time 2				-.026
	ΔR^2 at each step	.65***	.005	.004	.03

* p < .05, ** p < .01, *** p < .001

10.6.4. Health

A regression model for health was performed using data from questionnaire version B. The only significant predictor in all steps was health at time 1 (Table 99). There is no significant prediction of health status by work environment characteristics. There is a significant increase in explained variance at step 3. Two variables related to the office environment, indoor climate and workplace appropriateness at time 1, are only significant by trend (i.e. p < .1) in this step, however.

Table 99. Hierarchical longitudinal regression results (beta-values) on health (questionnaire version B; N = 72)

Step	Predictor	Step 1	Step 2	Step 3	Step 4
1	Health status time 1	.705***	.728***	.611***	.608***
2	Job Complexity		-.082	-.136	-.090
	Age		-.045	-.052	-.068
	Gender		-.030	-.151	-.208
	Stress (qualitative and quantitative overload) time 2		-.088	-.114	-.119
3	(LOG10 of) social density time 1			.099	.134
	Privacy time 1			-.180	-.117
	Lighting time 1			.098	.080
	Indoor climate time 1			.194	.121
	Workplace appropriateness time 1			.273	.210
4	(SQRT of) social density time 2				-.030
	Privacy time 2				-.059
	Lighting time 2				.101
	Indoor climate time 2				.167
	Workplace appropriateness time 2				.091
	ΔR^2 at each step	.50***	.01	.10*	.04

* p < .05, ** p < .01, *** p < .001

10.6.5. Individual work performance

Three regression models for individual work performance were analysed, employing different measures of self-assessed work performance. Data from questionnaire version A were used.

Table 100. Hierarchical longitudinal regression results (beta-values) on self-assessed performance (questionnaire version A; N = 54)

Step	Predictor	Step 1	Step 2	Step 3	Step 4
1	Self-assessed performance time 1	.628***	.506***	.477**	.349
2	Job Complexity		.243	.351*	.205
	Age		.080	.063	.007
	Gender		-.024	-.034	.045
	Scope of action time 2		.018	-.042	-.033
	Variety time 2		.161	.081	.285
	Holistic job time 2		.053	.169	.089
	Social support time 2		.152	.280	.133
3	Control time 1			-.022	-.028
	Office noise time 1			-.436*	-.295
	Privacy 2 time 1			-.299*	-.165
	(LOG10 of) social density time 1			-.265	-.187
	Distraction time 1			.522*	.368
	Social stress time 1			-.021	-.072
	Environmental stressors time 1			.117	-.094
	Work and storage space time 1			-.039	.030
	Workspace quality time 1			-.037	.028
	Crowding time 1			-.184	-.201
4	Control time 2				.003
	Office noise time 2				-.113
	Privacy 2 time 2				.052
	(SQRT of) social density time 2				.124
	Distraction time 2				-.332
	Social stress time 2				.190
	Environmental stressors time 2				.379
	Work and storage space time 2				.371
	Workspace quality time 2				-.010
	Crowding time 2				-.058
	ΔR^2 at each step	.40***	.08	.15	.06

* p < .05, ** p < .01, *** p < .001

Control, office noise, privacy, social density, distraction, social stressors, environmental stressors, workspace quality, work and storage spaces, and crowding were entered as predictors.

Results for self-assessed performance are displayed in Table 100. For this measure, no additional variance explanation by entry of variables could be shown. However, self-assessed performance based on feedback, a different outcome measure for performance, showed that variety, a job design variable, and privacy and social stress at time 2 are strong predictors of this outcome. In the longitudinal regression model for situational performance, no predictors related to job, social, and office environment add to explained variance (Table 102).

Table 101. Hierarchical longitudinal regression results (beta-values) on self-assessed performance based on feedbacks (questionnaire version A; N = 55)

Step	Predictor	Step 1	Step 2	Step 3	Step 4
1	Self-assessed job performance based on Feedbacks time 1	.477***	.342**	.229	.075
2	Job Complexity		-.019	.190	.120
	Age		-.105	-.188	-.285
	Gender		-.169	-.198	-.264
	Scope of action time 2		-.137	-.160	-.172
	Variety time 2		.199	.207	.373*
	Holistic job time 2		.121	.145	.112
	Social support time 2		.282*	.372*	.016
3	Control time 1			.086	.212
	Office noise time 1			-.208	.210
	Privacy 2 time 1			-.012	-.067
	(LOG10 of) social density time 1			-.118	-.202
	Distraction time 1			.249	-.035
	Social stress time 1			.031	.065
	Environmental stressors time 1			.300	.334
	Work and storage space time 1			.071	.177
	Workspace quality time 1			-.054	-.021
	Crowding time 1			-.411*	-.367
4	Control time 2				-.204
	Office noise time 2				-.525*
	Privacy 2 time 2				.647**
	(SQRT of) social density time 2				-.038
	Distraction time 2				-.285
	Social stress time 2				.476*
	Environmental stressors time 2				-.204
	Work and storage space time 2				.238
	Workspace quality time 2				.206
	Crowding time 2				-.111
	ΔR^2 at each step	.23***	.21*	.10	.24*

* p < .05, ** p < .01, *** p < .001

Table 102. Hierarchical longitudinal regression results (beta-values) on self-assessed situational performance (questionnaire version A; N = 56)

Step	Predictor	Step 1	Step 2	Step 3	Step 4
1	Situational performance time 1	.364**	.286	.373	.607**
2	Job Complexity		.007	.101	-.053
	Age		.233	.157	-.072
	Gender		.004	.031	.081
	Scope of action time 2		-.093	-.114	.097
	Variety time 2		-.097	-.202	-.057
	Holistic job time 2		.188	.376	.203
	Social support time 2		.227	.292	.047
3	Control time 1			-.213	-.165
	Office noise time 1			-.281	-.054
	Privacy 2 time 1			-.157	-.103
	(LOG10 of) social density time 1			-.216	-.037
	Distraction time 1			.070	-.378
	Social stress time 1			.090	.290
	Environmental stressors time 1			.269	.155
	Work and storage space time 1			.160	.203
	Workspace quality time 1			-.101	-.179
	Crowding time 1			-.184	-.110
4	Control time 2				-.066
	Office noise time 2				.024
	Privacy 2 time 2				.290
	(SQRT of) social density time 2				.158
	Distraction time 2				-.140
	Social stress time 2				-.068
	Environmental stressors time 2				.192
	Work and storage space time 2				.684*
	Workspace quality time 2				-.368
	Crowding time 2				-.005
	ΔR^2 at each step	.13**	.08	.13	.26

* p < .05, ** p < .01, *** p < .001

10.7. Summary of longitudinal regression models

Longitudinal regression models were employed for the analysis of relationships between changes in the office environment and outcomes. Longitudinal regression models are used to analyse whether changes in influencing variables are mirrored by corresponding changes in outcomes while third variables are controlled. The main class of controlled variables in this study consists in job characteristics.

Effects of office environment characteristics on job satisfaction, environmental satisfaction, and self-assessed performance based on feedback were found. On the other hand, no effects of office environment characteristics on organisational commitment, health, self-assessed performance, and situational performance were identified.

Job satisfaction was influenced by (lack of) privacy and office noise. Furthermore there are lagged effects of control, privacy, and social density at time 1. These results indicate that the reduction in privacy (Figure 37) may influence job satisfaction. Similarly, higher control over the office environment and social density at time 1 corresponds to lower job satisfaction at time 2. The perception of possibilities to influence the own work environment at time 1 reduces job satisfaction at time 2. This effect may also be due to a generalised experience of loss of this influence.
The effect size of the influences of office environment variables on job satisfaction can be estimated by the additional amount of variance that is explained through the integration of these variables in block 4 of the regression model. Environmental variables explain seventeen per cent of variance in job satisfaction at time 2 in addition to the variance explained by job satisfaction at time 1 and control variables including job design.
The influence of environmental factors on job satisfaction, however, is not confirmed in a second model using a different subset of data and different predictors related to the office environment.

Results from the longitudinal regression analyses for environmental satisfaction are inconclusive. The integration of the time 2 environmental variables in the fourth step of the hierarchical longitudinal regressions results in substantial increases in explained variance up to forty-five per cent. However, in the first model (questionnaire version A) no variable related to the office environment emerges as a significant predictor. In the second model (questionnaire version B) privacy and indoor climate at time 2 reach statistical significance.

For self-assessed job performance based on feedbacks office noise, privacy, variety, and social stress at time 2 emerged as significant predictors. Privacy and office noise appear with opposite algebraic signs. This indicates that better assessments of noise in the environment are associated with lower performance. Together with social stress as a further significant predictor this result may signify that with satisfactory levels of privacy and low social stress, office noise may contribute to higher performance.

Sample sizes in the longitudinal regression models range from 54 to 74. These sample sizes are sufficient for the detection of large effects. The chance to discover small and medium effects (given they exist), however, is very limited (Miles & Shevlin, 2001). The results found in the longitudinal analyses described above therefore point to strong effects and point to substantial influences of office design variables on job satisfaction, environmental satisfaction and job performance.

Organisational commitment and health, however, are not affected by changes in the office environment. Although the results are not unequivocal, privacy seems to be a key element of the office environment. Privacy has an effect on job satisfaction, environmental satisfaction, and self-assessed performance.

Reverse causation was not examined in this research. It is conceivable that outcomes analysed here have an impact on the job and environmental variables i.e. the perceptions of the environment. For example, employees' perceptions of the environment may be influenced by their health, satisfaction, or performance status (Zapf, Dormann & Frese, 1996). Research on reverse causation within the Job Demands-Resources framework did either result in no significant reversed associations (Hakanen et al., 2008) or in weaker associations for reverse causation than for causal relationships (De Lange, Taris, Kompier, Houtman & Bongers, 2004). A second methodological threat for the validity and reliability of the findings is regression toward the mean: extremely high or low scores at time 1 may be followed by more moderate scores at time 2. Longitudinal regression analysis corrects for the phenomenon of regression towards the mean by including the time 1 scores as a covariate. Thus, change is defined relative to the score at time 1 (Twisk, 2008).

10.8. Discussion of study 1

The aims of the first study are twofold. First, the analysis of effects of changes in the office environments on office users' perceptions, attitudes, and behaviour is analysed while controlling for job characteristics and influences from the social environment. Second, relationships between the perceived office environment and individual-level outcomes (job and environmental satisfaction, organisational commitment, health, and individual work performance) are analysed.

Specifically, the change from cellular structures to multi-space offices in four organisations has been studied. The impacts of this intervention in the office environment are different in the four organisations. As expected, the job characteristics remained unaffected by the change in the office environment. However, there was a significant interaction effect of time-x-organisation on perceived information and participation suggesting a decrease in the experimental groups that may be attributable to the change in office design because it is not paralleled by a corresponding change in the control group organisation. The change processes were not systematically analysed in this research, but informal interviews indicate that the change processes were similar between the experimental groups and involved users only indirectly i.e. by including user-representatives in the process. Perceptions of limited information and participation therefore may plausibly be attributed to the change management. The implication for the interpretation of the results concerning job characteristics is that the measurements accurately capture participants' perceptions. In relation to the results of changes in the perception and assessments of the office environments this documents that these results are not an expression of a general discontent. Rather, participants seem to give detailed account of their perceptions. Therefore, the results are less likely to be affected by common method biases (Podsakoff, MacKenzie, Lee & Podsakoff, 2003) than to represent veracious effects.

The repeated measures analyses of variance showed that the control group members' perceptions of the work environment remained stable over time. In the experimental groups, the changes in the office environments elicited changes in the reported perceptions and assessments of the office environment. There were no changes in perceptions of job characteristics or perceptions of the social environment. Also the preferences for open or enclosed offices remained unaffected. There is limited negative evidence of workplace openness on interpersonal relations from the literature reviewed in chapter 6. In the first study, however, there were no significant influences of changes in the physical office environments on perceptions of the social environment in terms of social stress and social climate. This implied that the influences from the social environment on satisfaction, health, and job performance are independent from the influences of the physical and socio-spatial environment. Social stressors and crowding stress can be understood as two independent concepts. Social support and social stressors therefore are included as predictors rather than outcomes in the regression models analysed subsequently.

10.8.1. Effects on job satisfaction

Repeated measures ANCOVAS showed that job satisfaction was affected significantly by an interaction of time and organisation ($F\ (4,242) = 5.50$ $p < .001$, partial $\eta^2 = .08$). In three experimental groups, job satisfaction was reduced after change of the office environment. In one organisation (organisation C) job satisfaction was higher after change. Change of office environment has an effect of medium size on job satisfaction (as indicated by the partial $\eta^2 = .08$).

Longitudinal regression analyses show that privacy and office noise are the main variables from the office environment that influence job satisfaction. Changes in the perceptions of privacy and office noise explain eighteen per cent of variance in addition to the variance explained by job satisfaction at time 1 and control variables including job design. This figure represents a medium to large effect. However, the influence of environmental factors on job satisfaction is not confirmed in a second model that uses a different subset of data and different predictors related to the office environment.
Cross-sectional regression analyses show that characteristics of the office environment such as distractions, privacy, crowding, climate, and workplace appropriateness explain 12 to 37 per cent of variance. Job characteristics explain additional 15 to 23 per cent and the social environment additional 0 to 7 per cent of variance in job satisfaction. In the cross-sectional regression models there are some indicators for mediation and suppressor effects concerning office and job characteristics. Specifically control may be mediated by job characteristics and crowding effects seem to be suppressed by social support and social stress respectively.

Taken together, these analyses indicate that the office environment has an impact on job satisfaction. The effect is of medium to large size and both, socio-spatial and environmental variables play a role.

10.8.2. Effects on Environmental satisfaction

The longitudinal, repeated measures analyses of variance show a main effect for organisation on work area satisfaction ($F (4,140) = 5.18$ $p < .01$, partial $\eta^2 = .13$). This effect most likely reflects the different office workplace and design standards applied in the participating organisations. The interaction of time and organisation was also significant ($F (4,140) = 5.48$ $p < .001$, partial $\eta^2 = .14$ for work area satisfaction and $F (3,100) = 4.83$ $p < .01$, partial $\eta^2 = .13$ for overall environmental satisfaction). The effect size of change in the office environment in these analyses is moderate. In contrast, the effect sizes obtained in the longitudinal regression analyses are substantially higher ($\Delta R^2 = .44$ and $\Delta R^2 = .50$). Both, the repeated measures ANCOVA and the longitudinal regressions, however, are inconclusive in discovering the aspects of the office environment that cause the change in environmental satisfaction. One longitudinal model identifies privacy and indoor climate as important factors. A second longitudinal model shows that changes in the perceptions of the office environments are associated with changes in environmental satisfaction by a statistically significant increment in variance explanation. However, none of the predictors is statistically significant. This result may be attributed to the sample size that is small in relation to the number of variables.
Cross-sectional regression models show that socio-spatial variables (privacy, crowding, and distraction), office design variables (workspace quality, work and storage spaces), and office environment conditions (noise, lighting, climate, and control) have influences on overall environmental satisfaction and explain 42 to 70 per cent of the variance in this construct. Furthermore, workplace appropriateness is very strongly correlated with environmental satisfaction. The models indicate that privacy may be mediated by other variables of the office environment (notably workspace quality and assessment of work and storage spaces).

Overall, because the results from the longitudinal analyses are less consistent than the results from the cross-sectional analyses it can be hypothesised that for environmental satisfaction change of the office environment may be less important than the quality level of the office environment.

While environmental satisfaction is very strongly related to perceptions of facets of the office environment, the theoretical and practical value of this construct remains unclear and the relationship between perceptions of the office environment and environmental satisfaction is equivocal. Based on the literature review (chapter 5), environmental satisfaction can be considered a facet of job satisfaction. There is a close relationship between environmental and job satisfaction (see Table 25 and Table 26). Practical and theoretical significance of environmental satisfaction would be greater if the causal relationship between the two constructs was better understood. The implications of environmental satisfaction as a mediator between characteristics of the office environment and job satisfaction or performance would be greater than as a correlate of job satisfaction or performance. The relationship between the constructs therefore deserves more empirical research.

10.8.3. Effects on Organisational commitment

Organisational commitment was not significantly altered by changes in the office environment. Neither the repeated measures ANCOVA nor the longitudinal regression indicate that variables of the office environment have an influence on organisational commitment. Cross-sectional regression analyses, however, indicate that 12 to 23 per cent of variance in organisational commitment can be explained by office environment variables.

Organisational commitment is very strongly correlated with job satisfaction (see Table 25 and Table 26). Furthermore there is an overlap between the stronger predictors relating to the office environment for the two variables: Workplace appropriateness, workspace quality, social stress and privacy have a similar impact on both, job satisfaction and organisational commitment. Results for organisational commitment therefore can be considered as a confirmation of the results for job satisfaction.

10.8.4. Effects on Health

The longitudinal statistical analyses for health status do not show significant effects of office environment variables. However, the cross-sectional regression models showed that workplace appropriateness, environmental stressors, and workspace quality add to variance explained by social stress and work overload. Variance explanation for regression models including job and environmental aspects ranges from 16 to 30 per cent. In these models, variables pertaining to the office environment explain a large share of total variance explained. However, the models with health as an outcome were incomplete with regard to job characteristics

10.8.5. Effects on Individual work performance

Individual work performance was captured with three different measurements for self-assessed performance. There were no significant effects for two of them in the repeated measures analyses. However, there was a significant main effect of organisation on situational job performance ($F(4,125) = 3.23$, $p < .05$, partial $\eta^2 = .10$) and there was a significant interaction between time and organisation ($F(4,125) = 4.72$, $p < .01$, partial $\eta^2 = .13$). The main effect may be explained by organisational culture. The time-x-organisation interaction effect, on the other hand, shows that self-assessments of situational performance are lower after changes in the office environment in 3 organisations. In organisation D and in the control group, self-assessments of situational performance remained unchanged.

The longitudinal regression analyses revealed that privacy and social stress at time 2 together with variety and crowding at time 1 explain 28 per cent of variance in

addition to job characteristics and control variables. Similarly, work and storage spaces at time 2 together with distraction and social stress at time 1 explain thirty per cent of variance in situational performance in addition to job characteristics and control variables.
Results from the cross-sectional regression analyses show lower figures for variance explanation. In cross-sectional regression models environmental characteristics explained between 0 and 24 per cent of variance, with an outlier of 41 per cent in one model with situational performance as the outcome. The most important predictors from this set of analysis are distractions and social density. Additional variance explanation by job characteristics is similar in size. Also for this outcome there are indicators for mediation and suppressor effects. Notably the effect of control on performance seems to be mediated by job characteristics.

10.8.6. Relationships between office design variables and outcomes

From the longitudinal and cross-sectional regression analyses conclusions regarding the influence of different office environment characteristics can be drawn. Although due to the limitations in research design imposed by the participating organisations not all variables could be analysed in their influence on outcomes in the same configurations, an overview of relationships between office design variables and outcomes can be given (Table 103). This overview shows different patterns of relationships. Three variables appear as key variables as they have an influence on most outcomes. These variables are workplace appropriateness, workspace quality, and privacy. Workplace appropriateness is a general assessment of the functional quality of the work setting. Workplace appropriateness is significantly associated with all outcome measures. Workspace quality refers to the quality of the furnishings. This variable is related to all outcomes but individual work performance. Privacy describes the possibility to regulate interaction between self and others. Privacy influences job and environmental satisfaction, organisational commitment, and work performance.

In comparison to the empirical literature, the results from the first study (summarised in Table 103) are mostly consistent with previous findings (Table 1). The negative effects of office noise on job and environmental satisfaction are confirmed. The effects on health or work performance, however, are not confirmed. As in previous research, a positive association between indoor climate and environmental satisfaction was statistically significant. Furthermore, indoor climate is also associated with job satisfaction in my research. Lighting is associated with environmental satisfaction, a finding that confirms previous results. However, lighting is not associated with health or work performance in my research but it is associated with organisational commitment. The results for control over the office environment confirm the association with work performance but not with job satisfaction and health. However, in my research control is associated with environmental satisfaction. The findings for social density in relation to job and environmental satisfaction was ambiguous in previous and there was a negative association between social density and work performance. In my research there is a negative relationship between social density and environmental satisfaction and a positive relationship with work performance. Evidence from previous research regarding effects of privacy is inconclusive for job satisfaction and work performance and there is a positive association between privacy and environmental satisfaction. This research shows a positive association between privacy, job satisfaction, environmental satisfaction, and work performance. Previous findings on the negative effects of distractions and interruptions on job and environmental satisfaction as well as on work performance are confirmed.

In addition to previously studied influencing variables, results from the first study show that characteristics of the material environment such as work and storage space and workplace quality and the functional quality (workplace appropriateness) play an important role.

Table 103. Summary of empirically significant relationships between office design variables and outcomes from the first study

	Outcomes				
	Job satisfaction	Environmental satisfaction	Organisational commitment	Health	Individual work performance
Lighting		+	+		
Indoor climate	+	+			
Office noise	-	-			
Environmental stressors				-	
Work and storage space		+			+
Workplace appropriateness	+	+	+	+	+
Workspace quality	+	+	+	+	
Distractions	-	-			-
Privacy	+	+			+
Crowding	-	-			
Control		+			+
Social density		-			+

+	positive influence
-	negative influence
0	inconclusive evidence
Empty	no evidence
Grey	Result from longitudinal regression

Comparing the results to previous longitudinal research on interventions in the office environment, the following points can be noted. Even though the organisations examined experienced the same type of change in the office environment, analyses show that the changes in the assessments of the office environment characteristics within organisations do not follow the same pattern (as is substantiated by the significant time-x-organisation interactions). Regarding changes from cellular offices to open structures, previous longitudinal research documents decreases in satisfaction with the physical environment, physical stress, co-worker relations, and perceived job performance (Brennan et al., 2002). Similarly, Oldham & Brass (1979) report decreases in work satisfaction, interpersonal satisfaction, motivation, and job characteristics. Zalesny & Farace (1987) report decreased environmental satisfaction due to reduced privacy. Furthermore, in their study interpersonal relations improved and job characteristics remained unaffected with the exception of feedback. However, the results on job characteristics are unreliable because in the pre- and post-change surveys different scales for the measurement were used. The results of my analyses suggest that changes in the office environment without any other organisational change do not affect job characteristics and social relations. They do, however, affect perceptions of the office environment. Unlike the previous longitudinal studies, not only satisfaction was examined as an outcome variable. Changes in the perceptions of the office environment were accompanied by changes in job and environmental satisfaction and situational job performance. Conversely, there were no changes in organisational commitment, health symptoms, and two measures of self-assessed job performance.

From the documented cases and my research, the causal relationships among the variables remain unclear. In my study, organisations A and B show similar patterns of change that differ from changes in organisations C and D. This pattern may be due to the magnitude of the change in the office environment: the increase in social density is about twice as big in organisations A and B as compared to organisations B and C (Figure 27). For most analyses, the pre-change assessments are lowest in organisation C and highest in organisation D. Employees in organisation C perceive the move to a different office building in a positive light while employees in organisations A and B are less favourable. In organisation D the high level of the pre-change situation is generally maintained. It can be hypothesised that organisational size plays a role. Organisation D is the smallest of all participating organisations and the more positive ratings on socio-spatial aspects may be due to higher familiarity among employees and an organisational culture that values human relations.

The importance of the relationships between characteristics of the office environment with outcomes can be assessed by looking at the amount of variance these variables explain. The proportion of variance accounted for by a certain variable is a measure of effect size (Cohen et al., 2003). Based on the longitudinal regression analyses, variance explanation by environmental variables for job satisfaction is eighteen per cent. Variance explanation for environmental satisfaction is 44 per cent in one model and 50 per cent in the second model. No significant influences from the office environment on organisational commitment and health could be identified in the longitudinal analyses. Privacy and social stress explain 28 per cent of self-assessed job performance and the combination of work and storage space with social stress and distraction (both at time 1) explains 30 per cent in variance of situational performance.
Variance explanation from the cross-sectional regression analyses is summarised in Table 104. Although the regression models did not contain all variables from the three broad classes of influence (environmental, job-related, social), the magnitude of the relative effects can be assessed. Variance explanation in job satisfaction by

aspects of the office environment ranges from 12 to 37 per cent. Job design variables explain additional 15 to 23 per cent.

Environmental satisfaction is mainly predicted by variables relating to the office environment and virtually unaffected by job design. Variance in organisational commitment is explained to a relatively large degree by aspect of the office environment (12 to 23 per cent). Variance in health status is accounted for by environmental variables to 16 to 26 per cent.

The range of variance explanation by environmental variables for self-assessed job performance is between 0 and 41 per cent. Variance explanation for the measure for situational performance by factors of the office environment is much higher compared to the other two measures.

Table 104. R-square change in cross-sectional regression analyses

	Version / time	ΔR^2 Office environment	ΔR^2 Job design	ΔR^2 Social environment
Job satisfaction	A pre	.28	.19	.05
	A post	.30	.23	0
	C post	.37	.15	
	B pre	.13	0	
	B post	.12	0	
	D post	.31		.07
Environmental satisfaction	A pre	.62	0	
	A post	.67	0	
	D post	.58	0	
	B pre	.51	.01	
	B post	.42	0	
	C post	.70	0	
Organisational commitment	B pre	.12	0	
	B post	.17	.09	
	D post	.23	0	.05
Health	B pre	.20	.03	
	B post	.16	0	
	D post	.26	.04	.05
Self-assessed job performance	A pre	.15	.12	0
	A post	.14	.13	0
	C post	.12	.13	
Self-assessed job performance based on feedbacks	A pre	.16	.10	.04
	A post	0	.24	.08
	C post	0	.12	
Situational job performance	A pre	.19	.12	0
	A post	.24	.07	0
	C post	.41	.04	

The situational measure of self-assessed job performance is based on an appraisal of the current situation rather than on an assessment of a longer period in time from memory. This type of measure may be less susceptible to distortions associated with assessments of performance over a longer period of time. However, it may be influenced by situation-specific biases. Therefore this measure should be considered as a supplement measure of other self-report measures (Semmer, Grebner & Elfering, 2004). The results on situational job performance should be considered in context with the results of the other scales. The results on situational performance in the post-change surveys indicate that job performance may be more strongly influenced by environmental factors than assumed on the basis of the use of traditional self-report measures. On the other hand, the results may represent a biased association between features of new office environments and job performance.

The relative sizes of changes in variance explained by the three classes of influence demonstrate that a thorough understanding of the influences on the outcomes examined requires the combination of at least office and job characteristics. The indicators for mediation and suppressor effects in the cross-sectional regression models show that the relationship between elements of office and job design seems to be a complex one. The findings from the first study show that more elaborate theoretical and methodological models regarding the interplay between office and job characteristics are needed.

The different regression models summarised in Table 104 generally show a consistent picture for the magnitude of effects. This consistency shows that the relationships are independent of the specific contexts. Also the results are consistent over different versions of the questionnaire. The similarity of patterns in results over questionnaire versions is an indicator for the stability of the measures and results. However, the differences between organisations in the repeated-measures ANCOVA show that similar interventions in office environments have different effects in different organisations. These differences may be dependent on characteristics of the initial situation, the change procedures, and the interplay between office and job design. They also show that the generalizability of results from single case studies (that build the largest share of the field research literature) is very limited.

10.8.7. Limitations of first study

The main limitation of the first study is based in the data collection procedure imposed by the participating organisations. The setup of the first study reflects a general limitation of real-world research, namely the dependence on data provided by participating organisations (Robson, 2011). Due to limitations in the number of questions, different versions of the questionnaire and questionnaire administration have been used. This procedure leads to a fragmented set of results that must be combined to an overall picture. A possible strength of the procedure lies in the reduction of common-method bias[25] (Podsakoff et al., 2003, however cf. Spector, 2006).

A further limitation of the study is the number of participating organisations. Effects of organisation size, degree of change of the environment, and industry cannot be analysed in this sample. Furthermore, the change management procedure could not be thoroughly described. In all projects user representatives were involved in project organisations. In all organisations, employees rated perceived information and

[25] Common-method bias refers to the fact that both, the independent and dependent variables are measured using the same method. This may result in common method variance, i.e. the increased proportion of variance attributable to the method of data collection (and not to the constructs the variables represent).

participation lower at time 2 than at time 1 (Figure 40). All other work design variables remained unchanged between the two points in time. Moreover, a similar decrease was not observed in the control group. Therefore, the change management process seems to have influenced perceived information and participation negatively in the participating organisations in a similar way.

Furthermore, the participating organisations represent a convenience sample. Organisations were included in the study on the basis of their willingness to participate and the condition that they applied a change in the office environment within a certain time frame. Convenience sampling threatens external validity, i.e. samples are not representative of the population and generalizing from the results obtained from a convenience sample may be erroneous (T. D. Cook et al., 1990). However, convenience sampling may be very useful in program evaluation and treatment outcome studies (Nugent, 2010). Also, nonprobability sampling is rather the rule than the exception in research practice and careful interpretation of the results allow conclusions about causal connection within the boundaries of formal causal generalizability (Shadish et al., 2002).

There may be a bias in the longitudinal sample due to non-random attrition in the sample. The group of stayers is more homogenous compared to the complete sample and is composed of employees experiencing higher social support, higher satisfaction with work and storage spaces, lower social stress, and a higher preference for open office environments. Additionally, stayers are more likely to be male, employed to a higher degree (i.e. less part-time workers), and have higher education and more complex jobs. The effect sizes of these differences, however, are small and the homogeneity of the subsample may have led to underestimations of correlations involving social density and control due to variance restrictions.
On the other hand, attrition in the longitudinal sample limits the power of the longitudinal analyses. Sample sizes in this study are sufficient for the detection of large effects in the longitudinal regressions.
For a more complete longitudinal design, a second post-change measurement would be desirable (Cohen et al., 2003). It may be argued that change of office environments require time for adjustments and adaptation. However, the two empirical studies of office-related changes that employed two post-change measurement waves did not detect differences between the two points in time after the change had occurred (Brennan et al., 2002; Oldham & Brass, 1979). The sample sizes for the longitudinal analyses are sufficiently large to detect large effects only (Miles & Shevlin, 2001). Cross-sectional regression models therefore were also analysed in order to detect smaller effects. The causal interpretation of cross-sectional effects, however, is more tentative than with longitudinal analyses.

10.8.8. Conclusions and implications

The analysis of the effects of office design, job characteristics, and social environment on the outcomes shows that each of the classes has significant influences. Moreover, the results show that job and office characteristics are

interrelated in complex ways and there are indicators for mediation and suppressor effects. These findings imply that focusing only on one class of influences is insufficient for a thorough understanding of job and environmental satisfaction, organisational commitment, health, and individual performance.
The Job Demands-Resources framework allows the integration of the effects from the different classes of influences (Figure 45).

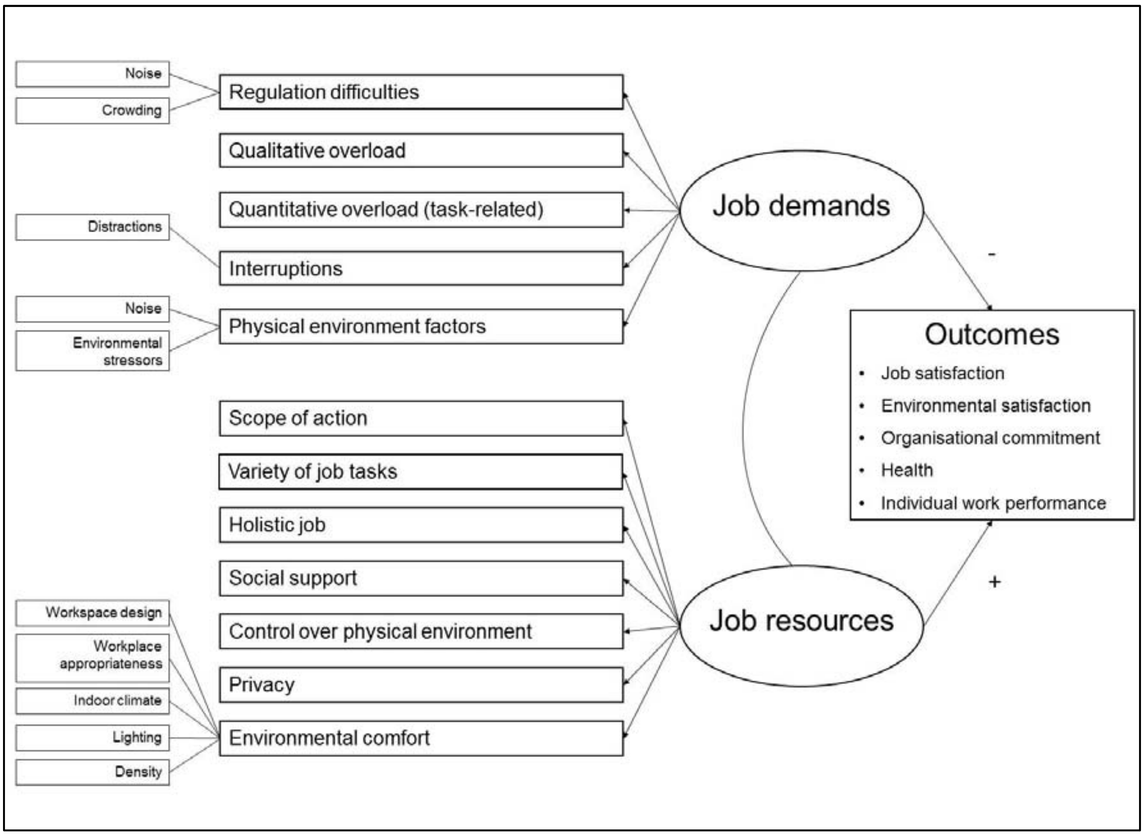


Figure 45. Position of environmental variables in Job Demands-Resources framework based on results of first study

Relating the findings to the theoretical model based on the Job Demands-Resources framework, some hypothesised associations need to be discussed: Workplace appropriateness, workspace quality, and privacy have positive relationships to the outcomes and therefore can be considered as resources (Figure 45) rather than demands (cf. Figure 22). The same is true for control, work and storage space, lighting, and indoor climate. Based on the review of literature and theoretical considerations, ambient environmental factors (such as lighting, noise, and climate) were expected to appear as demands rather than resources. The results from my field research in the first study, however, indicate that ambient environmental conditions tend to have no or small positive relations to the outcomes. This result indicates that these conditions were in an acceptable range in the organisations analysed. Other factors contributing positively to the outcomes are related to functional environmental comfort. These factors are work and storage space, workplace appropriateness, and workspace quality.
Environmental stressors, office noise, distractions, and crowding appear as demands as expected. However, ambient environmental variables seem to contribute to

resources through environmental comfort rather than as demands related to physical environment factors as had been hypothesised on the basis of previous evidence. The reason for this association of environmental variables to resources may lie in the nature of field research. Previous research on environmental aspects such as indoor climate and lighting has relied on laboratory experiments. The conditions generated in the laboratories may not be generalizable to field settings. The findings, however, may also be due to the use of bipolar rating scales used in the environmental features rating scales (Schaeffer & Presser, 2003). Bipolar scales assume unidimensionality of a construct from dissatisfactory to satisfactory. This assumption has been challenged in comfort research based on evidence that comfort and discomfort may be separate dimensions of experience (Zhang, 1996).

The study results confirm the assumption that interventions in office environments have effects on office users' perceptions of the work environment but do not affect job characteristics and perceptions of the social environment. Furthermore, individual preferences for open or encloses workspaces remain unaffected. These changes in perceptions of the office environment were accompanied by changes in job and environmental satisfaction and situational job performance. On the other hand, there were no changes in organisational commitment, health symptoms, and two measures of self-assessed job performance. The magnitude of the change in social density may explain the different patterns of change in the organisations studies. The causal relationship between changes in the quality of office environments and changes in perceptions and outcomes, however, is unclear.
Longitudinal analyses indicate that office noise and privacy are causes for changes in job satisfaction. Workplace appropriateness causes changes in environmental satisfaction. Privacy and the assessment of work and storage spaces may have a causal effect on self-assessed individual work performance. Additional cross-sectional regression analyses reveal more correlations between perceptions and assessments of the office environment and outcomes analysed. These results are based on models that control for the influence of job characteristics and the social environment. Perceptions and assessments of the office environment therefore add to variance explained by these classes of influence. Noise, crowding, and environmental stressors appear as demands, while workspace design variables, workplace appropriateness, indoor climate, lighting, and social density act as resources. However, the pattern of influence is not the same for all outcomes (job satisfaction, environmental satisfaction, organisational commitment, health, and individual work performance). The variables affecting most of the outcomes simultaneously are workplace appropriateness, workspace quality, and privacy.
The findings imply that because different outcomes are affected by different aspects of environmental perception, interventions in office design should be tailored to the goals prioritised in a specific project. Furthermore, many of the variables studied act as resources rather than demands. Previous research tended to focus on hindrances or aspects of office environment that can either hinder or support employees. The results from this study suggest that there may be more supporting aspects than previously studied. Thus the search for and analysis of further resources in office environments may expand our knowledge of effects of office design.

The results in the participating four organisations with pre-post change comparisons show heterogeneity in size and direction of effects. In order to better understand the contribution of office design on these changes, in the second study a larger sample of buildings is analysed and data on office design parameters are included in data collection and analysis. Mainly, a more detailed account is given for floor areas which are crucial space planning dimensions of office design (A. Marmot & Eley, 2000) and may affect satisfaction and job performance (Table 103).

11. Study 2: Models of influences of office and job characteristics on employee perceptions and reactions

The second study extends the scope of the first study and more objective physical office environment parameters are included in a cross-sectional design. The research goals of the second study consist in

- Combined analysis of two levels of influence related to office environments on office users: (1) building and design parameters and (2) office users' experience.
- Differentiation of within- and between-building effects on users' experience.
- Modelling effects of job design and design of physical office environment on users' experience.

With regard to contents of these research goals, the focus on building level is on office layout or office type and space allocation, respectively. This set of design parameters is on the one hand relevant for user experience on the social-organisational dimension of status and on individual dimension of experience (Vischer, 2005). On the other hand the analysis of this set of parameters contributes to a better scientific understanding user perceptions of the socio-spatial environment, a field of knowledge that carries important applications for balancing cost, status, comfort, and employee performance in space planning and design practice (A. Marmot & Eley, 2000). The emphasis among the outcomes (satisfaction, health, and work performance) is on individual work performance: different measures of individual work performance are employed in order to study the relationship between characteristics of office design and this class of outcomes.

11.1. Aim and research questions

Models of the effects of the environment on office users can capture influences that are constants across office environments. The environmental quality of one specific office, however, is a combination of design elements in interaction with users and the organisation-specific conditions and work tasks. Thus environmental quality is not exactly the same in every office (Vischer, 1989). For theoretical and practical reasons, it is desirable to know the objective office building characteristics that cause the differences in environmental quality.

The aim of the second study consists in the analysis of the degree to which relationships between office design and user perceptions is context-dependent. This aim refers to the influence of building-organisational unit entities[26] on individual-level outcomes. The analyses are performed using multilevel-models, a statistical technique that accounts for hierarchical structures in data. In this study data on the individual level (user perceptions) can be assigned to higher order units (buildings)

[26] The object of empirical studies of office buildings is an entity that is composed of a certain organisational unit in a specific building. In this study, the term building is used in the sense of such an entity.

that are characterised by certain attributes[27]. Thus, within- and between-building effects on users' experience are differentiated and the variance is correctly partitioned to the adequate level. With this procedure the research questions which are formulated as follows can be studied:

> *Research questions*: Which building level variables explain variance in employee-level outcomes (employee satisfaction, health, and work performance)? How much variance in employee level outcomes is explained by building level variables? Do building level variables moderate individual-level relationships between perceptions of the office environment and outcomes (i.e. are individual-level relationships different in different contexts)?

These questions are translated into multilevel model comparisons with incrementally added variables. Model 0 contains the dependent variable only and serves as a baseline. In model 0 variance is partitioned between level 1 (employees) and level 2 (buildings). It describes the variance explanation caused by membership to groups, i.e. buildings. Models 1 to 3 contain level 1 variables only. In model 1 control variables are added, model 2 contains office environment characteristics while model 3 includes perceived job characteristics. In model 4 level 2 variables are added. Each model can be compared to its predecessor and this comparison shows whether the more complex model fits the data better than the simpler model (deviance statistic; Hox, 2010). Thus, the explanatory value of different predictors can be analysed. The goal of a series of model comparisons consists in finding the model that fits best and is at the same time as parsimonious as possible.

The models analysed in the second study are based on known individual level associations between perceived characteristics of the office environment, perceived job characteristics, and outcomes. The building level extensions include office type and spatial density. These variables have received a relatively large amount of attention and have been shown to influence job and environmental satisfaction (see chapter 6.3). However, office type and spatial density have not been analysed in multilevel approaches. The analysis of office type and spatial density on individual level may be misleading and an atomistic fallacy may be present. This type of fallacy refers to drawing inferences regarding variability across groups based on individual level data. This fallacy describes the possible difference between associations at the individual and the group level. This problem arises when a conceptual model that belongs to the higher level (e.g. associations of spatial density and group performance) is tested with data collected only at a lower level (Hox, 2010).
This fallacy is also relevant for the study of effects of openable windows and ventilation. Ventilation type (Jaakkola & Miettinen, 1995; Mendell, Fisk, Deddens, Seavey, Smith, Smith, Hodgson, Daisey & Goldman, 1996; Zweers et al., 1992) and operable windows (Brager & Baker, 2009; Brager, Paliaga & De Dear, 2004) have

[27] Organisations are a third, higher-level, hierarchical unit. However, the number of organisations with multiple buildings in the sample is too small for the study of 3-level models (Bickel, 2007, p. 282, mentions a rule of thumb that suggests to do a multilevel analysis with at least 20 groups and 30 observations per group). In this study, 6 out of 24 organisations provided more than one building in the office building sample.

been shown to affect building users' health and satisfaction. Therefore these two building characteristics are included in the analyses. Furthermore, many parameters of office buildings and their perceived quality may be related to building age and time since the last indoor refurbishment, respectively (Thomas, 2010). In addition to these variables, building size as a building level measure of social density (cf. chapter 6.4 of theory section).

11.2. Method

11.2.1. Research design, Sample, and Data Collection

The second study is based on a cross-sectional research design. Twenty-four organisations volunteered to participate in the study and a total of thirty-nine buildings could be analysed. All but one of the buildings are located in the German speaking part of Switzerland, one building is located in Germany. Table 105 gives an overview of the organisations and buildings analysed. The building sample consists of eleven cell office concepts, eleven small group offices, fourteen large group offices, two open space offices, and one combi-office. The thirty-nine offices in the office building sample are spread over twenty-four organisations. Participation in the study was voluntary for organisations and employees. Six organisations participated with more than one office building: three organisations participated with two buildings, and three organisations participated with four, five, and seven office buildings, respectively (see Table 105).

Table 105. List of participant organisations and buildings analysed in second study

Sector	Building	Tenant	Owner/Occupier	Whole building	Part of building	Mechanical ventilation	Openable windows	Building age (years)	Duration since last refurbishment	Number of workspaces in building	Office type (dominant)	Number of respondents
Technology	A2	X			X	X		8	8	529	SG	57
Public Administration	B2	X			X	X		69	3	80	LG	27
IT	C2		X		X			3	3	18	SG	12
Construction	D2	X			X		X	43	5	39	C	23
Public Administration	E2		X	X			X	11	11	250	C	93
Public Administration	F2		X		X		X	108	10	280	C	66
Financial services	G2		X	X		X	X	40	1	258	SG	27
Financial services	H2		X	X			X	3	3	700	CO	45
Construction	I2a	X			X		X	38	11	32	LG	23
Construction	I2b	X			X		X	3	3	31	SG	18
Construction	J2	X			X		X	18	18	30	SG	18
Higher Education	K2a		X	X			X	40	1	30	C	39

	Higher Education	K2b		X	X		X	X	2	2	150	C	43
	Higher Education	M2	X			X		X	102	1	28	C	45
	Higher Education	N2		X	X			X	4	4	70	SG	24
	Construction	O2		X		X		X	32	0	35	C	35
	Construction	P2	X			X		X	4	4	70	SG	25
	Construction	Q2		X		X		X	17	0	105	LG	43
	Facility Management	R2a	X			X		X	38	11	70	LG	22
	Pharmaceutical Industry	S2a		X	X				2	2	217	SG	29
	Pharmaceutical Industry	S2b		X	X		X		2	2	248	LG	28
	Pharmaceutical Industry	S2c		X	X		X	X	0	0	145	LG	33
	Pharmaceutical Industry	S2d		X	X		X		3	3	256	LG	46
	Consulting	T2	X		X		X	X	3	3	989	OS	16
	Professional Association	U2	X			X	X		38	0	37	SG	16
	Technology	V2a	X		X				3	3	380	LG	30
	Technology	V2b		X		X		X	63	4	450	SG	36
	Telecom	W2a		X		X		X	19	2	173	LG	30
	Telecom	W2b	X		X		X	X	26	0	102	LG	19
	Telecom	W2c		X	X			X	103	2	750	LG	57
	Telecom	W2d	X		X				28	7	80	LG	12
	Telecom	W2e	X			X		X	28	2	830	LG	65
	Telecom	W2f		X		X		X	33	2	45	LG	10
	Telecom	W2g	X		X			X	2	2	1630	OS	65
	Financial Services	X2a	X			X		X	155	3	80	SG	28
	Financial Services	X2b	X			X		X	72	5	64	C	27
	Financial Services	X2c		X		X		X	57	5	100	C	32
	Financial Services	X2d		X		X		X	67	4	130	C	60
	Financial Services	X2e		X		X		X	45	4	25	C	20
Sum		*39*	*18*	*21*	*16*	*23*	*10*	*30*					*1344*
	Missing information												29
Mean									*34*	*4*	*245*		*35*
Std. Dev.									*36*	*4*	*333*		*18*
Total		*39*											*1373*

C = Cell office, SG = Small group, LG = Large group, OC = Open space, CO = combi-office

Organisations were invited to participate and if they did they received a link to the on-line survey they could distribute to the employees in the office building. Reminders for employees were also sent via e-mail and via a contact person in the building. Due to this procedure, no response rates can be calculated. The lower bound of the response rate can be calculated by dividing the number of participants by the number of workspaces in the office buildings. This calculation results in a theoretical value of 14 per cent. Since the links to the surveys were sent to employees of certain organisational units and not to all occupants in the buildings, the real response rate is much higher. Collection of objective building-related data was carried out by floor plan analyses and site inspection. Data were collected in the period from October through December 2008.

The total sample of employees consists of 1373 participants. The mean age of the participants is 40.1 years (standard deviation 10.6 years). The age distribution of the total sample is presented in Figure 46. Forty-six per cent of the participants are women. Seventy-five per cent of the participants are full-time employees (Figure 47).

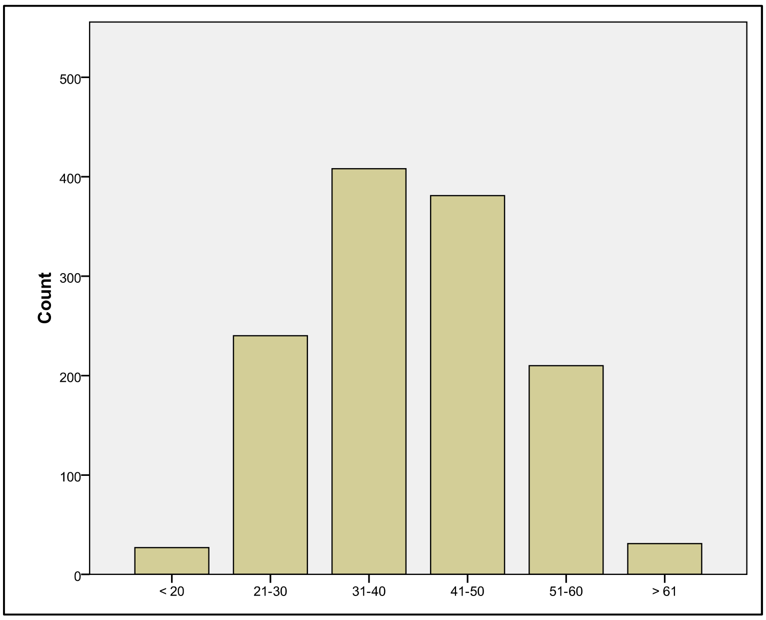


Figure 46. Age distribution of participants in the second study

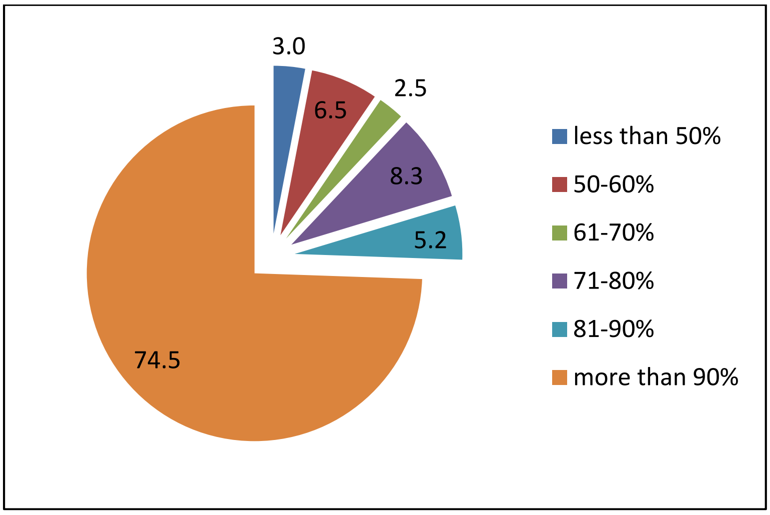


Figure 47. Degree of employment

Study participants were asked to estimate the amount of time they spend in the office buildings in relation to their total working time. The results are presented in Figure 48. Three quarters of all participants spend more than 70 per cent of their working time in their home base office building. The main activity in the office is desk work with a median of more than 70 per cent (Figure 49).

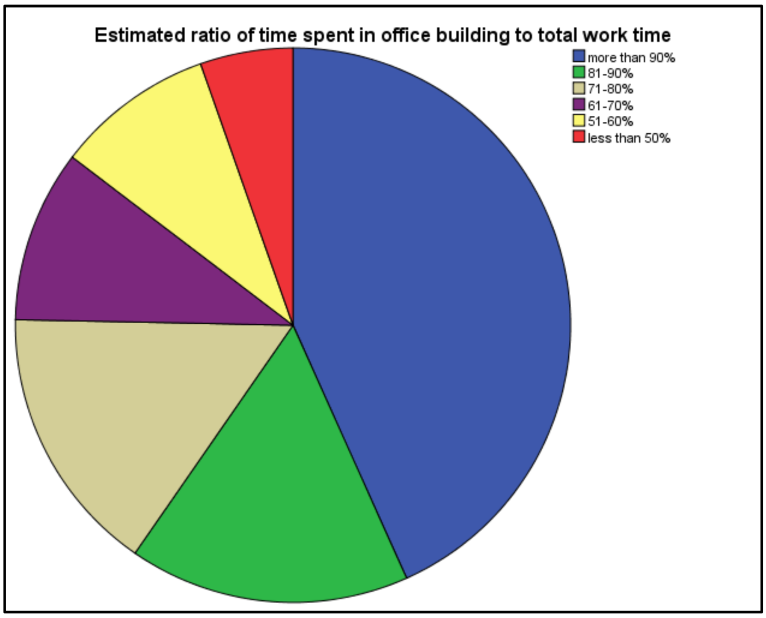


Figure 48. Ratio of working time spent in the office building (N = 1333)

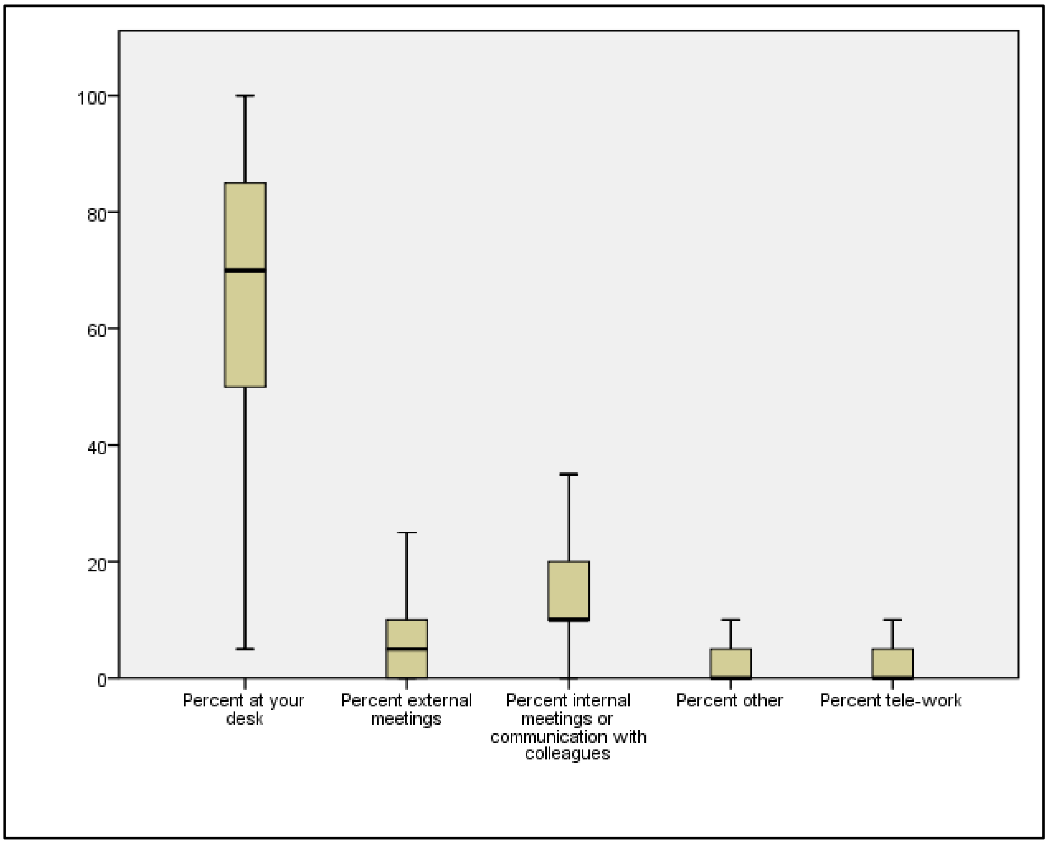


Figure 49. Amount of time spent in different activities (N = 1331)

Offices are defined by their form and their function. Consequently, architectural and functional features other than plan layouts are required for the description of offices. Office typologies therefore combine environmental factors that may have additively or otherwise combined elements, and that may have mediating or compensatory effects on each other (Bodin Danielsson & Bodin, 2008). Combinations of architectural and functional features can be clustered to categorise office types. The main and dominant architectural feature is spatial organisation. The functional features reflect the work practices that take place in the office (i.e. the functional quality for the office user). Office types can be described as follows (Bodin Danielsson & Bodin, 2008; Staniek, 2005):

- Open space offices are characterised by large open plans that are mostly free of columns and contain more than 50 workspaces. Often workstations are freely arranged in groups and screens are used between workstations to reduce noise and provide a minimal degree of privacy. While originally open offices were mainly used to provide cheap workspace (Boje, 1971), today the advantages for interaction among employees are stressed (e.g. Laing, 2006). Open space offices are recommended for routine work with spontaneous communication demands (Eisele & Staniek, 2005).
- Group offices (or small open space offices) contain 4 to 50 workspaces. The development of this type can be seen as a refinement of the open space office. The utilisation of advantages of open space offices (few status markers, communication) is combined with the compensation of their disadvantages (noise, light and distance to windows, no individual regulation of climate). Group offices are recommended for formal work groups, i.e. for people with similar work assignments or people that use information from each other or need to collaborate for their tasks (Eisele & Staniek, 2005). In this study small (3 to 15 workspaces) and large (16 to 50 workspaces) group offices are differentiated.
- Cellular offices are small enclosed offices with 1 to 2 users. Cellular offices consist of rooms along the façade of a building and thus every room has access to a window. The plan layout is characterised by long corridors that connect small offices to each other. Office work in cellular offices is characterised by independence and the possibility to concentrate, or to work without being disturbed or distracted respectively. This is true mainly if a cellular office is occupied by one person. Comfort ratings vary significantly between one and two person cellular offices in a study from Denmark (Pejtersen et al., 2006). These differences in comfort rating, however, do not translate into differences in health symptoms in this study. Thus, while cellular offices in office typologies usually are discussed as offices for 1 to 2 users, this definition may obscure important differences between solo use and other cellular offices.
- Combi-Offices combine cellular and open spaces. They provide high levels of personal enclosure at the building perimeter and shared spaces in the internal space. This type of office allows a quick change from individual to group work and vice versa. Combi-offices thus provide spaces on an “as-needed” basis and take advantage of open and enclosed spaces.

Primarily, office types are differentiated according to their spatial and functional characteristics. However, modern office concepts cannot be defined only by their spatial features but include temporal occupancy of workspaces (Gottschalk, 1994; Laing, 2006; Staniek, 2005). Non-territorial office use (flex office), however, is uncommon in Switzerland and none of the participating organisations employed non-territorial concepts at the time of the study. Contemporary open space and group offices in Switzerland usually are implemented as multi-space offices (Staniek, 2005). The multi-space character refers to employees having personal workstations and can use additional function-specific spaces according to their tasks and needs. Open space and group offices can be designed in very different forms. Therefore, several measures of available space per person are examined in this study in order to characterise different variants of the same office type.

11.2.2. Measures

Measures on the individual level include demographic control variables (gender, age, and tenure), job characteristics, perceptions of the office environment, and outcomes (see Table 106 for an overview). The level 2 variables are office type, spatial density (workspace area; total space per person and ratio of workspace to shared space per workstation), ventilation, windows, building age, time since last refurbishment, and size of organisation-building unit in terms of workplaces.

11.2.2.1. Level 1 measures: perceived office environment

A major limitation to multilevel modelling is the complexity of the models. Multilevel models tend to become instable with increasing complexity, mainly due to cross-level interactions and multicollinearity (Kreft & De Leeuw, 1998). Theoretical and substantive literature on office building level effects is very limited. Simplicity of the models analysed in this study is therefore considered a limiting yet necessary factor. Complex models often are not informative and tend to render interpretation and application of results difficult (Bickel, 2007). Therefore, the set of explanatory level 1 variables was limited and the following variables were selected to measure the core aspects of office environment perception (cf. chapter 6):

- Ambient environment: office noise, lighting, and indoor climate
- Socio-spatial environment: privacy, distractions, and social density
- Material environment: workplace appropriateness, work and storage space, and workspace quality
- Control over the office environment.

The scales used in the second study (Table 106) are generally the same as in the first study (see section 9.2.4). The measures of job characteristics were reduced to scope of action, variety, and qualitative and quantitative overload at work. Most theoretical approaches and empirical results tend to find scope of action (autonomy) the most important job characteristic (e.g. Frese & Zapf, 1994; Humphrey et al., 2007; Karasek, 1979; Karasek & Theorell, 1990). Variety is the second most important job characteristic in a meta-analysis (Fried & Ferris, 1987). Qualitative and quantitative overload are crucial factors (job demands) for well-being (e.g. Karasek & Theorell, 1990; Schaufeli, Bakker & Van Rhenen, 2009).
Outcome measures were completed with a scale on work engagement. Work engagement is defined as “a positive, fulfilling, work-related state of mind that is

characterized by vigour, dedication, and absorption" (Demerouti & Bakker, 2008, p. 69). The scale on work engagement was taken from Demerouti (1999; Demerouti, Mostert & Bakker, 2010; Oldenburg Burnout Inventory, OLBI). Originally developed to assess burnout, it includes positively and negatively phrased items and therefore can also be used to assess work engagement (Bakker, Schaufeli, Leiter & Taris, 2008; Demerouti et al., 2010; Gonzàlez-Romà, Schaufeli, Bakker & Lloret, 2006). The work engagement measure contains two dimensions, the first one representing vigour (exhaustion) and the second one representing dedication (disengagement). Vigour refers to high levels of energy at work and dedication describes a sense of significance, enthusiasm, inspiration, and pride.

Table 106. Overview of the scales used in the second study

	Scale	*Low values*	*High values*
Job characteristics	**Scope of action**	Low control, low degree of autonomy, few decision possibilities	High control, high degree of autonomy, many decision possibilities
	Variety	Few skills and abilities required	Many skills and abilities required
	Cognitive demand at work	High qualitative overload	No qualitative overload
	Quantitative overload at work	Strong time pressure or high quantitative overload	No time pressure or quantitative overload
Office environment	**Social density**	Low social density	High social density
	Work and storage space	Not enough work and storage space	Enough work and storage space
	Workspace quality	Inappropriate and unappealing office furniture	Highly appropriate and appealing office furniture
	Indoor climate	Poor lighting conditions	Excellent lighting conditions
	Lighting	Poor indoor climate	Excellent indoor climate
	Workplace appropriateness	Inadequate workspace	Highly adequate workspace
	Control	Low control over own working environment	High control over own working environment
	Office noise	Much disturbing noise	Little disturbing noise
	Distraction	Many auditory and visual distractions	Few auditory and visual distractions
	Privacy	Low privacy	High privacy
outcomes	**Work area satisfaction**	Low work area satisfaction	High work area satisfaction
	Overall environmental satisfaction	Low overall environmental satisfaction	High overall environmental satisfaction
	Job satisfaction	Low job satisfaction	High job satisfaction
	Health symptoms	Bad health, high frequency of psychosomatic symptoms	Good health, low frequency of psychosomatic symptoms
	Dedication	Disengagement	Engagement
	Vigour	Exhaustion	Vigour
	Self-assessed job performance	Low performance	High performance
	Self-assessed job performance based on Feedbacks	Low performance	High performance
	Situational job performance	Low performance	High performance

Work engagement has been shown to be positively related to job performance (Bakker & Demerouti, 2008 for an overview). Work engagement was used as an outcome measure in this study and was chosen to complement the performance measures used in the first study.

11.2.2.2. Level 2 measures: objective office environment

In addition to self-report measures, in this study measures for the description of building-related office aspects are employed:

- Office type (coded as 1 = cell office, 2 = small group office, 3 = large group office, 4 = open space, and 5 = combi-office)
- Ventilation type (0 = natural, 1 = mechanical)
- Building age in years
- Time since last indoor refurbishment in years (equal to building age in case no indoor refurbishment has been carried out since the building has been built)
- Windows (0 = not openable, 1 = openable)
- Building size (number of workspaces)
- Spatial density (see below)

Floor area measures for spatial density are used as an operationalization of physical density. At present, there is no standard measure of physical density in office workplace research (Duval, Charles & Veitch, 2002). Measures for floor areas therefore were developed using categories based on DIN 277 (DIN Deutsches Institut für Normung e.V., 1987) and the descriptions of the primary function areas therein. This norm serves for calculation of floor areas and cubature of buildings or parts of buildings. DIN 277 specifies the rules for the calculation of these areas and volumes. However, in DIN 277 function areas are confounded with office types, e.g. open plan offices are a subcategory of office space as a primary function area. This leads to illogical categorisations, for example closed break rooms in open plans are not considered part of the office area but open cafeteria areas are counted as part of the office area although the function of both types of spaces is the same. Therefore, categories were developed that are more appropriate for the description of contemporary office structures that often are hybrid forms of different office types (i.e. multi-space offices, see above). These categories should also represent different functions in relation to activities in diverse areas. The DIN 277 categories therefore were extended by a description of different zones in open space offices and focus rooms were added as a category of office space (Figure 50). Grey squares in Figure 50 are DIN 277 categories and white squares represent alterations. With this extension, spaces are differentiated according to their use and office areas for individual and social work activities can be distinguished.
Categories used for the description of offices in this study are the following:

- Workspace area includes space for accommodation of desk, chair, storage, and other necessary equipment in cell offices or open spaces. It also includes visitor chairs as well as small rooms for concentrated work (“focus rooms”) in open-plan offices.

- Circulation area includes circulation areas in the lettable area (primary circulation on the workplace floors) and circulation areas within the usable office space (secondary circulation).
- Meeting area includes meeting rooms and meeting zones.
- Communication area includes break rooms, break zones, recreation rooms, cafeterias and kitchenettes.

All measures were standardised in relation to total workspaces in the building and thus represent different facets of physical density.

Based on this differentiation of floor areas, spatial density can be calculated in three different ways:

- Spatial density I: workspace area per person (individual space)
- Spatial density II: total office space per person (available space per person, composed of individual and shared spaces: workspace area, circulation area, meeting area, and communication area)
- Spatial density III: ratio of workspace area to shared spaces per person

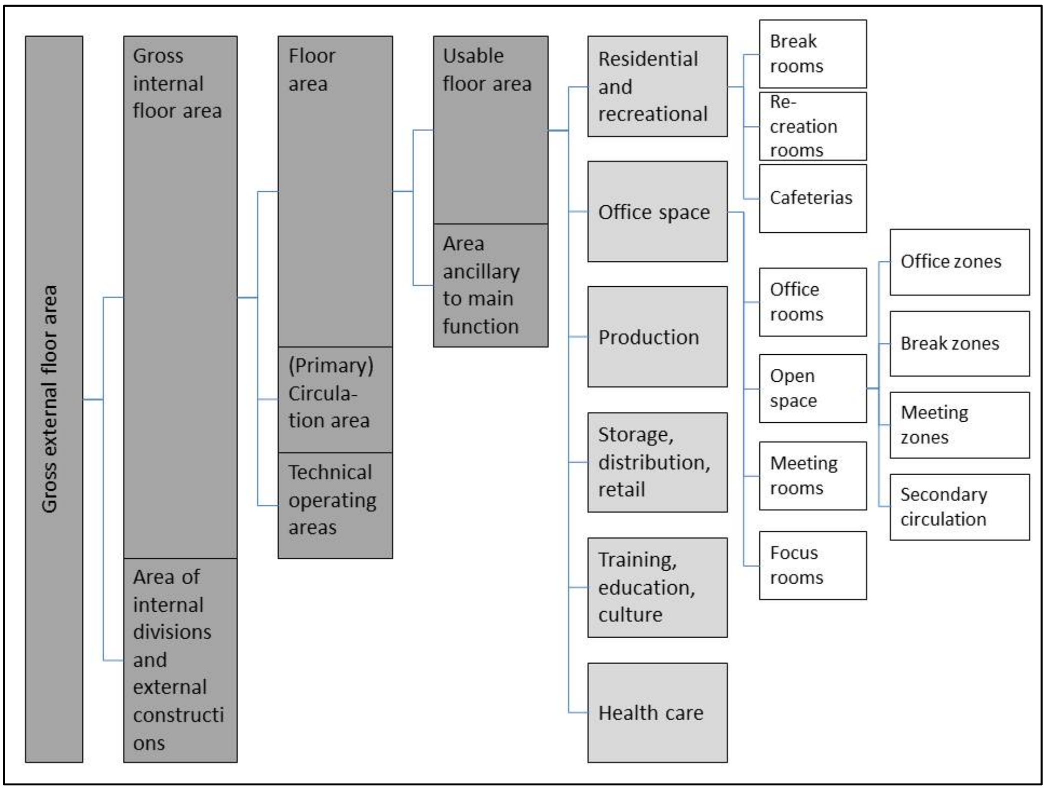


Figure 50. Area definitions (based on DIN 277, 1987, see text)

All floor area measures were calculated on the basis of floor plans. Office type and building size were identified using floor plans and was validated during a building inspection. Where there were several office types, the dominant type was coded for the building (see Table 105). Information on building size was also asked from the facilities manager. The categorisation of ventilation type (natural vs. mechanical) and windows (openable vs. not openable) is also based on information from the facilities manager and the building walkthrough. Building age and time since last indoor refurbishment was asked from the facilities manager.

11.2.3. Construct validity and internal consistency of scales

The items of the work engagement scale were analysed in a principal component analysis and internal consistency was computed. The procedure for assessing construct validity and internal consistency of scales is the same as in the first study (see chapter 9.2.5).

Table 107. Pattern matrix of the principal component analysis for OLBI items

	Component		
	1	2	3
OLBI4	.741		
OLBI12	.736		
OLBI10	.709		
OLBI8	.653		
OLBI5	.647		
OLBI14	.617	-.432	
OLBI16	.514		
OLBI2	.478		
OLBI6		.712	
OLBI7		.711	
OLBI1		.627	
OLBI11		.620	
OLBI9		.620	
OLBI3		.555	
OLBI13			.737
OLBI15			.666

Note: factor loadings below .4 are omitted

In disagreement with published results, the principal components analysis for the sixteen work engagement items resulted in three components (Table 107). Basically, the factor structure could be reproduced; however, two items from the original dedication component built a separate component (“This is the only type of work that I can imagine myself doing.” and „I feel more and more engaged in my work.”). These two items therefore were excluded from subsequent analyses and a second PCA was conducted without them. This second PCA confirmed the factor structure of the work engagement measure (Table 109).

The internal consistencies of the new scales are presented in Table 109. The values for internal consistency are satisfactory.

Table 108. Pattern matrix of the confirmatory principal component analysis for OLBI items

	Component	
	1	2
OLBI12	.723	
OLBI4	.716	
OLBI10	.714	
OLBI14	.674	
OLBI5	.655	
OLBI8	.616	
OLBI16	.518	
OLBI2	.446	
OLBI7		.778
OLBI1		.734
OLBI6		.725
OLBI9		.639
OLBI11		.621
OLBI3		.605
Note: factor loadings below .4 are omitted		

Table 109. Internal consistency (Coefficient Alpha) of the additional work engagement scales

Scale / construct (variable codes in brackets)	Subscales	Number of items	Internal consistency (Coefficient Alpha) as published in source of scale	Internal consistency
Work engagement (OLBI1-OLBI16)	Vigour (OLBI2, OLBI4, OLBI5, OLBI8, OLBI10, OLBI12, OLBI14, OLBI16)	8	0.73	0.82; N = 1275
	Dedication (OLBI1, OLBI3, OLBI6, OLBI7, OLBI9, OLBI11)	6	0.83	0.81; N = 1307

11.2.4. Data screening and transformation

Analyses of the distributions of the variables showed that most variables are moderately negatively skewed. Similarly to the first study, distributions for social stress caused by colleagues and by supervisors had the shape of exponential distributions. Therefore also in the second study the two scales were integrated to form a measure of social stress. This measure was log-transformed in order to further improve its distribution. Other variables that were log-transformed in order to improve the normality of the distributions are work area satisfaction, social density, health, and self-assessed performance based on feedbacks. Situational performance was transformed using square root transformations.

As in the first study, qualitative and quantitative overload were integrated to form a general overload at work scale in order to improve the distribution and internal consistency.

The descriptive statistics for the variables used in the second study are presented in Table 110. The Alpha values are appropriate.

Table 110. Descriptive statistics for the level 1 measures used in the second study

	N	Minimum	Maximum	Mean	Std. Deviation	Cronbach's Alpha
Scope of action	1335	1.00	5.00	3.78	0.79	.78
Variety	1339	1.00	5.00	3.87	0.78	.78
Overload	1337	1.00	5.00	2.74	0.75	.69
(LG10) of Social Density	1305	0.00	2.00	0.84	0.59	n/a[28]
(Log of) Work and storage space	1368	0.00	0.70	0.43	0.22	.86
Workspace quality	1366	1.00	5.00	3.61	0.92	.84
Lighting	1369	1.00	7.00	4.84	1.10	.85
Indoor climate	1369	1.00	7.00	4.22	1.24	.85
Workplace appropriateness	1369	1.00	7.00	4.24	1.02	.83
Control	1361	1.00	5.00	3.13	0.84	.84
Office noise	1360	1.00	7.00	4.72	1.11	.74
Distraction	1356	1.00	7.00	4.27	1.36	.83
Privacy	1363	1.00	5.00	3.21	0.82	.84
(Log of) Work area satisfaction	1366	0.00	0.70	0.40	0.18	.94
Job satisfaction	1364	1.00	7.00	4.75	1.10	.77
(Log of) health symptoms	1344	0.00	0.70	0.47	0.14	.87
Dedication (work engagement)	1343	1.17	4.00	3.18	0.53	.81
Vigour (work engagement)	1342	1.00	4.00	2.18	0.49	.82
Self-assessed job performance	1337	2.00	5.00	3.87	0.52	.76
(Log of) Self-assessed job performance based on Feedbacks	1332	0.00	0.70	0.44	0.13	.84
(Log of) Situational job performance	1336	0.00	1.52	0.81	0.27	.71
Valid N (listwise)	1252					

The building sample consists of eleven cell office concepts, eleven small group offices, fourteen large group offices, two open space offices, and one combi-office.

[28] Cronbach's Alpha cannot be computed for social density because this is an objective measure (and not a multi-item scale) of the number of persons in an office room.

The quantitative level 2 data are summarised in Table 111. Screening of the nominal and ordinal data revealed that 29 buildings have natural ventilation and 10 buildings have mechanical ventilation. In 30 buildings the windows can be opened and in 9 buildings windows are not openable.

The descriptions of the space categories per workspace are summarised in Table 111. The average office space per workplace is 18.4 m^2 (median 16.9m^2). These values are consistent with values from a FM market and benchmarking survey for Swiss offices (pom+ Consulting AG, 2009). Mean values for total workspace per person in this survey were 19m^2 (standard deviance 6m^2), the median value was 18m^2.

Table 111. Floor space categories per workstation in m^2

		Workspace area per workplace	Circulation space per workstation	Meeting space per workstation	Communication space per workstation	*Sum of social spaces per workstation*	***Total***
N	Valid	*39*	38	38	38	*38*	**38**
	Missing	*0*	0	1	1	*1*	**1**
Mean		*10.54*	5.36	1.86	.66	*7.80*	**18.41**
Median		*10.34*	3.87	1.69	.37	*6.45*	**16.89**
Std. Deviance		*2.34*	2.99	1.29	.70	*4.19*	**5.61**
Minimum		*7.40*	1.26	.23	.00	*2.28*	**10.12**
Maximum		*15.38*	13.78	7.16	2.44	*19.38*	**32.72**

11.2.5. Statistical analysis

Office buildings differ from each other in various ways. In order to examine the influence of building characteristics on (individual level) outcomes, multilevel analyses are employed. This type of statistical analysis is an extension of multivariate regression. It takes account of research designs where data are organised at more than one level. Multilevel analyses incorporate hierarchical structure by allowing intercepts (means) and slopes (relationships between variables) to vary between higher level units (i.e. building characteristics) (Tabachnick & Fidell, 2007). This procedure allows the identification of within- and between-building effects on users' experience.
Multilevel analyses account for the fact that data are organised by higher level constructs. In this study, individuals are nested within offices. It can be assumed that higher level (contextual) variables in the hierarchy introduce dependency in the data (Field, 2009). This dependency can be assessed using intraclass correlation: The higher the intraclass correlation, the more homogeneity among participants within buildings (or groups defined by building level characteristics). Because individuals in certain contexts are more similar to each other than individuals across contexts, level 1 linear models may differ across contexts (i.e. level 2 variables). More precisely,

while explanatory variables and outcomes are the same, regression coefficients vary between contexts. The two levels may be linked by using a hierarchical system of regression equations (Hox, 2010) that link together the models by a level 2 model in which the regression coefficients of the level 1 models are regressed on the level 2 explanatory variables. Multilevel models thus involve a statistical integration of different models. In random coefficient models, level 1 regression coefficients are treated as random variables at level 2 (*"random"* coefficients) varying randomly across groups around an overall solution valid for the whole sample or population (*"fixed"* coefficients). Level 1 regression coefficients are viewed as originating from a probability distribution. Mean and variance are the most important parameters of this distribution. These parameters are estimated in the multilevel model. Unexplained variance in the dependent variable is divided into different components and this more complex structure of error variance allows a more precise estimation of the regression coefficients of the multilevel model. Adding level 2 explanatory variables to the random coefficient model makes it more general and useful (Kreft & De Leeuw, 1998).

Multilevel modelling is often conducted in a sequence of steps (Hox, 2010; Tabachnick & Fidell, 2007). The starting point is an intercept-only model (i.e. a model with no explanatory variables) that is useful as a null model and serves as a benchmark with which other models are compared. This model allows the calculation of an intraclass correlation as an initial examination of the degree of between-group variation. An intraclass correlation represents the proportion of the total variability in the outcome that is attributable to the level-2 explanatory variable (Field, 2009). Thus it is a measure of effect size (Tabachnick & Fidell, 2007). If buildings have a large effect on users' perceptions then the variability within the building will be small because users tend to report similar perceptions and assessments. This leads to minimized variability in self-reports within buildings and to maximised variability between buildings. In this case, the intraclass correlation will be large.
Further models including predictors are compared to the intercept-only using a statistic called *deviance* which indicates how well the model fits the data (Hox, 2010). Models with level 1 independent variables are analysed first, yielding random coefficient regression models. Level 2 independent variables are entered in the models subsequently to see how they affect the level 1 intercepts and slopes (Field, 2009; Hox, 2010; J. H. Kahn, 2011; Tabachnick & Fidell, 2007).

The advantages of the multilevel approach are fourfold (Field, 2009; Tabachnick & Fidell, 2007). First, multilevel models correctly partition variance to the adequate level. They overcome the assumption of homogeneity of regression slopes between different groups by modelling this variability in relationships. Second, with multilevel models the consistency of the relationship between independent and dependent variables across different contexts (level 2 variables) can be examined. Third, multilevel models are robust against violations of homoscedasticity and sphericity and do not require independent data. Fourth, multilevel models are robust in relation to missing data.

12. Results of Study 2

12.1. Descriptive results

Table 112 displays the correlation matrix for level 1 variables. The correlation matrix shows that degree of employment, education level, and ratio of time spent in the office building have few statistically significant correlations with workplace perceptions and outcomes. Correlations between these control variables and job characteristics, health symptoms, and dedication are significant, but small in size. Tenure is significantly correlated with all work environment variables whereas age is not. Furthermore, social density is negatively correlated with all other work environment variables, i.e. higher social density is associated with lower ratings of office environment. The intercorrelations between variables pertaining to the office environment are statistically significant and the sizes are medium to high.

The correlation matrix for level 2 variables is presented in Table 113. The matrix shows a significant negative correlation between building age and office type indicating that older buildings tend to have office rooms of low social density (i.e. cell offices or small group offices) and newer buildings tend to have larger office rooms. Furthermore, size of office building is correlated with predominant office type and workspace size, indicating that larger office buildings contain larger office rooms with less individual workspace per employee. Ventilation and openable windows are correlated as can be expected: in buildings with natural ventilation windows can be opened. Ventilation is also significantly correlated with the spatial density measure that combines shared space with workspace area per person. In buildings with high ratios of shared space, mechanical ventilation is employed. Measures of spatial density are correlated as follows: individual workspace per employee is significantly correlated with total available space per person. The sum of available space per person is also significantly correlated to the ratio of shared space to workspace, i.e. the higher the total available space the higher also the ratio of shared space. This finding indicates that increases in total space per person are due to increases in shared spaces.

Table 112. Correlation matrix for level 1 variables

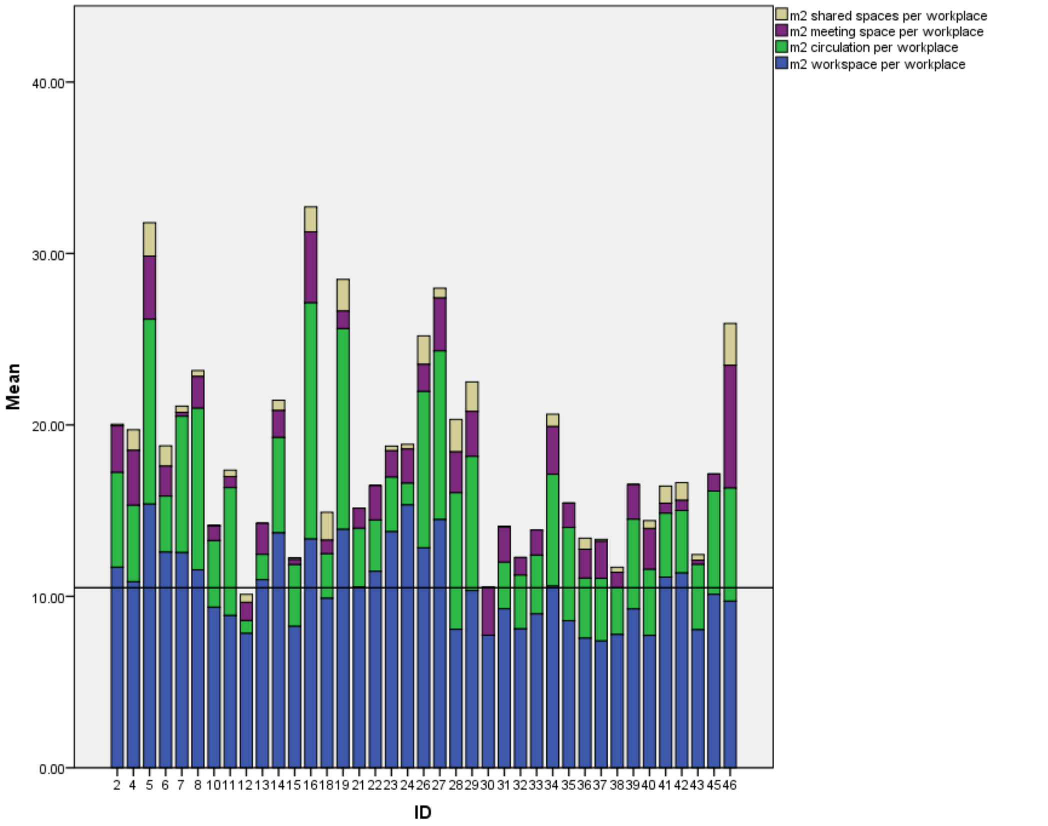
	Age	Tenure	Sex	Degree of employment	highest degree	Ratio of time spent in office building to total work time	Scope of action	Variety	Qualitative and quantitative stress at work	(LG10) of Social_Density	Assessment of diverse spaces offered in building	(Log of) Work and storage space	Workspace assessment	Lighting	Ventilation / temperature	Workplace appropriateness	Control	Controllability and adaptability of work environment	Office noise	Distraction	Privacy	(Sqrt of) Crowding	(Log of) Work area satisfaction	Overall environmental satisfaction	Job satisfaction	(Log of) health symptoms	Dedication	Vigour	Self-assessed job performance	(Log of) Self-assessed job performance based on Feedbacks
Tenure	.588**																													
Sex	.191**	.151**																												
Degree of employment	-.037	.061*	.320**																											
highest degree	.129**	-.047	.274**	.121**																										
Ratio of time spent in office building to total work time	-.141**	-.109**	-.204**	.090**	-.182**																									
Scope of action	.103**	.058*	.060*	.097**	.153**	-.217**																								
Variety	.109**	.045	.080**	.132**	.147**	-.211**	.502**																							
Qualitative and quantitative stress at work	.027	.079**	.145**	.151**	.122**	-.050	-.017	.237**																						
(LG10) of Social_Density	-.032	.171**	.115**	.132**	.059*	-.059*	-.084**	-.080**	.056																					
Assessment of diverse spaces offered in building	-.027	.047	.141**	.170**	.149**	-.188**	.178**	.188**	.043	.216**																				
(Log of) Work and storage space	-.019	-.117**	-.046	-.051	.018	-.021	.175**	.141**	-.159**	-.200**	.104**																			
Workspace assessment	-.033	-.086**	-.038	-.035	-.020	-.036	.184**	.207**	-.056	-.092**	.236**	.449**																		
Lighting	-.019	-.061*	.123**	-.004	.056	-.056	.143**	.188**	-.020	-.074*	.188**	.376**	.484**																	
Ventilation / temperature	.023	-.098**	.141**	-.048	.092**	-.046	.145**	.199**	-.007	-.254**	.164**	.317**	.434**	.504**																
Workplace appropriateness	-.060*	-.133**	-.018	-.037	-.031	-.008	.209**	.213**	-.106**	-.359**	.190**	.539**	.653**	.546**	.580**															
Control	-.069*	-.119**	-.079**	-.022	-.038	-.010	.296**	.237**	-.075**	-.415**	.149**	.456**	.507**	.381**	.408**	.696**														
Controllability and adaptability of work environment	-.067*	-.153**	.036	-.049	-.032	.013	.110**	.149**	-.017	-.465**	.012	.321**	.304**	.392**	.561**	.483**	.458**													
Office noise	-.044	-.082**	-.022	-.056	-.055	-.021	.160**	.144**	-.145**	-.302**	.080**	.322**	.367**	.343**	.436**	.626**	.456**	.353**												
Distraction	-.030	-.113**	-.059*	-.078**	-.069*	.004	.186**	.159**	-.201**	-.419**	.056	.344**	.391**	.338**	.385**	.683**	.558**	.398**	.656**											
Privacy	-.047	-.141**	-.036	-.037	-.051	-.002	.190**	.167**	-.179**	-.478**	.066*	.354**	.400**	.331**	.405**	.697**	.638**	.453**	.613**	.752**										
(Sqrt of) Crowding	.070*	.131**	.056	.052	.006	.009	-.135**	-.131**	.138**	.356**	-.081**	-.431**	-.412**	-.369**	-.421**	-.678**	-.516**	-.399**	-.516**	-.535**	-.601**									
(Log of) Work area satisfaction	-.052	-.111**	-.067*	-.047	-.037	-.005	.225**	.256**	-.109**	-.241**	.249**	.483**	.728**	.476**	.497**	.722**	.594**	.409**	.468**	.545**	.553**	-.548**								
Overall environmental satisfaction	-.075**	-.145**	-.026	-.038	-.016	-.004	.175**	.193**	-.072*	-.255**	.205**	.470**	.663**	.537**	.519**	.826**	.600**	.432**	.512**	.564**	.582**	-.616**	.705**							
Job satisfaction	.026	-.037	-.027	-.034	-.008	-.034	.338**	.451**	-.081**	-.145**	.187**	.294**	.471**	.341**	.347**	.482**	.440**	.242**	.373**	.435**	.409**	-.339**	.566**	.488**						
(Log of) health symptoms	.007	-.001	.183**	.082**	.127**	-.124**	.257**	.223**	-.176**	-.021	.157**	.209**	.237**	.230**	.257**	.284**	.204**	.150**	.292**	.342**	.287**	-.213**	.306**	.245**	.363**					
Dedication	.110**	.001	.055	.052	.164**	-.144**	.405**	.653**	.059*	-.076**	.169**	.157**	.280**	.246**	.236**	.268**	.267**	.149**	.267**	.259**	.245**	-.218**	.337**	.279**	.634**	.325**				
Vigour	.000	-.070*	.003	-.031	.033	-.050	.287**	.250**	-.417**	-.031	.146**	.238**	.237**	.210**	.190**	.257**	.219**	.115**	.271**	.339**	.299**	-.209**	.319**	.241**	.525**	.536**	.492**			
Self-assessed job performance	.112**	.057*	-.034	.027	.037	-.052	.217**	.390**	.019	-.023	.078**	.049	.143**	.045	.082**	.121**	.092**	.037	.082**	.153**	.119**	-.069*	.167**	.146**	.335**	.168**	.428**	-.249**		
(Log of) Self-assessed job performance based on Feedbacks	.004	-.039	-.081**	.001	.035	-.014	.250**	.240**	-.121**	-.017	.088**	.077**	.116**	.070*	.063*	.114**	.128**	.021	.095**	.139**	.109**	-.067*	.160**	.096**	.231**	.140**	.290**	-.260**	.471**	
(Log of) Situational job performance	.150**	.068*	-.017	.015	.016	-.064*	.307**	.414**	-.044	-.076**	.082**	.119**	.178**	.155**	.179**	.176**	.160**	.156**	.162**	.220**	.213**	-.102**	.232**	.192**	.405**	.290**	.461**	-.373**	.536**	.364**

* p < .05, ** p < .01; listwise n = 1197

Table 113. Correlation matrix for level 2 variables

	Building age	Duration since last refurbishment	Number of workspaces in building	Predominant office type	Spatial density I: m2 workspace per workplace per person	Spatial density II: m2 total available space per person	Spatial density III: ratio of shared space to workspace area per person	Ventilation
Duration since last refurbishment	.046							
Number of workspaces in building	-.228	-.116						
Predominant office type	-.353*	-.139	.516**					
Spatial density I: m2 workspace per workplace per person	-.157	.292	-.369*	-.286				
Spatial density II: m2 total available space per person	-.301	.072	-.165	-.171	.743**			
Spatial density III: ratio of shared space to workspace area per person	-.244	-.184	.111	.060	.037	.681**		
Ventilation	-.247	-.272	.114	.201	-.042	.237	.340*	
Openable windows	.258	.073	.048	-.163	-.146	-.237	-.168	-.375*
* p < .05, ** p < .01; listwise n = 38								

Figure 51 gives an overview over ratios between different space categories in the buildings analysed. The heterogeneity of the offices is visible in the bandwidth of available spaces per workstation (Figure 51). Figure 52 shows the ratio of workspace to shared spaces per workstation in relation to office type. This figure shows that ratios of space are not determined by office type. Rather, different office types are realised with different spatial configurations. The correlation between workspace and shared space is moderate ($r = .44$, $p<.01$) indicating that there is no strong linear relationship between the sizes of individual and shared office spaces.



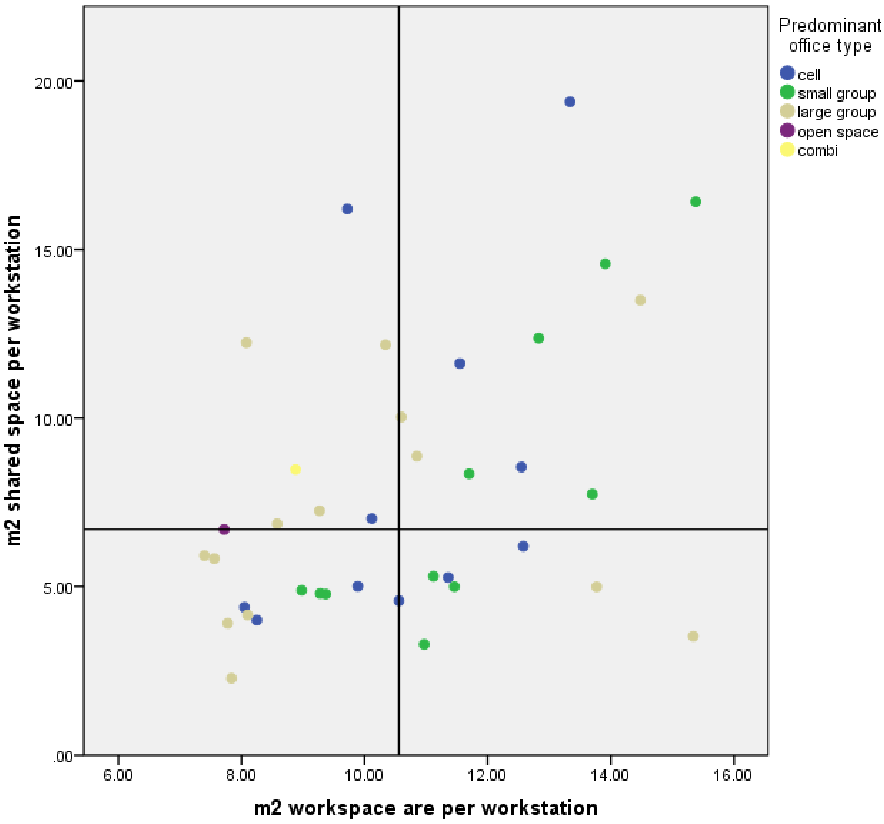
Note: data on circulation and shared spaces are missing for building 30; the horizontal line represents the median of workspace size

Figure 51. Size of different categories of floor spaces per building (n = 39)

Table 114 shows descriptive statistics for outcome variables aggregated on building level. The values show the degree to which the outcome variables vary between buildings. This variation is visualised in Figure 54 to Figure 60 to show how outcome variables differ between buildings.

Table 114. Means and standard deviances of outcomes (aggregated on building level; n = 39)

	(Log of) work area satisfaction	Job satisfaction	(Log of) health symptoms	Self-assessed job performance	(Log of) self-assessed job performance based on feedbacks	(Sqrt of) situational job performance	Dedication	Vigour
Mean	.39	4.70	.47	3.84	.44	.79	3.14	2.81
Standard deviance	.08	.34	.03	.18	.03	.08	.15	.10
Minimum	.21	3.80	.37	3.48	.37	.64	2.86	2.60
Maximum	.53	5.48	.53	4.13	.51	.93	3.44	3.03



Note: the horizontal and vertical lines represent median values

Figure 52. Ratio of workspace to shared spaces per workstation in relation to office type

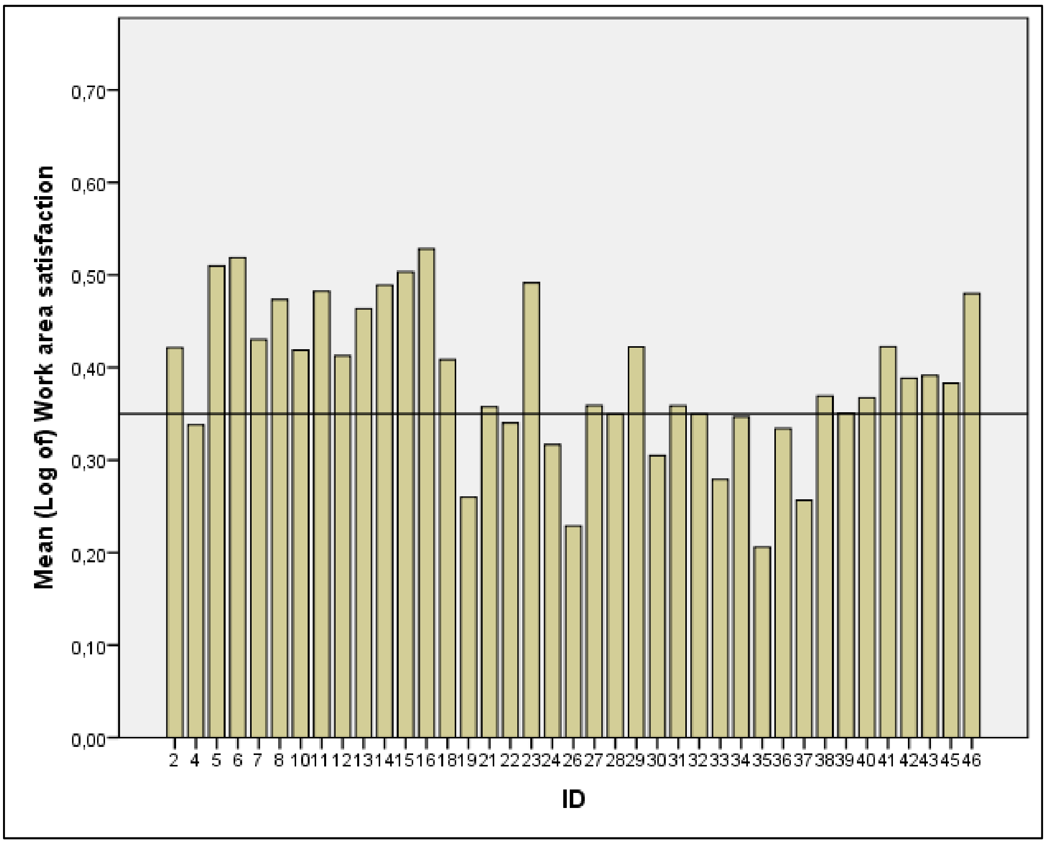


Figure 53. Mean values of (log of) work area satisfaction on building level

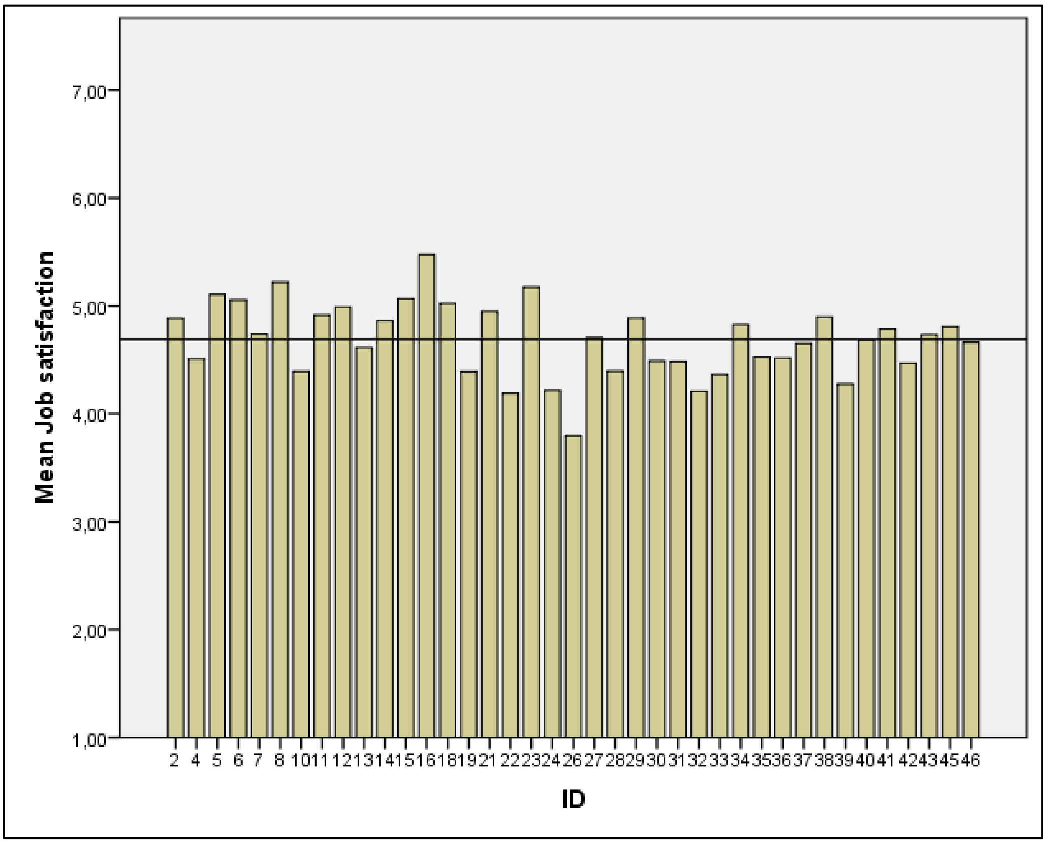


Figure 54. Mean values of job satisfaction on building level

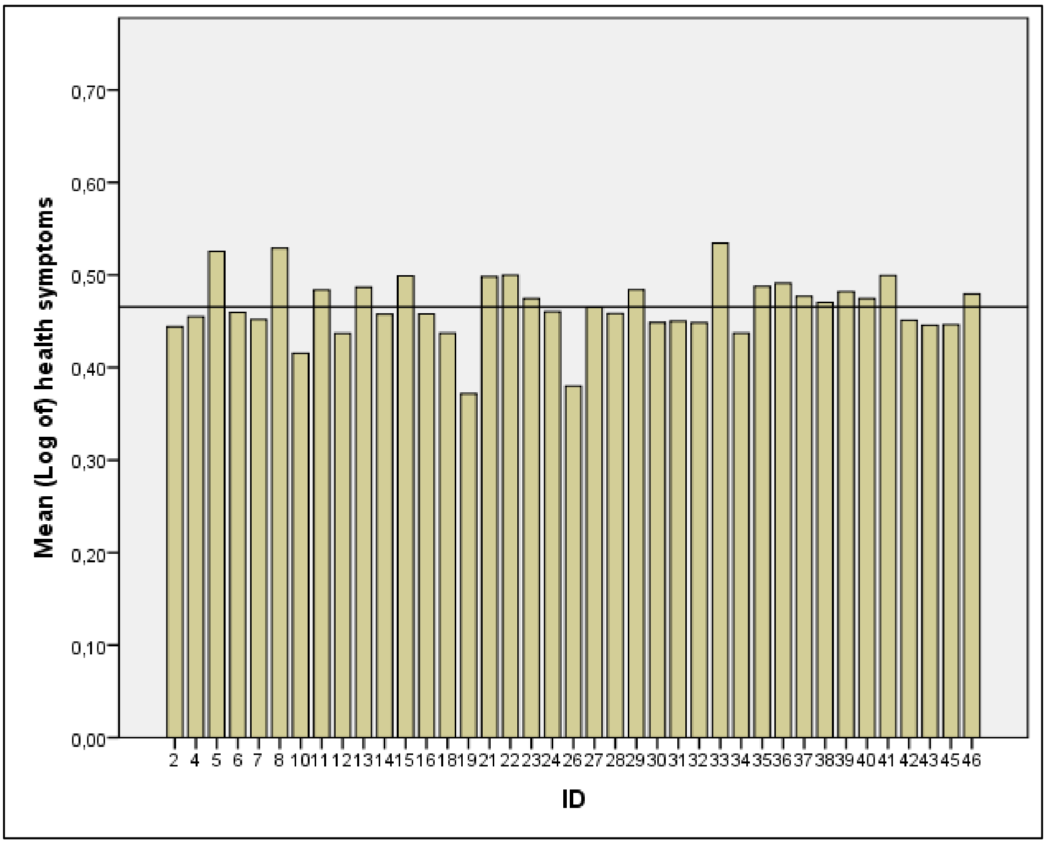


Figure 55. Mean values of health symptoms on building level

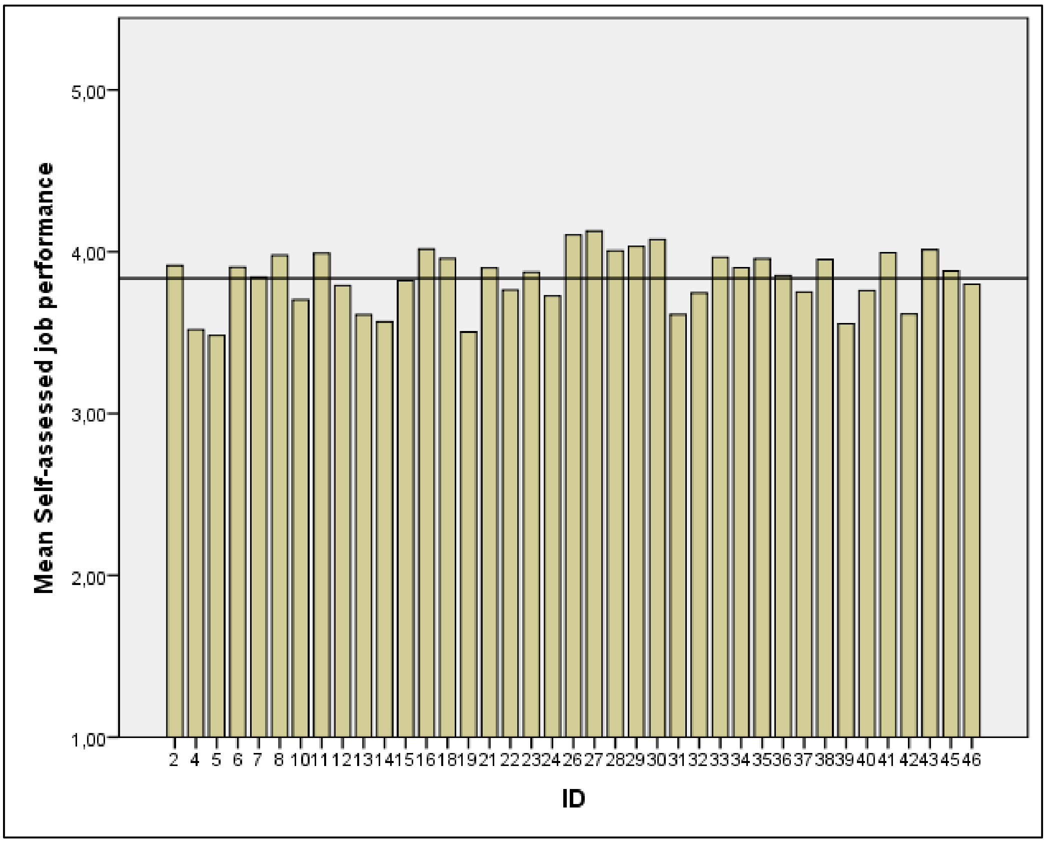


Figure 56. Mean values of self-assessed job performance on building level

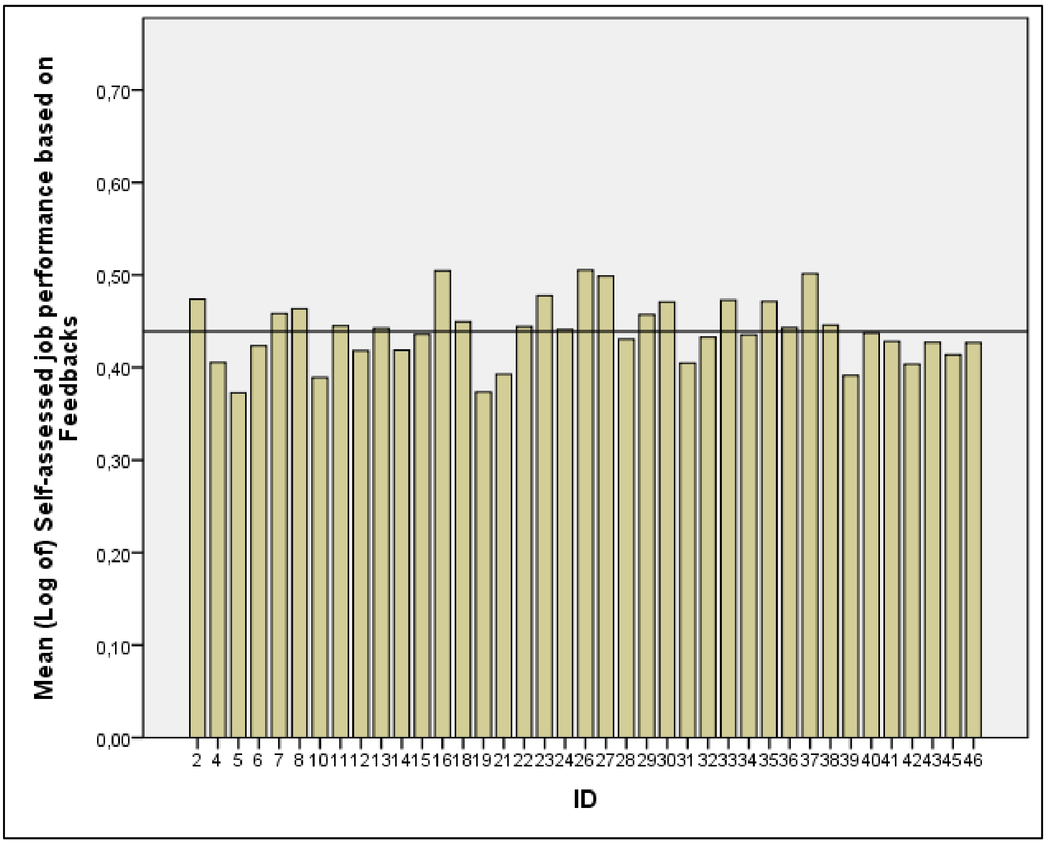


Figure 57. Mean values of self-assessed job performance based on feedbacks on building level

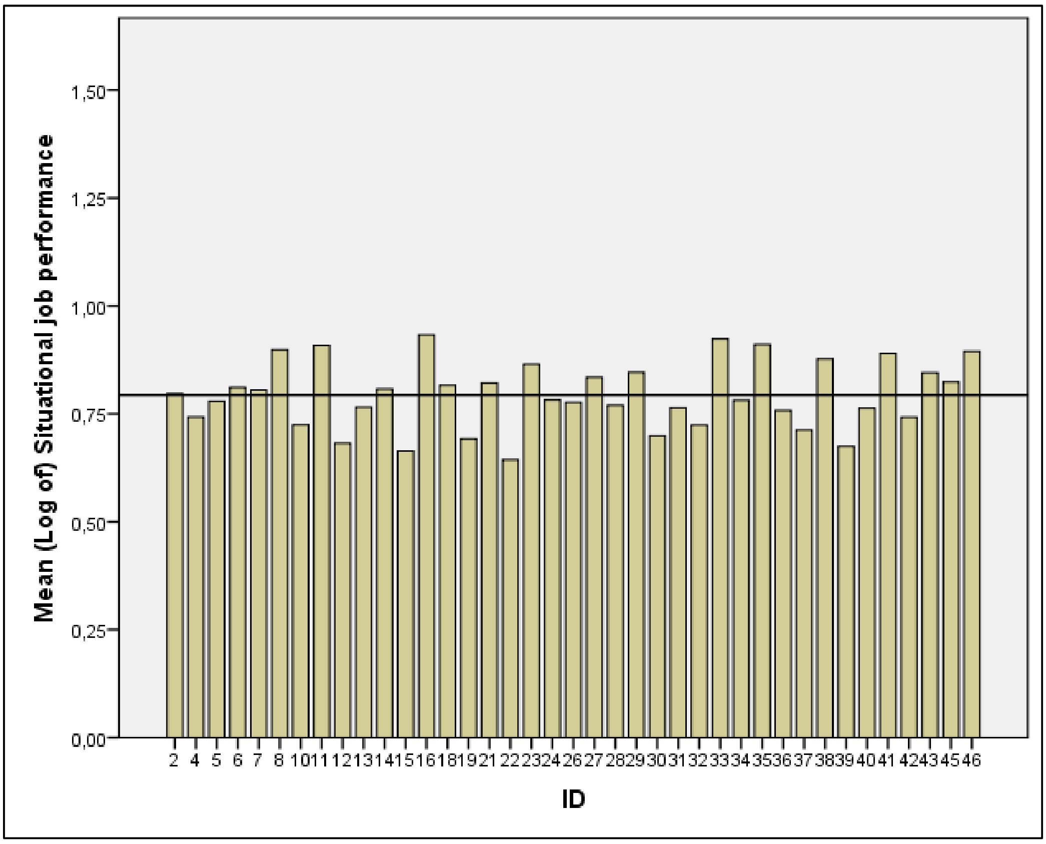


Figure 58. Mean values of situational job performance on building level

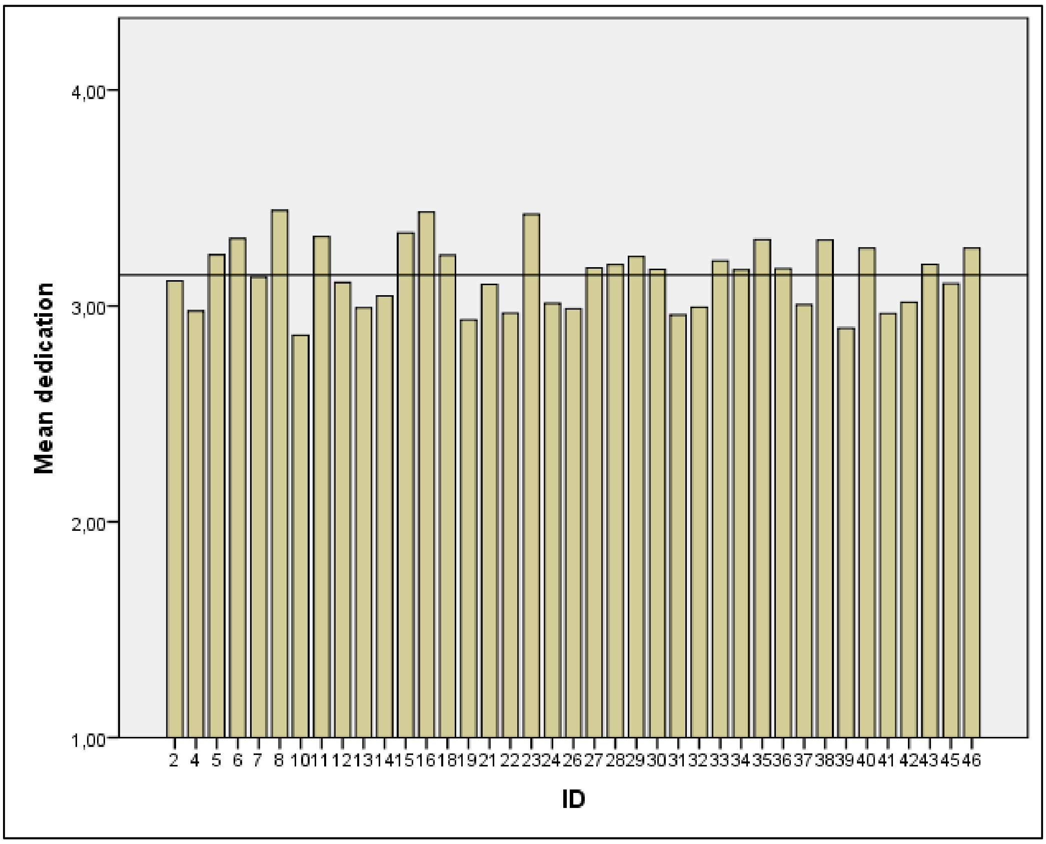


Figure 59. Mean values of dedication on building level

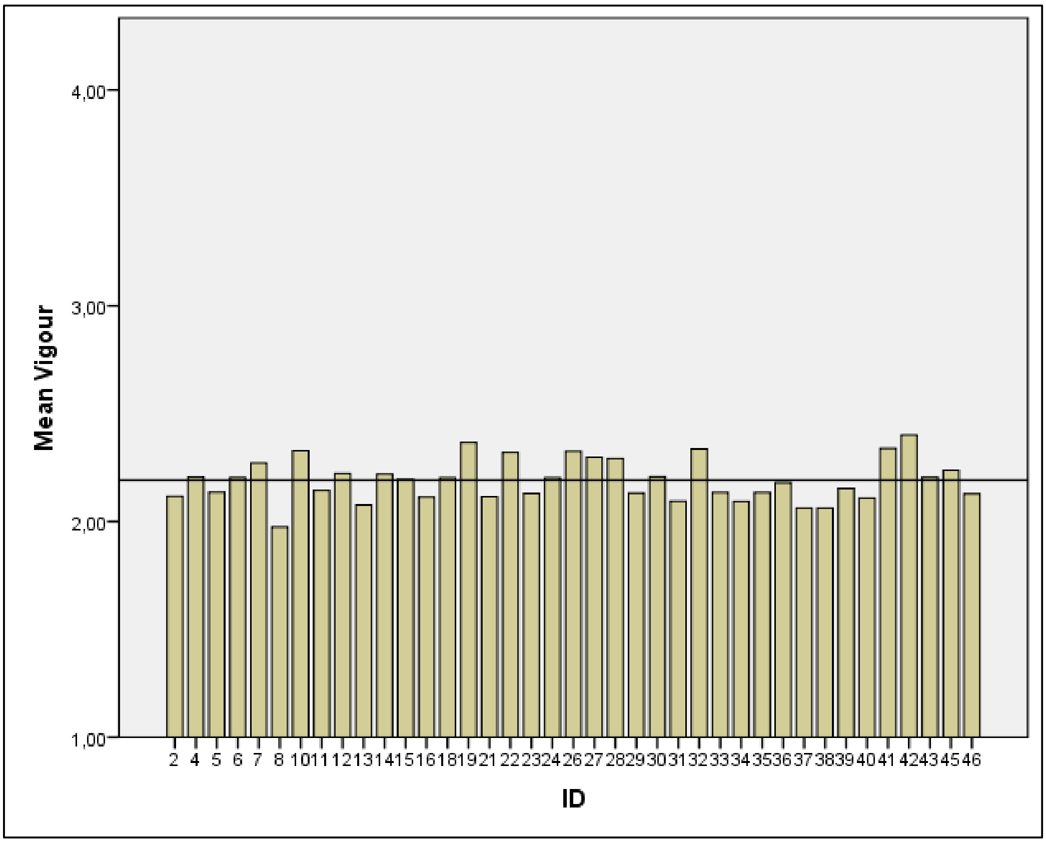


Figure 60. Mean values of vigour on building level

12.2. Multilevel analyses

As described in chapter 11.2 the point of departure in multilevel modelling is the partitioning of variance between level 1 (employees) and level 2 (buildings). This partitioning is described by the intraclass correlation. The intraclass correlation is a measure for the size of contextual variables' effects on outcomes. In this study, intraclass correlations describe the degree to which individuals share common experiences due to closeness in space (and time) (Kreft & De Leeuw, 1998). Even small intraclass correlation may lead to false conclusions in comparisons of groups. Barcikowski (1981) shows that intraclass correlation as small as 0.01 may substantially inflate type I error (alpha level[29]) probabilities, especially with large groups (see also Kreft & De Leeuw, 1998). Hox (2010, p. 244) suggests using .05, .10, and .15 as small, medium, and large values for intraclass correlations. Table 115 shows the intraclass correlations and the corresponding variance components for the outcome variables of the second study.

The results in Table 115 indicate that the proportion of total variability in the outcomes that is attributable to building level differs for different outcomes. The effect of buildings is strongest for work area satisfaction. Job satisfaction and self-assessed performance are affected by a lesser degree, but the intraclass correlations still represent a small to medium size effect. Health and vigour seem mainly to depend on individual level differences. Overall, the sizes of the intraclass correlations indicate that multi-level modelling is appropriate.

Table 115. Intraclass correlations and variance components for outcome variables (39 buildings, n = 1332 to 1366)

	Work area satisfaction	Job satisfaction	Health	Self-assessed performance	Self-assessed performance based on feedbacks	Situational performance	Vigour	Dedication
Intraclass correlation	.160	.062	.024	.061	.026	.045	.014	.052
Variance Components								
Between buildings	15.95%	6.19%	2.41%	6.13%	2.59%	4.47%	1.42%	5.22%
Within buildings	84.05%	93.81%	97.59%	93.87%	97.41%	95.53%	98.58%	94.78%

Multilevel analyses were carried out using the MIXED procedure in IBM SPSS Statistics 19. Predictors were centred at the grand mean in order to increase stability and interpretability of the models (Kreft & De Leeuw, 1998). Grand mean centring (subtracting the overall mean from all values of a variable) renders the intercept in a regression equation interpretable as the expected value of the outcome variable, when all predictor variables have their mean value (Hox, 2010). Different multilevel

[29] Type I error refer to false positives, i.e. rejections of true null hypotheses by a statistical test and decide in favour of a difference where there is none.

models are compared using the log-likelihood, a deviance statistic. This measure is based on summing the probabilities of the predicted and the actual outcomes (Tabachnick & Fidell, 2007) and is an indicator of how much unexplained information remains after the model has been fitted. Large values of the log-likelihood therefore indicate more unexplained information and this implies a poor fit of the statistical model. The log-likelihood allows for comparisons between models by using their deviances if two models are nested, i.e. one of the models is derived from the other (more general) model. For nested models, the differences of the deviances have a chi-square distribution with degrees of freedom equivalent to the difference in number of parameters estimated in the two models.

Multilevel modelling was conducted in a series of steps:
Model 0 only contains the intercept that varies among groups (i.e. buildings) and no explanatory variables (intercept-only-model; Hox, 2010). It describes the variance explanation caused by membership to groups. It also serves as a benchmark value of the deviance (i.e. the degree of misfit of the model). The intercept-only model is based on the following two equations (following the notation proposed by Hox, 2010):

Level 1: $Y_{ij} = \beta_{0j} + e_{ij}$ (1)

Level 2: $\beta_{0j} = \gamma_{00} + u_{0j}$ (2)

Substituting equation 2 in equation 1 leads to:

$$Y_{ij} = \gamma_{00} + u_{0j} + e_{ij} \quad (3)$$

with β_{0j} representing the intercept (constant in the regression) that describes the expected value of the dependent variable when the predictor has the value of 0 and e_{ij} the residual, describing the deviance of the observed values from the theoretical values. γ_{00} (constant) and u_{0j} (residual) are the corresponding elements on level 2.

Model 1 additionally contains control variables as level 1 predictors:

$$Y_{ij} = \gamma_{00} + \gamma_{10}X_{1ij} + \gamma_{20}X_{2ij} + \gamma_{30}X_{3ij} + u_{0j} + e_{ij} \quad (4)$$

with X_{1ij} representing gender, X_{2ij} age, and X_{3ij} tenure while γ_{10}, γ_{20}, and γ_{30} represent the corresponding regression weights.
Model 2 includes office environment characteristics and model 3 contains perceived job characteristics. The equations for these models are extensions of equation 4.

Models 4 and higher additionally include building level variables. In these models, level 2 variables are considered:

$$Y_{ij} = \gamma_{00} + \gamma_{p0}X_{pij} + \gamma_{0q}Z_{qj} + u_{0j} + e_{ij} \quad (5)$$

where the Z_{qj} are the q explanatory variables at group level that usually are added to the models one by one in order to examine changes in deviance (Hox, 2010).
The sequence of the models tested is as follows:

- Model 4: office type
- Model 5: spatial density 1 (workspace area per person)
- Model 6: spatial density 2 (total office space per person including workspace area, circulation area, meeting area, and communication area)
- Model 7: spatial density 3 (ratio of workspace area to shared spaces per person)
- Model 8: ventilation type (natural vs. mechanical)
- Model 9: building age
- Model 10: time since last indoor refurbishment
- Model 11: Windows (openable vs. not openable)
- Model 12: Building size (number of workspaces)

The results of the multilevel analyses are described in the following sections, structured by outcome (work area satisfaction, job satisfaction, health, individual work performance). The first step in the analyses consists in a baseline model: Model 0 is used to estimate the amount of variation in the dependent variable. It is based on the assumption that buildings differ in the initial value (intercept). Therefore this parameter is the only random component in this model ("intercept-only model"). Regression coefficients in the multilevel models vary around an overall solution for the sample ("fixed effects") and are treated as random variables at level 2, i.e. they are considered as randomly ("random effects") originating from a distribution of all possible coefficients and are comparable to error terms in ordinary least squares regression.
The variance between buildings is described with the term σ^2_{u0} and σ^2_{e} describes the variance within buildings. As there are no explanatory variables in model 0 (except the constant intercept term), these variances can be interpreted as error variances (Hox, 2010).

Model 1 adds control variables as level 1 predictors, model 2 includes perceived office environment characteristics and model 3 contains perceived job characteristics. The variables entered into model 2 are determined on the basis of theoretical considerations and prior evidence. From model 4 to model 12 building level variables are examined one by one in order to examine changes in deviance. Changes in deviance for these models are therefore compared to the deviance score of model 3 whereas in models 1-3 deviance is compared to the previous model because it is assumed that the additional variables add information. Chi-square tests are used for comparisons of the deviances (log-likelihood score) of nested models (see above).

Variance explained by MLM models is expressed as the difference in the residual error variance between a model containing predictors and the intercept-only model. This difference is expressed as a proportion of the total error variance separately, level by level. The proportion of variance explained at the first level can be described by the following formula (Hox, 2010, p.71 based on Raudenbush & Bryk, 2002):

$$R_1^2 = \left(\frac{\sigma^2_{e|b} - \sigma^2_{e|m}}{\sigma^2_{e|b}}\right), \tag{6}$$

where $\sigma^2_{e|b}$ is the lowest-level residual variance for the baseline model (i.e. the intercept-only model) and $\sigma^2_{e|m}$ is the lowest-level residual variance for the comparison model. Variance explained at the second level is described by the following formula (Hox, 2010, p.71 based on Raudenbush & Bryk, 2002):

$$R_2^2 = \left(\frac{\sigma^2_{u0|b} - \sigma^2_{u0|m}}{\sigma^2_{u0|b}}\right), \tag{7}$$

where $\sigma^2_{u0|b}$ is the second-level residual variance for the baseline model (i.e. the intercept-only model) and $\sigma^2_{u0|m}$ is the lowest-level residual variance for the comparison model.

In the following chapters the analyses for each of the outcome categories are presented.

12.2.1. Work area satisfaction

Multilevel analyses for work area satisfaction are presented in Table 116 to Table 118. In model 2 variables describing the perceived office environment are introduced into the analysis. The bases for variable selection are theoretical considerations and the literature reviewed in chapter 6. The variables selected are the same as in study 1 (chapter 10.4.2). Workplace appropriateness was excluded from the analyses because it correlates very highly (r = .73) with work area satisfaction.
All variables were coded so that high values correspond to positive or desirable experiences, e.g. high values in office noise represent a positive assessment of the environment.
The analyses show that the introduction of the perceived office environment variables in model 2 substantially reduces residuals both, at level 1 and level 2. The variables related to the perceived office environment account for 64 per cent of variance explanation in work area satisfaction. Variance reduction at level 2 is even higher and in models 3 to 12 variance at level 2 is not significantly different from zero. Between-building variance is fully explained by level 1 variables. Office type, density, building age and building characteristics do not explain variance in work area satisfaction. However, in models 6, 7, and 12 the deviance statistic is significantly lower. This indicates a better model fit for the models that include total office space per person (model 6), ratio of workspace area to shared spaces per person (model 7), and building size (model 12). The γ-weights associated with the level 2 variables in these models, however, are very small in size and not statistically significant. The general suggestion is to rely on reduction in the deviance statistic rather than on significance testing of coefficients (Berkhof & Snijders, 2001; Hox, 2010), i.e. to use

the multiparameter test rather than the single-parameter approach for testing whether the variance of a random coefficient is positive. The results for models 6, 7, and 12 are therefore indicating a possible contribution of the building-level predictors included in these models.

In model 3 job characteristics are entered in the model. Variety appears as a significant predictor. While this leads to a significant reduction in the deviance statistic, it does not increase variance explained at level 1. The analyses show that – ordered according to γ-weights - workspace quality, work and storage spaces, privacy, distraction, control, indoor climate, and lighting are significant predictors of office satisfaction. There is also an effect of gender, indicating that men are generally more satisfied with the office environment than women.

Table 116. Multilevel models for effects of office and job characteristics on work area satisfaction

	Model 0		**Model 1**		**Model 2**		**Model 3**	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	3.77***	.06	3.90***	.12	3.89***	.07	3.91***	.07
Fixed effects								
Gender			.04	.05	.07*	.03	.07*	.03
Age			-.003	.003	-.003	.002	-.004*	.002
Tenure			-.002	.004	.002	.002	.002	.002
Privacy					.11***	.03	.11***	.03
Office noise					-.01	.02	-.01	.02
Control					.11***	.03	.10***	.03
Indoor climate					.08***	.02	.08***	.02
Lighting					.05**	.02	.05**	.02
Social density					.01	.03	.01	.03
Workspace quality					.44***	.02	.44***	.02
Work and storage spaces					.31***	.08	.30***	.08
Distraction					.11***	.02	.11***	.02
Scope of action							-.002	.02
Variety							.06*	.02
Overload							.02	.02
Random effects								
σ_e^2	.676***	.027	.663***	.027	.244***	.010	.243***	.010
σ_{u0}^2	.139***	.038	.120***	.034	.006	.004	.006	.003
-2 Log Likelihood	3353.2		3096.7***		1747.8***		1727.7***	
R_1^2			.02		.64		.64	
R_2^2			.14					
*p<.05; **p<.01; ***p<.001								

Table 117. Multilevel models for effects of office and job characteristics on work area satisfaction (continued from Table 116)

	Model 4		Model 5		Model 6		Model 7	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	3.86***	.12	3.86***	.11	3.93***	.09	3.94***	.07
Fixed effects								
Gender	.06*	.03	.07*	.03	.07*	.03	.07*	.03
Age	-.004*	.002	-.004*	.002	-.004*	.002	-.004*	.002
Tenure	.002	.002	.002	.002	.002	.002	.002	.002
Privacy	.11***	.03	.11***	.03	.11***	.03	.11***	.03
Office noise	-.007	.018	-.007	.018	-.01	.02	-.01	.02
Control	.10***	.03	.10***	.03	.10***	.03	.10***	.03
Indoor climate	.07***	.02	.08***	.02	.08***	.02	.08***	.02
Lighting	.05**	.02	.05**	.02	.05**	.02	.05**	.02
Social density	.05	.04	.02	.03	.02	.03	.02	.03
Workspace quality	.44***	.02	.44***	.02	.44***	.02	.44***	.02
Work and storage spaces	.30***	.08	.30***	.08	.28**	.08	.28**	.08
Distraction	.11***	.02	.11***	.02	.11***	.02	.11***	.02
Scope of action	-.002	.02	-.002	.02	-.004	.02	-.003	.02
Variety	.06*	.02	.06*	.02	.06*	.02	.06*	.02
Overload	.02	.02	.02	.02	.02	.02	.02	.02
Office type 1	.12	.11						
Office type 2	.01	.11						
Office type 3	.02	.11						
Office type 4	-.06	.13						
Spatial density 1			.005	.009				
Spatial density 2					-.001	.004		
Spatial density 3							-.04	.06
Ventilation								
Building age								
Time since last indoor refurbishment								
Random effects								
σ_e^2	.242***	.010	.243***	.010	.240***	.010	.241***	.010
σ_{u0}^2	.005	.003	.006	.003	.004	.01	.004	.003
-2 Log Likelihood	1722.1		1727.4		1694.2***		1693.7***	
R_1^2	.64		.64		.64		.64	
R_2^2								
*p<.05; **p<.01; ***p<.001								

Table 118. Multilevel models for effects of office and job characteristics on work area satisfaction (continued from Table 117)

	Model 8		Model 9		Model 10		Model 11		Model 12	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	3.88***	.08	3.89***	.07	3.89***	.07	3.94***	.08	3.90***	.07
Fixed effects										
Gender	.07*	.03	.07*	.03	.07*	.03	.07*	.03	.08*	.03
Age	-.004*	.002	-.004*	.002	-.004*	.002	-.004*	.002	-.004*	.002
Tenure	.002	.002	.002	.002	.002	.002	.002	.002	.001	.002
Privacy	.11***	.03	.11***	.03	.11***	.03	.11***	.03	.11***	.03
Office noise	-.01	.02	-.01	.02	-.01	.02	-.01	.02	-.01	.02
Control	.10***	.03	.10***	.03	.10***	.03	.10***	.03	.10***	.03
Indoor climate	.08***	.02	.08***	.02	.08***	.02	.08***	.02	.07***	.02
Lighting	.05**	.02	.05**	.02	.05**	.02	.05**	.02	.05**	.02
Social density	.02	.03	.02	.03	.02	.03	.01	.03	.02	.03
Workspace quality	.44***	.02	.44***	.02	.44***	.02	.44***	.02	.45***	.02
Work and storage spaces	.30**	.08	.30**	.08	.30**	.08	.30**	.08	.27**	.08
Distraction	.11***	.02	.11***	.02	.11***	.02	.11***	.02	.10***	.02
Scope of action	-.002	.02	-.002	.02	-.002	.02	-.002	.02	-.007	.02
Variety	.06*	.02	.06*	.02	.06*	.02	.06*	.02	.06*	.02
Overload	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
Office type 1										
Office type 2										
Office type 3										
Office type 4										
Spatial density 1										
Spatial density 2										
Spatial density 3										
Ventilation	.03	.05								
Building age			.001	.001						
Time since last indoor refurbishment					-.005	.005				
Windows							-.026	.05		
Building size									<.001	<.001
Random effects										
σ^2_e	.243***	.010	.242***	.010	.243***	.010	.243***	.010	.241***	.010
σ^2_{u0}	.005	.003	.005	.003	.005	.003	.005	.003	.003	.003
-2 Log Likelihood	1727.2		1726.7		1726.7		1727.4		1643.9***	
R^2_1	.64		.64		.64		.64		.64	
R^2_2										
*p<.05; **p<.01; ***p<.001										

12.2.2. Job satisfaction

On the basis of the literature review and the results from the first study, privacy, office noise, workplace appropriateness, control, social density, and distraction were entered in model 2. The job characteristics (scope of action, variety, and overload) are added in model 3 (Table 119).

The analyses are presented in Table 119 to Table 121. The introduction of variables related to perceptions of the office environment significantly reduces the deviance statistic and residuals at level 1 and level 2. Variance explained in job satisfaction is 28 and 40 per cent, respectively. The following variables from pertaining to the perceived office environment appear as significant predictors: workplace appropriateness, social density, control, and distraction. All of these variables are positively associated with job satisfaction, notably higher social density is associated with higher job satisfaction. Job characteristics further contribute to increased model fit. With this class of variables, variety has a very strong influence (as can be seen from the γ-value around .50). Additionally, overload at work also contributes to job satisfaction. This variable is coded in a way where high values signify low overload. Thus, high overload at work reduces job satisfaction.

Table 119. Multilevel models for effects of office and job characteristics on job satisfaction

	Model 0		Model 1		Model 2		Model 3	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	4.71***	0.05	4.52***	.15	4.46***	.12	4.63***	.11
Fixed effects								
Gender			.04	.07	.06	.06	.08	.05
Age			.01	.004	.006*	.003	.002	.003
Tenure			-.01	.005	-.003	.004	-.002	.004
Privacy					.05	.06	.04	.05
Office noise					.05	.03	.04	.03
Control					.19***	.05	.11*	.04
Indoor climate					.07*	.03	.05*	.03
Lighting					.05	.03	.03	.03
Social density					.11	.06	.11	.06
Workspace quality					.29***	.04	.27***	.04
Work and storage spaces					-.02	.15	-.12	.13
Workplace appropriateness					.02	.05	.03	.05
Distraction					.15***	.03	.12***	.03
Scope of action							.06	.04
Variety							.47***	.04
Overload							.14***	.03
Random effects								
σ^2_e	1.15**	0.05	1.13***	0.05	0.78***	0.03	0.65***	0.03
σ^2_{u0}	0.08***	0.03	0.06**	0.02	0.03*	0.01	0.02	0.01
-2 Log Likelihood	4018.4		3738.2***		3150.1***		2919.6***	
R^2_1			.02		.32		.43	
R^2_2			.21		.61			
*p<.05; **p<.01; ***p<.001								

Similarly to the results for work area satisfaction, building level variance is fully explained by level 1 variables and the office type, density, building age and building characteristics do not explain variance in job satisfaction. However, also for job satisfaction in models 6, 7, and 12 the deviance statistic is significantly lower, indicating a better model fit for the models that include total office space per person (model 6), ratio of workspace area to shared spaces per person (model 7), and building size (model 12). However, the γ-weights associated with the level 2 variables in these models are very small in size and not statistically significant.

Table 120. Multilevel models for effects of office and job characteristics on job satisfaction (continued from Table 119)

	Model 4		**Model 5**		**Model 6**		**Model 7**	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	4.36***	.20	4.70***	.19	4.62***	.15	4.61***	.12
Fixed effects								
Gender	.08	.05	.08	.05	.09	.05	.09	.05
Age	.002	.003	.002	.003	.002	.003	.002	.003
Tenure	-.001	.004	-.002	.004	-.002	.004	-.002	.004
Privacy	.04	.05	.04	.05	.03	.05	.03	.05
Office noise	.04	.03	.04	.03	.04	.03	.04	.03
Control	.11*	.04	.11*	.04	.10*	.05	.10*	.05
Indoor climate	.05*	.03	.05*	.03	.04	.03	.04	.03
Lighting	.03	.03	.03	.03	.04	.03	.04	.03
Social density	.12	.07	.10	.06	.10	.06	.10	.06
Workspace quality	.27***	.04	.27***	.04	.28***	.04	.28***	.04
Work and storage spaces	-.11	.13	-.12	.13	-.13	.13	-.13	.13
Workplace appropriateness	.03	.05	.04	.05	.04	.05	.04	.05
Distraction	.12***	.03	.12***	.03	.12***	.03	.12***	.03
Scope of action	.06	.04	.06	.04	.06	.04	.06	.04
Variety	.47***	.04	.47***	.04	.48***	.04	.48***	.04
Overload	.14***	.03	.14***	.03	.15***	.03	.15***	.03
Office type 1	.30	.18						
Office type 2	.25	.18						
Office type 3	.27	.18						
Office type 4	.22	.22						
Spatial density 1			-.007	.015				
Spatial density 2					<.001	.006		
Spatial density 3							.04	.10
Ventilation								
Building age								
Time since last indoor refurbishment								
Windows								
Building size								
Random effects								
σ^2_e	0.65***	0.03	0.65***	0.03	0.65***	0.03	0.65***	0.03
σ^2_{u0}	0.012	0.009	0.014	0.009	0.017	0.010	0.017	0.010
-2 Log Likelihood	2916.7		2919.4		2873.7***		2873.6***	
R^2_1	.40		.40		.40		.40	
R^2_2								
*p<.05; **p<.01; ***p<.001								

Table 121. Multilevel models for effects of office and job characteristics on job satisfaction (continued from Table 120)

	Model 8		Model 9		Model 10		Model 11		Model 12	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	4.62***	.11	4.55***	.12	4.67***	.12	4.69***	.14	4.62***	.12
Fixed effects										
Gender	.08	.05	.09	.05	.08	.05	.08	.05	.09	.05
Age	.001	.003	.002	.003	.002	.003	.001	.003	.002	.003
Tenure	-.002	.004	-.001	.004	-.002	.004	-.001	.004	-.002	.004
Privacy	.04	.05	.04	.05	.04	.05	.04	.05	.03	.05
Office noise	.04	.03	.04	.03	.05	.03	.04	.03	.06	.03
Control	.11*	.04	.11*	.04	.11*	.04	.11*	.04	.11*	.05
Indoor climate	.05*	.03	.05*	.03	.05*	.03	.05*	.03	.05	.03
Lighting	.03	.03	.03	.03	.03	.03	.03	.03	.03	.03
Social density	.10	.06	.13*	.06	.10	.06	.10	.06	.09	.06
Workspace quality	.27***	.04	.27***	.04	.27***	.04	.27***	.04	.27***	.04
Work and storage spaces	-.11	.14	-.12	.13	-.12	.13	-.12	.13	-.12	.14
Workplace appropriateness	.03	.05	.04	.05	.04	.05	.03	.05	.04	.05
Distraction	.12***	.03	.12***	.03	.12***	.03	.12***	.03	.12***	.03
Scope of action	.06	.04	.06	.04	.06	.04	.06	.04	.06	.04
Variety	.47***	.04	.47***	.04	.47***	.04	.47***	.04	.48***	.04
Overload	.14***	.03	.14***	.03	.14***	.03	.14***	.03	.15***	.04
Office type 1										
Office type 2										
Office type 3										
Office type 4										
Spatial density 1										
Spatial density 2										
Spatial density 3										
Ventilation	.07	.08								
Building age			.002	.001						
Time since last indoor refurbishment					-.011	.009				
Windows							-.06	.08		
Building size									<.001	<.001
Random effects										
σ^2_e	0.65***	0.03	0.65***	0.03	0.65***	0.03	0.65***	0.03	0.65***	0.03
σ^2_{u0}	0.016	0.01	0.012	0.009	0.015	0.01	0.016	0.01	0.017	0.011
-2 Log Likelihood	2918.9		2916.0		2918.0		2919.1		2794.4***	
R^2_1	.40		.40		.40		.40		.40	
R^2_2										
*p<.05; **p<.01; ***p<.001										

12.2.3. Health

Previous research has shown that both, environmental and socio-spatial factors of office environments may affect occupants' health. The following office environment variables were entered in the multilevel models for health: noise, indoor climate, lighting, control, privacy, workspace quality, workplace appropriateness, distraction, and social density. The results of the analyses are presented in Table 122 to Table 124. The introduction of control variables in model 1 shows a highly significant effect of gender that accounts for 3 per cent of level 1 variance. This gender effect indicates that women report more health-related complaints than men, i.e. women's health status scores are lower. The effect remains statistically significant after the inclusion of office environment and job characteristics variables (models 2 and 3) and therefore seems to be independent of office and job design. Significant predictors related to the office environment are social density, distraction, workspace quality, office noise, and indoor climate.

Table 122. Multilevel models for effects of office and job characteristics on health (continued in Table 123)

	Model 0		**Model 1**		**Model 2**		**Model 3**	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	4.19***	.02	4.37***	.08	4.34***	.07	4.42***	.07
Fixed effects								
Gender			-.21***	.04	-.20***	.03	-.21***	.03
Age			-.002	.002	-.002	.002	-.004	.002
Tenure			-.002	.003	<.001	.002	.002	.002
Privacy					.06	.03	.05	.03
Office noise					.05*	.02	.04*	.02
Control					.001	.03	-.04	.03
Indoor climate					.04*	.02	.04*	.02
Lighting					.02	.02	.02	.02
Social density					.12**	.04	.11**	.03
Workspace quality					.06*	.02	.05*	.02
Workplace appropriateness					-.08*	.03	-.06*	.03
Work and storage spaces					.25**	.09	.16	.09
Distraction					.12***	.02	.10***	.02
Scope of action							.11***	.02
Variety							.10***	.02
Overload							.13***	.02
Random effects								
σ_e^2	.38***	.015	.37***	.015	.30***	.01	.28***	.01
σ_{u0}^2	.01*	.005	.005	.004	.004	.004	.003	.004
-2 Log Likelihood	2479.7		2319.0***		1984.1***		1880.1***	
R_1^2			.03		.21		.26	
R_2^2								
*p<.05; **p<.01; ***p<.001								

All three job characteristics appear as significant predictors of health status (model 3). Level 1 variance explanation by control variables, office environment, and job characteristics is 26 per cent. Including level 2 variables does not reduce the deviance statistic or explain additional variance in residuals. As with work area satisfaction and job satisfaction multilevel analyses, the deviance statistic is significantly lower in models 6, 7, and 12 as compared to model 3. Furthermore, model 9 also has a significantly lower deviance statistic than model 3. This indicates that the models including include total office space per person (model 6), ratio of workspace area to shared spaces per person (model 7), building age (model 9), and building size (model 12) have a better model fit than model 3. The associated level 2 γ-weights, however, are not statistically significant.

Table 123. Multilevel models for effects of office and job characteristics on health (continued from Table 122

	Model 4		Model 5		Model 6		Model 7	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	4.37***	.13	4.52***	.11	4.46***	.09	4.41***	.08
Fixed effects								
Gender	-.21***	.03	-.20***	.03	-.20***	.03	-.20***	.03
Age	-.003	.002	-.004	.002	-.003	.002	-.003	.002
Tenure	.002	.002	.001	.002	.001	.002	.001	.002
Privacy	.05	.03	.05	.03	.05	.03	.05	.03
Office noise	.04*	.02	.04*	.02	.04*	.02	.04*	.02
Control	-.04	.03	-.04	.03	-.04	.03	-.04	.03
Indoor climate	.04*	.02	.04*	.02	.04**	.02	.04*	.02
Lighting	.02	.02	.02	.02	.01	.02	.01	.02
Social density	.12**	.04	.10**	.04	.10**	.04	.11**	.03
Workspace quality	.05*	.02	.05*	.02	.05*	.02	.05*	.02
Workplace appropriateness	-.06*	.03	-.06	.03	-.06	.03	-.07*	.03
Work and storage spaces	.16	.09	.15	.09	.16	.09	.16	.09
Distraction	.10***	.02	.10***	.02	.11***		.11***	.02
Scope of action	.11***	.02	.11***	.02	.10***	.02	.11***	.02
Variety	.10***	.02	.10***	.02	.10***	.02	.10***	.02
Overload	.13***	.02	.13***	.02	.13***	.02	.14***	.02
Office type 1	.06	.11						
Office type 2	.06	.11						
Office type 3	.05	.11						
Office type 4	.01	.13						
Spatial density 1			-.01	.009				
Spatial density 2					-.003	.004		
Spatial density 3							.02	.06
Random effects								
σ_e^2	.28***	.01	.28***	.01	.28***	.01	.28***	.01
σ_{u0}^2	.003	.004	.003	.003	.004	.004	.004	.004
-2 Log Likelihood	1879.6		1878.7		1857.1***		1857.7***	
R_1^2	.26		.26		.26		.26	
R_2^2								
*p<.05; **p<.01; ***p<.001								

Table 124. Multilevel models for effects of office and job characteristics on health (continued from Table 123)

	Model 8		Model 9		Model 10		Model 11		Model 12	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	4.42***	.07	4.35***	.07	4.46***	.08	4.42***	.09	4.41***	.08
Fixed effects										
Gender	-.21***	.03	-.21***	.03	-.21***	.03	-.21***	.03	-.20***	.03
Age	-.004	.002	-.003	.002	-.004*	.002	-.004	.002	-.003	.002
Tenure	.002	.002	.002	.002	.001	.002	.002	.002	.002	.002
Privacy	.05	.03	.04	.03	.05	.03	.05	.03	.06	.03
Office noise	.04*	.02	.04*	.02	.04*	.02	.04*	.02	.04*	.02
Control	-.04	.03	-.04	.03	-.04	.03	-.04	.03	-.04	.03
Indoor climate	.04*	.02	.04*	.02	.04*	.02	.04*	.02	.04**	.02
Lighting	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
Social density	.11**	.04	.13***	.03	.10**	.03	.11**	.04	.11**	.04
Workspace quality	.05*	.02	.05*	.02	.05*	.02	.05*	.02	.05*	.02
Workplace appropriateness	-.06*	.03	-.06	.03	-.06	.03	-.06*	.03	-.07*	.03
Work and storage spaces	.16	.09	.16	.09	.16	.09	.16	.09	.15	.09
Distraction	.10***	.02	.10***	.02	.10***	.02	.10***	.02	.10***	.02
Scope of action	.11***	.02	.11***	.02	.11***	.02	.11***	.02	.10***	.02
Variety	.10***	.02	.10***	.02	.10***	.02	.10***	.02	.10***	.02
Overload	.13***	.02	.13***	.02	.13***	.02	.13***	.02	.13***	.02
Ventilation	-.01	.05								
Building age			.001**	<.001						
Time since last indoor refurbishment					-.008	.005				
Windows							.004	.049		
Building size									<.001	<.001
Random effects										
σ^2_e	.28***	.01	.28***	.01	.28***	.01	.28***	.01	.28***	.01
σ^2_{u0}	.003	.004	<.001	<.001	.004	.003	.003	.004	.004	.004
-2 Log Likelihood	1880.1		1871.4***		1877.6		1880.1		1813.5***	
R^2_1	.26		.26		.26		.26		.26	
R^2_2										
*p<.05; **p<.01; ***p<.001										

12.2.4. Individual work performance

For the measurement of individual work performance different scales were used. The scales used in the first study (chapter 9.2.4.3) were complemented by two scales measuring dedication and vigour, two components of work engagement (chapter 11.2.2). The correlations between the measures are presented in Table 125. The correlations are moderate to high in size. However, the size of the correlations shows that the different measures do only partially overlap and common variance (calculated by squared correlation values) is between 6.7 and 27.8 per cent.

Therefore the different measurements are considered as different aspects of the individual work performance construct.
The environmental variables used for the work performance multilevel analyses are privacy, office noise, control, indoor climate, lighting, social density, workspace quality, workplace appropriateness, and distraction.

Table 125. Correlation matrix for individual work performance measures (n = 1325)[30]

	Self-assessed job performance	(Log of) Self-assessed job performance based on Feedbacks	(Log of) Situational job performance	Dedication
(Log of) Self-assessed job performance based on Feedbacks	,460**			
(Log of) Situational job performance	,527**	,354**		
Dedication	,439**	,278**	,456**	
Vigour	,258**	,268**	,378**	,493**
** Correlation is significant at the .01 level.				

12.2.4.1. Self-assessed job performance

The analyses for self-assessed job performance are summarised in Table 126 to Table 128. There is a very small but statistically significant effect of age on job performance. Older employees report slightly higher scores in self-assessed job performance. Variables pertaining to the office environment explain 8 per cent of level 1 variance. The significant predictors are workspace quality and distraction (model 2). These predictors remain statistically significant also in model 3 where job characteristics are added. Variety is the only significant job characteristics and adds substantially to variance explained. Level 1 variance explained in the model with office and job characteristics is 20 per cent (model 3).
Level 2 variables lead to a reduction in the deviance statistic for models 6 (total office space per person), 7 (ratio of workspace area to shared spaces per person), and 12 (building size). This reduction in the deviance characteristic, however, is not matched by a reduction of level 2 residual variance and the γ-weights associated with the level 2 variables in these models are not statistically significant.

[30] Differences of these correlations compared to Table 112 are due to sample size; the correlation matrices are based on cases with complete data for all variables. Because Table 125 contains fewer variables than Table 112, fewer cases are excluded in the correlation matrix.

Table 126. Multilevel models for effects of office and job characteristics on self-assessed performance

	Model 0		Model 1		Model 2		Model 3	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	3.85***	.03	3.57***	.07	3.60***	.07	3.67***	.06
Fixed effects								
Gender			.06	.03	.05	.03	.06*	.03
Age			.01***	.002	.01**	.002	.004*	.002
Tenure			<.001	.002	<.001	.002	<.001	.002
Privacy					.04	.03	.04	.03
Office noise					-.02	.02	-.03	.02
Control					.005	.03	-.04	.03
Indoor climate					.001	.02	-.003	.01
Lighting					-.02	.02	-.03	.02
Social density					.03	.04	.04	.03
Workspace quality					.08**	.02	.06**	.02
Workplace appropriateness					-.02	.03	-.004	.03
Work and storage spaces					-.02	.08	-.04	.08
Distraction					.06**	.02	.05**	.02
Scope of action							.01	.02
Variety							.26***	.02
Overload							.04	.02
Random effects								
σ_e^2	.25***	.01	.25***	.01	.23***	.01	.20***	.01
σ_{u0}^2	.02**	.01	.02**	.01	.01*	.01	.01*	.005
-2 Log Likelihood	1964.3		1821.7***		1708.7***		1514.0***	
R_1^2			0		.08		.20	
R_2^2			0		.50		.50	
*p<.05; **p<.01; ***p<.001								

Table 127. Multilevel models for effects of office and job characteristics on self-assessed performance (continued from Table 126)

	Model 4		Model 5		Model 6		Model 7	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	3.80***	.13	3.80***	.12	3.68***	.09	3.62***	.07
Fixed effects								
Gender	.06*	.03	.06*	.03	.07*	.03	.06*	.03
Age	.004*	.002	.004*	.002	.004*	.002	.004*	.002
Tenure	<.001	.002	< -.001	.002	< -.001	.002	< -.001	.002
Privacy	.04	.03	.04	.03	.04	.03	.03	.03
Office noise	-.03	.02	-.03	.02	-.03	.02	-.03	.02
Control	-.04	.03	-.04	.03	-.03	.03	-.03	.03
Indoor climate	-.005	.01	-.003	.01	.002	.01	.001	.01
Lighting	-.03	.02	-.03	.02	-.03*	.02	-.03*	.02
Social density	.05	.04	.03	.03	.04	.03	.04	.03
Workspace quality	.06**	.02	.06**	.02	.05*	.02	.06**	.02
Workplace appropriateness	-.004	.03	-.002	.03	-.005	.03	-.007	.03
Work and storage spaces	-.04	.08	-.04	.08	-.04	.08	-.04	.08
Distraction	.05**	.02	.05**	.02	.05**	.02	.05**	.02
Scope of action	.01	.02	.01	.02	.01	.02	.01	.02
Variety	.26***	.02	.26***	.02	.26***	.02	.26***	.02
Overload	.04	.02	.04	.02	.04	.02	.04	.02
Office type 1	-.10	.12						
Office type 2	-.17	.12						
Office type 3	-.14	.12						
Office type 4	-.15	.15						
Spatial density 1			-.01	.01				
Spatial density 2					-.001	.004		
Spatial density 3							.07	.07
Random effects								
σ_e^2	.20***	.01	.20***	.01	.20***	.01	.20***	.01
σ_{u0}^2	.01	.004	.01*	.004	.01*	.005	.01*	.005
-2 Log Likelihood	1511.4		1512.2		1493.9***		1492.9***	
R_1^2	.20		.20		.20		.20	
R_2^2	.50		.50		.50		.50	

*p<.05; **p<.01; ***p<.001

Table 128. Multilevel models for effects of office and job characteristics on self-assessed performance (continued from Table 127)

	Model 8		Model 9		Model 10		Model 11		Model 12	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	3.66***	.06	3.65***	.07	3.70***	.07	3.68***	.08	3.67***	.07
Fixed effects										
Gender	0.06*	0.03	0.06*	0.03	0.06*	0.03	0.06*	0.03	0.05	0.03
Age	0.004*	0.002	0.004*	0.002	0.004*	0.002	0.004*	0.002	0.004*	0.002
Tenure	< -.001	.002	< -.001	.002	< -.001	.002	< -.001	.002	< -.001	.002
Privacy	0.04	0.03	0.03	0.03	0.04	0.03	.04	.03	.03	.03
Office noise	-0.03	0.02	-0.03	0.02	-0.03	0.02	-0.03	0.02	-0.03	0.02
Control	-0.04	0.03	-0.04	0.03	-0.04	0.03	-0.04	0.03	-0.03	0.03
Indoor climate	-.002	.01	-.003	.01	-.003	.01	-.003	.01	< -.001	.01
Lighting	-0.03	0.02	-0.03	0.02	-0.03	0.02	-0.03	0.02	-0.03*	0.02
Social density	0.03	0.03	0.05	0.03	0.04	0.03	0.04	0.03	0.04	0.03
Workspace quality	0.06**	0.02	0.06**	0.02	0.06**	0.02	0.06**	0.02	0.05*	0.02
Workplace appropriateness	-0.005	0.03	-0.002	0.03	-0.003	0.03	-0.004	0.03	0.002	0.03
Work and storage spaces	-.03	.08	-.04	.08	-.04	.08	-.04	.08	-.04	.08
Distraction	0.05**	0.02	0.05**	0.02	0.05**	0.02	0.05**	0.02	0.05**	0.02
Scope of action	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02	0.01	0.02
Variety	0.26***	0.02	0.26***	0.02	0.26***	0.02	0.26***	0.02	0.26***	0.02
Overload	0.03	0.02	0.04	0.02	0.04	0.02	0.03	0.02	0.03	0.02
Ventilation	.07	.05								
Building age			.001	.001						
Time since last indoor refurbishment					-.007	.006				
Windows							-.01	.05		
Building size									<.001	<.001
Random effects										
σ^2_e	.20***	.01	.20***	.01	.20***	.01	.20***	.01	.20***	.01
σ^2_{u0}	.01*	.004	.01*	.005	.01*	.005	.01*	.005	.01*	.005
-2 Log Likelihood	1512.2		1513.1		1512.7		1514.0		1423.2***	
R^2_1	.20		.20		.20		.20		.20	
R^2_2	.50		.50		.50		.50		.50	

*p<.05; **p<.01; ***p<.001

12.2.4.2. Work performance based on feedback

In Table 129 to Table 131 the results of the multilevel analyses for self-assessed performance based on feedback are summarised. For this outcome, an effect of gender is significant, indicating higher self-reported values by men. Two variables from the office environment, control and distraction, appear as significant predictors in model 2, explaining 4 per cent of level 1 variability. With the introduction of job characteristics in model 3, however, the effects of control over the office environment and distraction disappear. All three of the job characteristics appear as significant predictors in this model. With this model, fifteen per cent of level 1 variance is explained.
When level 2 predictors are examined in models 4 to 12, the same pattern as with the first measure of job performance appears: the deviance statistic is reduced for models 6, 7, and 12 although the predictors are not significant.

Table 129. Multilevel models for effects of office and job characteristics on self-assessed performance based on feedbacks

	Model 0		**Model 1**		**Model 2**		**Model 3**	
	γ	SE	γ	SE	γ	SE	γ	SE
Intercept	*4.11****	*.02*	*4.06****	*.07*	*3.01****	*.07*	*4.10****	*.07*
Fixed effects								
Gender			.07*	.03	.08*	.03	.08*	.03
Age			.001	.002	.003	.002	<.001	.002
Tenure			-.003	.002	-.004	.002	-.003	.002
Privacy					.005	.03	-.008	.03
Office noise					-.006	.02	-.01	.02
Control					.06*	.03	.02	.03
Indoor climate					-.005	.02	-.006	.02
Lighting					.01	.02	.01	.02
Social density					.06	.03	.06	.03
Workspace quality					.04	.02	.03	.02
Workplace appropriateness					-.03	.03	-.01	.03
Work and storage spaces					-.06	.08	-.13	.08
Distraction					.05*	.02	.03	.02
Scope of action							.10***	.02
Variety							.14***	.02
Overload							.10***	.02
Random effects								
σ^2_e	.26***	.01	.26***	.01	.25***	.01	.22***	.01
σ^2_{u0}	.01	.004	.01	.004	.01	.004	.01	.004
-2 Log Likelihood	1977.4		1854.2***		1746.9***		1622.5***	
R^2_1			0		.04		.15	
R^2_2								
*p<.05; **p<.01; ***p<.001								

Table 130. Multilevel models for effects of office and job characteristics on self-assessed performance based on feedbacks (continued from Table 129)

	Model 4		Model 5		Model 6		Model 7	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	4.15***	.13	4.02***	.11	4.02***	.09	4.06***	.07
Fixed effects								
Gender	.08**	.03	.08*	.03	.08*	.03	.08**	.03
Age	<.001	.002	<.001	.002	<.001	.002	<.001	.002
Tenure	-.004	.002	-.003	.002	-.003	.002	-.003	.002
Privacy	-.007	.03	-.007	.03	-.007	.03	-.007	.03
Office noise	-.01	.02	-.01	.02	-.01	.02	-.01	.02
Control	.02	.03	.02	.03	.03	.03	.03	.03
Indoor climate	-.006	.02	-.006	.02	-.004	.02	-.005	.02
Lighting	.007	.02	.008	.02	.006	.02	.006	.02
Social density	.04	.04	.07*	.03	.07*	.03	.06	.03
Workspace quality	.03	.02	.03	.02	.03	.02	.03	.02
Workplace appropriateness	-.01	.03	-.01	.03	-.01	.03	-.01	.03
Work and storage spaces	-.13	.08	-.13	.08	-.13	.08	-.13	.08
Distraction	.03	.02	.03	.02	.03	.02	.03	.02
Scope of action	.10***	.02	.10***	.02	.10***	.02	.10***	.02
Variety	.14***	.02	.14***	.02	.14***	.02	.14***	.02
Overload	.10***	.02	.10***	.02	.11***	.02	.11***	.02
Office type 1	-.09	.12						
Office type 2	-.06	.12						
Office type 3	-.02	.12						
Office type 4	-.07	.15						
Spatial density 1			.007	.009				
Spatial density 2					.004	.004		
Spatial density 3							.05	.06
Random effects								
σ_e^2	.22***	.01	.22***	.01	.22***	.01	.22***	.01
σ_{u0}^2	.01	.004	.01	.004	.01	.004	.01	.004
-2 Log Likelihood	1620.7		1621.9		1601.8***		1602.3***	
R_1^2	.15		.15		.15		.15	
R_2^2								
*p<.05; **p<.01; ***p<.001								

Table 131. Multilevel models for effects of office and job characteristics on self-assessed performance based on feedbacks (continued from Table 130)

	Model 8		Model 9		Model 10		Model 11		Model 12	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	4.09***	.07	4.11***	.07	4.09***	.07	4.18***	.08	4.1^1***	.07
Fixed effects										
Gender	.08*	.03	.08*	.03	.08*	.03	.08*	.03	.08**	.03
Age	<.001	.002	<.001	.002	<.001	.002	<.001	.002	<.001	.002
Tenure	-.003	.002	-.003	.002	-.003	.002	-.003	.002	-.003	.002
Privacy	-.007	.03	-.007	.03	-.008	.03	-.005	.03	-.005	.03
Office noise	-.01	.02	-.01	.02	-.01	.02	-.01	.02	-.01	.02
Control	.02	.03	.02	.03	.02	.03	.02	.03	.02	.03
Indoor climate	-.006	.02	-.006	.02	-.006	.02	-.006	.02	-.008	.02
Lighting	.008	.02	.008	.02	.008	.02	.009	.02	.005	.02
Social density	.06	.03	.06	.03	.06	.03	.05	.03	.05	.04
Workspace quality	.03	.02	.03	.02	.03	.02	.03	.02	.02	.02
Workplace appropriateness	-.01	.03	-.01	.03	-.01	.03	-.01	.03	-.01	.03
Work and storage spaces	-.13	.08	-.13	.08	-.13	.08	-.13	.08	-.10	.08
Distraction	.03	.02	.03	.02	.03	.02	.03	.02	.03	.02
Scope of action	.10***	.02	.10***	.02	.10***	.02	.10***	.02	.10***	.02
Variety	.14***	.02	.14***	.02	.14***	.02	.14***	.02	.15***	.02
Overload	.10***	.02	.10***	.02	.10***	.02	.10***	.02	.10***	.02
Ventilation	.03	.05								
Building age			< -.001	.001						
Time since last indoor refurbishment					.002	.005				
Windows							-.09	.05		
Building size									< -.001	< -.001
Random effects										
σ_e^2	.22***	.01	.22***	.01	.22***	.01	.22***	.01	.22***	.01
σ_{u0}^2	.01	.004	.01	.004	.01	.004	.01	.004	.01	.004
-2 Log Likelihood	1622.0		1622.2		1622.4		1619.6		1548.6***	
R_1^2	.15		.15		.15		.15		.15	
R_2^2										
*p<.05; **p<.01; ***p<.001										

12.2.4.3. Situational Work performance

Results of the multilevel analyses for situational work performance are presented in Table 132 to Table 134. There is a small but statistically significant effect of age for situational work performance. Perceived environmental characteristics explain 10 per cent of level 1 variance (model 2). The significant predictors are privacy, workplace appropriateness, workspace quality, distraction, and indoor climate. With the introduction of job characteristics (model 3), indoor climate is not statistically significant anymore. In contrast to the other two measures of job performance, in the analyses with situational work performance workplace appropriateness appears as a statistically significant negative predictor. Higher assessments of workplace appropriateness are related to lower assessments of situational performance.
In addition to the environmental characteristics mentioned before, all of the job characteristics are statistically significant in this model. Gender also emerges as a significant predictor of situational performance in model 3. As with other measures of performance, men assess their own performance higher than women.
In model 3 not only level 1 residual variance is reduced (as compared to model 0) but also level 2 residual variance. Level 2 residual variance is not further reduced by the models containing level 2 predictors (models 4 to 12), although in models 6, 7, and 12 the deviance statistic is smaller (compared to model 3). The level 2 predictors, however, are not statistically significant.

Table 132. Multilevel models for effects of office and job characteristics on self-assessed situational performance

	Model 0		Model 1		Model 2		Model 3	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	4.97***	.04	4.39***	.12	4.38***	.12	4.55***	.11
Fixed effects								
Gender			.07	.06	.09	.06	.11*	.05
Age			.01***	.003	.01***	.003	.01**	.003
Tenure			<.001	.004	.003	.004	.002	.004
Privacy					.16**	.05	.16**	.05
Office noise					< -.001	.03	-.01	.03
Control					.02	.05	-.07	.04
Indoor climate					.06*	.03	.05	.03
Lighting					.06	.03	.04	.03
Social density					.05	.06	.07	.06
Workspace quality					.10*	.04	.07*	.04
Workplace appropriateness					-.15**	.05	-.12*	.05
Work and storage spaces					.09	.14	.02	.13
Distraction					.09**	.03	.07*	.03
Scope of action							.12**	.04
Variety							.44***	.04
Overload							.10**	.03
Random effects								
σ_e^2	.84***	.03	.83***	.03	.76***	.03	.63***	.03
σ_{u0}^2	.04*	.02	.04*	.02	.04*	.01	.03*	.01
-2 Log Likelihood	3528.8		3323.6***		3120.4***		2894.7***	
R_1^2			.01		.10		.25	
R_2^2			0		0		.25	

*p<.05; **p<.01; ***p<.001

Table 133. Multilevel models for effects of office and job characteristics on self-assessed situational performance (continued from Table 132)

	Model 4		Model 5		Model 6		Model 7	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	4.82***	.24	4.48***	.22	4.51***	.17	4.52***	.14
Fixed effects								
Gender	.11*	.05	.11*	.05	.12*	.05	.12*	.05
Age	.01**	.003	.01**	.003	.01**	.003	.01**	.003
Tenure	.002	.004	.002	.004	.002	.004	.002	.004
Privacy	.16**	.05	.16**	.05	.16**	.05	.16**	.05
Office noise	-.01	.03	-.01	.03	-.02	.03	-.02	.03
Control	-.08	.04	-.07	.04	-.07	.04	-.07	.05
Indoor climate	.05	.03	.05	.03	.05	.03	.05	.03
Lighting	.04	.03	.04	.03	.04	.03	.04	.03
Social density	.11	.07	.08	.06	.08	.06	.08	.06
Workspace quality	.07*	.04	.07*	.04	.07*	.04	.08*	.04
Workplace appropriateness	-.12**	.05	-.13**	.05	-.12**	.05	-.12*	.05
Work and storage spaces	.02	.13	.02	.13	-.01	.13	-.01	.13
Distraction	.07*	.03	.07*	.03	.07*	.03	.07*	.03
Scope of action	.12**	.04	.12**	.04	.11**	.04	.11**	.04
Variety	.44***	.04	.44***	.04	.44***	.04	.44***	.04
Overload	.10**	.03	.10**	.03	.10**	.03	.10**	.03
Office type 1	-.22	.22						
Office type 2	-.27	.23						
Office type 3	-.29	.23						
Office type 4	-.55	.27						
Spatial density 1			.007	.02				
Spatial density 2					.003	.007		
Spatial density 3							.07	.12
Random effects								
σ_e^2	.63***	.03	.64***	.03	.63***	.03	.63***	.03
σ_{u0}^2	.03*	.01	.03*	.01	.03*	.01	.03*	.01
-2 Log Likelihood	2890.4		2894.6		2857.9***		2857.7***	
R_1^2	.25		.24		.25		.25	
R_2^2	.25		.25		.25		.25	

*p<.05; **p<.01; ***p<.001

Table 134. Multilevel models for effects of office and job characteristics on self-assessed situational performance (continued from Table 133)

	Model 8		Model 9		Model 10		Model 11		Model 12	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	4.58***	.14	4.46***	.12	4.54***	.12	4.52***	.15	4.56***	.11
Fixed effects										
Gender	.11*	.05	.12*	.05	.11*	.05	.11*	.05	.10	.05
Age	.01**	.003	.01**	.003	.01**	.003	.01**	.003	.01**	.003
Tenure	.002	.004	.002	.004	.002	.004	.002	.004	.003	.004
Privacy	.16**	.05	.15**	.05	.16**	.05	.16**	.05	.14**	.05
Office noise	-.01	.03	-.01	.03	-.01	.03	-.01	.03	-.02	.03
Control	-.07	.04	-.08	.04	-.07	.04	-.07	.04	-.03	.04
Indoor climate	.05	.03	.05	.03	.05	.03	.05	.03	.05	.03
Lighting	.04	.03	.04	.03	.04	.03	.04	.03	.03	.03
Social density	.07	.06	.09	.06	.07	.06	.07	.06	.05	.06
Workspace quality	.07*	.04	.07*	.04	.07*	.04	.07*	.04	.07*	.04
Workplace appropriateness	-.13*	.05	-.12*	.05	-.13*	.05	-.12*	.05	-.12*	.05
Work and storage spaces	.02	.13	.01	.13	.02	.13	.02	.13	.04	.13
Distraction	.07*	.03	.07*	.03	.07*	.03	.07*	.03	.07*	.03
Scope of action	.12**	.04	.12**	.04	.12**	.04	.12**	.04	.11**	.04
Variety	.44***	.04	.44***	.04	.44***	.04	.44***	.04	.45***	.04
Overload	.10**	.03	.10**	.03	.10**	.03	.10**	.03	.11**	.03
Ventilation	-.03	.09								
Building age			.002*	.001						
Time since last indoor refurbishment					.002	.01				
Windows							.03	.10		
Building size									< -.001	< -.001
Random effects										
σ_e^2	.63***	.03	.63***	.03	.64***	.03	.63***	.03	.61***	.03
σ_{u0}^2	.03*	.01	.03*	.01	.03*	.01	.03*	.01	.02	.01
-2 Log Likelihood	2894.6		2889.8*		2894.7		2894.6		2707.8***	
R_1^2	.25		.25		.24		.25		.27	
R_2^2	.25		.25		.25		.25			

*p<.05; **p<.01; ***p<.001

12.2.4.4. Dedication

Dedication is one of two components of work engagement. The results for this measure of job performance are displayed in Table 135 to Table 137. The results show a small but statistically significant effect of age. The statistically significant predictors pertaining to the office environment are control, workspace quality, office noise, workplace appropriateness, lighting, and distraction (model 2). The same variables are statistically significant in model 3 with the exception of control and distraction. All environmental variables are positively related to dedication with the exception of workplace appropriateness.
The job characteristics introduced in model 3 are statistically significant with variety having a markedly higher γ-weight than scope of action and overload, respectively. In model 3 also tenure appears as a significant predictor. Tenure is negatively related to dedication, i.e. employees with a higher tenure report lower values in dedication. The effect, however, is small as the low γ-weight indicates. Level 1 variance explained is 46 per cent in model 3 and level 2 residual variance is close to 0 in this model. The models including level 2 predictors therefore do not provide further information. The deviance statistic is significantly smaller for models 6, 7, and 12 as in the previous analyses.

Table 135. Multilevel models for effects of office and job characteristics on dedication

	Model 0		Model 1		Model 2		Model 3	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	3.16***	.02	2.92***	.07	2.90***	.07	3.02***	.05
Fixed effects								
Gender			-.02	.03	-.02	.03	.01	.02
Age			.008***	.002	.008***	.002	.005**	.001
Tenure			-.006*	.002	-.004*	.002	-.004*	.002
Privacy					.006	.03	.01	.02
Office noise					.06**	.02	.06***	.01
Control					.09***	.03	.02	.02
Indoor climate					.02	.02	.005	.01
Lighting					.05**	.02	.03*	.01
Social density					.03	.03	.04	.02
Workspace quality					.08***	.02	.05**	.02
Workplace appropriateness					-.06*	.03	-.05*	.02
Work and storage spaces					-.07	.08	-.09	.06
Distraction					.04*	.02	.02	.01
Scope of action							.04**	.02
Variety							.40***	.02
Overload							.04*	.02
Random effects								
σ^2_e	.26***	.01	.26***	.01	.23***	.01	.14***	.01
σ^2_{u0}	.015**	.005	.012*	.005	.008*	.004	<.001	.001
-2 Log Likelihood	2022.1		1886.8***		1661.8***		1069.4***	
R^2_1			0		.12		.46	
R^2_2			.20		.46			

*p<.05; **p<.01; ***p<.001

Table 136. Multilevel models for effects of office and job characteristics on dedication (continued from Table 135)

	Model 4		Model 5		Model 6		Model 7	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	3.03***	.08	3.11***	.07	3.01***	.06	2.98***	.05
Fixed effects								
Gender	.01	.02	.01	.02	.01	.02	.001	.02
Age	.005**	.001	.005**	.001	.004**	.001	.004**	.001
Tenure	-.004*	.002	-.004*	.002	-.004*	.002	-.004**	.002
Privacy	.01	.02	.01	.02	.01	.02	.004	.02
Office noise	.06***	.01	.06***	.01	.05***	.01	.05***	.01
Control	.01	.02	.02	.02	.02	.02	.02	.02
Indoor climate	.002	.01	.005	.01	.003	.01	<.001	.01
Lighting	.03*	.01	.03*	.01	.03*	.01	.03*	.01
Social density	.04	.03	.03	.02	.04	.02	.04	.02
Workspace quality	.06**	.02	.05**	.02	.05**	.02	.06**	.02
Workplace appropriateness	-.05*	.02	-.04*	.02	-.05*	.02	-.05**	.02
Work and storage spaces	-.09	.06	-.10	.06	-.10	.06	-.10	.06
Distraction	.02	.01	.02	.01	.02	.01	.03	.01
Scope of action	.04**	.02	.04**	.02	.05**	.02	.04**	.02
Variety	.39***	.02	.40***	.02	.40***	.02	.40***	.02
Overload	.04*	.02	.04*	.02	.04*	.02	.04**	.02
Office type 1	< -.001	.06						
Office type 2	-.06	.07						
Office type 3	-.004	.07						
Office type 4	.03	.08						
Spatial density 1			-.009	.005				
Spatial density 2					.001	.002		
Spatial density 3							.10**	.04
Random effects								
σ_e^2	.14***	.01	.14***	.01	.14***	.01	.14***	.01
σ_{u0}^2	<.001	<.001	<.001	<.001	<.001	.001	<.001	<.001
-2 Log Likelihood	1063.9		1066.2		1057.3***		1050.7***	
R_1^2	.46		.46		.46		.46	
R_2^2								
*p<.05; **p<.01; ***p<.001								

Table 137. Multilevel models for effects of office and job characteristics on dedication (continued from Table 136)

	Model 8		Model 9		Model 10		Model 11		Model 12	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	3.02***	.05	3.00***	.05	3.04***	.05	2.97***	.06	2.99***	.05
Fixed effects										
Gender	.01	.02	.01	.02	.01	.02	.01	.02	.02	.02
Age	.004**	.001	.005***	.001	.005***	.001	.005***	.001	.005***	.001
Tenure	-.004*	.002	-.004*	.002	-.005**	.002	-.004**	.002	-.004**	.002
Privacy	.01	.02	.01	.02	.01	.02	.01	.02	.01	.02
Office noise	.06***	.01	.06***	.01	.06***	.01	.06***	.01	.06***	.01
Control	.02	.02	.02	.02	.02	.02	.02	.02	.02	.02
Indoor climate	.005	.01	.004	.01	.005	.01	.005	.01	.006	.01
Lighting	.03*	.01	.03*	.01	.03*	.01	.03*	.01	.03*	.01
Social density	.04	.02	.05*	.02	.04	.02	.05*	.02	.03	.02
Workspace quality	.05**	.02	.05**	.02	.05**	.02	.05**	.02	.05**	.02
Workplace appropriateness	-.05**	.02	-.04*	.02	-.05*	.02	-.05*	.02	-.05	.02
Work and storage spaces	-.09	.06	-.09	.06	-.09	.06	-.09	.06	-.12	.06
Distraction	.02	.01	.02	.01	.02	.01	.02	.01	.02	.01
Scope of action	.04**	.02	.05**	.02	.04*	.02	.04**	.02	.04*	.02
Variety	.40***	.02	.40***	.02	.40***	.02	.40***	.02	.39***	.02
Overload	.04*	.02	.04*	.02	.04*	.02	.04*	.02	.04**	.02
Ventilation	.01	.03								
Building age			<.001	<.001						
Time since last indoor refurbishment					-.004	.003				
Windows							.04	.03		
Building size									.00007*	.00003
Random effects										
σ_e^2	.14***	.01	.14***	.01	.14***	.01	.14***	.01	.14***	.01
σ_{u0}^2	<.001	.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
-2 Log Likelihood	1069.2		1067.7		1067.3		1067.7		1024.8***	
R_1^2	.46		.46		.46		.46		.46	
R_2^2										

*p<.05; **p<.01; ***p<.001

12.2.4.5. Vigour

The results for the second component of work engagement, vigour, are summarised in Table 138 to Table 140. Out of the set of control variables, tenure appears as significant predictor in models 1 and 2 but not in model 3. The following variables from the office environment appear as significant predictors in models 2 and 3: social density, privacy, workplace appropriateness, workspace quality, and distraction. Similarly to the results for dedication workplace appropriateness is negatively associated with vigour. Level 1 variance explanation in model 2 is seventeen per cent, i.e. this share of variance is explained by office characteristics. In model 3 level 1 variance explanation increases to thirty-nine per cent. This increase is due to the integration of job characteristics in this model. All three variables regarding job characteristics are highly significant predictors. Like in the analyses for the other facets of work performance, the deviance statistic is significantly reduced for models 6, 7, and 12. Similarly to the results for dedication, level 2 residual variance is very small in the baseline model (model 0) and almost reduced to 0 in model 3. Also for vigour the level 2 predictors do not contain information and predictors are not statistically significant.

Table 138. Multilevel models for effects of office and job characteristics on vigour

	Model 0		**Model 1**		**Model 2**		**Model 3**	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	2.81***	.02	2.76***	.06	2.73***	.06	2.83***	.05
Fixed effects								
Gender			.005	.03	.01	.03	-.03	.02
Age			.002	.002	.003	.002	<.001	.001
Tenure			-.006**	.002	-.004*	.002	-.003	.002
Privacy					.08**	.03	.05*	.02
Office noise					.02	.02	.02	.01
Control					.01	.02	-.01	.02
Indoor climate					.02	.01	.02	.01
Lighting					.02	.02	.02	.01
Social density					.12***	.03	.10***	.02
Workspace quality					.04**	.02	.03*	.02
Workplace appropriateness					-.09**	.03	-.07**	.02
Work and storage spaces					.28***	.07	.13*	.06
Distraction					.09***	.02	.07***	.01
Scope of action							.07***	.02
Variety							.16***	.02
Overload							.27***	.02
Random effects								
σ_e^2	.23***	.01	.22***	.01	.19***	.01	.14***	.01
σ_{u0}^2	.004	.002	.004	.002	.003	.002	<.001	<.001
-2 Log Likelihood	1797.5		1667.7***		1403.2***		1056.3***	
R_1^2			.04		.17		.39	
R_2^2								
*p<.05; **p<.01; ***p<.001								

Table 139. Multilevel models for effects of office and job characteristics on vigour (continued from Table 138)

	Model 4		Model 5		Model 6		Model 7	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	2.81***	.08	2.92***	.07	2.83***	.06	2.80***	.05
Fixed effects								
Gender	-.02	.02	-.02	.02	-.02	.02	-.03	.02
Age	<.001	.001	<.001	.001	<.001	.001	<.001	.001
Tenure	-.003	.002	-.003	.002	-.003	.002	-.003	.002
Privacy	.05*	.02	.05*	.02	.05	.02	.04	.02
Office noise	.02	.01	.02	.01	.01	.01	.01	.01
Control	-.01	.02	-.01	.02	-.01	.02	-.01	.02
Indoor climate	.02	.01	.02	.01	.02	.01	.01	.01
Lighting	.02	.01	.02	.01	.02	.01	.02	.01
Social density	.09**	.03	.09***	.03	.10***	.02	.10***	.02
Workspace quality	.03*	.02	.03	.02	.03	.02	.04*	.02
Workplace appropriateness	-.07*	.02	-.06**	.02	-.06**	.02	-.07**	.02
Work and storage spaces	.13*	.06	.12*	.06	.12*	.06	.12*	.06
Distraction	.07***	.01	.06***	.01	.07***	.01	.07***	.01
Scope of action	.07***	.02	.06***	.02	.06***	.02	.06***	.02
Variety	.16***	.02	.16***	.02	.16***	.02	.16***	.02
Overload	.27***	.02	.27***	.02	.27***	.02	.27***	.02
Office type 1	.02	.06						
Office type 2	.02	.07						
Office type 3	.03	.07						
Office type 4	.04	.08						
Spatial density 1			-.009	.005				
Spatial density 2					<.001	.002		
Spatial density 3							.07	.04
Random effects								
σ_e^2	.14***	.01	.14***	.01	.14***	.01	.14***	.01
σ_{u0}^2	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
-2 Log Likelihood	1056.0		1053.8		1043.2***		1039.4***	
R_1^2	.39		.39		.39		.39	
R_2^2								

*p<.05; **p<.01; ***p<.001

Table 140. Multilevel models for effects of office and job characteristics on vigour (continued from Table 139)

	Model 8		Model 9		Model 10		Model 11		Model 12	
	γ	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*	*γ*	*SE*
Intercept	2.85***	.06	2.82***	.05	2.85***	.05	2.86***	.06	2.82***	.05
Fixed effects										
Gender	-.03	.02	-.02	.02	-.03	.02	-.03	.02	-.02	.02
Age	<.001	.001	<.001	.001	<.001	.001	<.001	.001	<.001	.001
Tenure	-.003	.002	-.003	.002	-.003	.002	-.003	.002	-.003*	.002
Privacy	.05*	.02	.05*	.02	.05*	.02	.05*	.02	.04	.02
Office noise	.01	.01	.02	.01	.02	.01	.01	.01	.02	.01
Control	-.01	.02	-.01	.02	-.01	.02	-.01	.02	-.01	.02
Indoor climate	.02	.01	.02	.01	.02	.01	.02	.01	.02	.01
Lighting	.02	.01	.02	.01	.02	.01	.02	.01	.02	.01
Social density	.10***	.02	.11***	.02	.10***	.02	.10***	.02	.09***	.02
Workspace quality	.03	.02	.03*	.02	.03	.02	.03*	.02	.03	.02
Workplace appropriateness	-.07**	.02	-.07**	.02	-.07**	.02	-.07**	.02	-.06*	.02
Work and storage spaces	.13*	.06	.13*	.06	.13*	.06	.13*	.06	.12	.06
Distraction	.07***	.01	.07***	.01	.07***	.01	.07***	.01	.07***	.01
Scope of action	.07***	.02	.07***	.02	.06***	.02	.07***	.02	.06***	.02
Variety	.16***	.02	.16***	.02	.16***	.02	.16***	.02	.16***	.02
Overload	.27***	.02	.27***	.02	.27***	.02	.27***	.02	.27***	.02
Ventilation	-.01	.02								
Building age			.0002	.0003						
Time since last indoor refurbishment					-.005	.003				
Windows							-.02	.03		
Building size									<.001	<.001
Random effects										
σ^2_e	.14***	.01	.14***	.01	.14***	.01	.14***	.01	.14***	.01
σ^2_{u0}	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
-2 Log Likelihood	1056.1		1055.8		1053.9		1055.8		1015.7***	
R^2_1	.39		.39		.39		.39		.39	
R^2_2										

*p<.05; **p<.01; ***p<.001

12.2.4.6. Summary individual work performance

Five measures of work performance were employed in the second study. These measures cover different aspects of individual work performance and their intercorrelations are moderate (Table 125). The results of the multilevel analyses for each of the work performance measure show that workspace quality is the most consistent predictor of work performance. This variable is statistically significant in 4 out of 5 multilevel models. Workplace appropriateness and distraction appear as predictors in three models. Contrary to expectations, workplace appropriateness is negatively associated with the outcome. Privacy appears as a statistically significant

predictor in two models (situational performance and vigour). In three models a weak effect of age is identified and in two models a statistically significant effect of gender resulted. Men seem to assess their performance higher than women (see also Deaux & Farris, 1977). All of the job characteristics are statistically significant in all the models except the analysis for self-assessed job performance where variety appears as the only significant job characteristic. Variance explanation on level 1 attributable to characteristics of the office environment is between four (self-assesses performance based on feedbacks) and seventeen (vigour) per cent.
In none of the analyses of work performance level 2 predictors were statistically significant. Level 2 residual variance is small from the outset of the analyses (see also Table 115) and is reduced be level 1 rather than level 2 variables. However, deviance statistics are consistently reduced for models 6, 7, and 12, indicating a generally better fit for these models.

12.3. Discussion of study 2

In Study 2 the influence of building level parameters on employee-level outcomes (work area satisfaction, job satisfaction, health, and work performance) are analysed. Preliminary analyses showed that intraclass correlations for the outcomes are between very small (.014 for vigour) and large (.16 for work area satisfaction), showing different degrees of homogeneity of participants within buildings. The sizes of the intraclass correlations may inflate type I error. Furthermore, preliminary analyses of floor space categories per workstation show considerable variation between buildings. Together, these results indicate that multi-level analyses are appropriate. Multi-level analyses were conducted in a sequence of steps, starting with an intercept-only model without any exploratory variables followed by models that successively contain more explanatory variables (control variables, characteristics of the office environment, and job characteristics, respectively). In further steps, building characteristics were tested one by one. For the models with building-level explanatory variables, the following variables were added to floor space measures: office type, ventilation type, building age, time since last indoor refurbishment, windows, and building size.
The pattern of results is similar for all outcome variables. The second-level (i.e. building level) variables analysed in the multi-level models are not generally statistically significant coefficients in the models. The models containing total office space, ratio of workspace area to shared spaces per person, and building size are associated with significant reductions in deviance, a measure describing how well the model fits the data. Additionally, building age is a significant coefficient in the models for health and situational performance. The regression coefficients of these building-level effects are marginal in size. They are, however, associated with a statistically significant reduction of deviance, a measure considered better and more reliable for the assessment of multi-level models than significance tests of multi-level regression coefficients (Hox, 2010). Thus, the deviance reductions suggest that total office space, ratio of workspace area to shared spaces per person, and building size may contribute to employee satisfaction, health, and performance. Compared to individual-level effects, however, the effects are very small. In order to understand

these influences better more research is needed. Especially the number of buildings should be increased for a reliable analysis of small effects.

Since the between-building variance is largely explained by employee-level variables and the marginal size of level 2 coefficients, no random slope models were analysed. The most informative models in the sequences of analyses are step-3 models, i.e. individual level models containing office characteristics and job characteristics as explanatory variables (summarised in Table 141). These models are similar to ordinary least square linear regression models (Hox, 2010) such as the ones employed in study 1.

The results show, that work area satisfaction is explained to a large degree (62 per cent) by the perceived office characteristic variables included in the study. Two variables related to the furniture are the most important coefficients: workspace quality and work and storage space. The variables related to the socio-spatial environment – distraction and privacy – are highly significant but lower sized coefficients. Two of the variables referring to the ambient environment (indoor climate and lighting) and control over the individual work environment are also statistically significant. Office noise and social density are the only variables pertaining to the office environment that do not appear as significant predictors. These findings for work area satisfactions are in line with results from other studies. Frontczak, Schiavon, Goins, Arens, Zhang & Wargocki (2011) report that satisfaction with amount of space was the most important predictor of overall occupant satisfaction in their research. Satisfaction with amount of work and storage space may mediate the influence of level-2 measures of available space.

Office characteristics also have explanatory power for job satisfaction. Here, workspace quality is the strongest predictor. In addition to workspace quality, the coefficients for distraction, control, and indoor climate are significant.

In the model for health social density, distraction, workplace appropriateness, workspace quality, indoor climate, and office noise are statistically significant explanatory variables. Generally, women report more symptoms of ill health than men. The results for the individual work performance measures are heterogeneous. For two of the three measures of self-assessed job performance the coefficients for workspace quality and distraction are statistically significant. Additionally, for situational work performance privacy and workplace appropriateness are significant explanatory variables. Workspace quality and workplace appropriateness are statistically significant for the work engagement measures. Furthermore, for the dedication component of work engagement, office noise and lighting appear as significant predictors. For the vigour component the coefficients for work and storage spaces, social density, distractions, and privacy are significant.

The control variables indicate moderate gender effects for work area satisfaction and the self-assessment of individual work performance and a strong effect for health. Age and tenure have marginal influences. The job characteristics are statistically significant and consistent predictors of all outcomes except work area satisfaction. Variety is the strongest predictor in most models and is unexpectedly also significant for work area satisfaction.

The results summarised in Table 141 show that not all office characteristics are relevant for all outcomes. Control over the own work environment is significant for work area and job satisfaction but not for the other outcomes. Similarly, indoor climate is an explanatory variable for work area satisfaction, job satisfaction, and health only. Social density contributes to variance explained in health and vigour and office noise is significant in the health and dedication models. Similarly as in the first study, also in the second study there are some indictors for mediation effects for control over the environment by job characteristics (in the models for job satisfaction, job performance based on feedback, and dedication). The direction of the relationships indicates whether they act as demands or resources. The results confirm the position of the environmental variables in the Job Demands-Resources framework from the first study (Figure 45).

Variance explained by office environment factors in the models is sixty-two per cent for work area satisfaction, thirty per cent for job satisfaction, eighteen per cent for health, four to nine per cent for work performance and twelve to thirteen per cent for work engagement. Variance explanation is generally higher for satisfaction than for behaviour (individual work performance) (see also Humphrey et al., 2007).

The main aim of this study was to identify building-level variables that explain variance in employee-level outcomes. The statistical models show that office space per employee and building size may contribute to variance explanation for the outcome variables studied. This effect, however, is detectable only in the overall model fit, i.e. the description of the fit between a statistical model and a set of observations. The effects of office space per employee and building size are not statistically significant on the level of significance tests for coefficients. This indicates that they do not contribute unique variability. Building-level variables may be confounded with individual-level perceptions and assessments or may act as proxies for other influencing variables. Further research should examine this relationship by including aggregated level-1 characteristics in multi-level models, i.e. by including aggregated level-1 variables as structural level-2 variables (see Hox, 2010; Raudenbush & Bryk, 2002). If aggregated level-1 variables are statistically related to an outcome even after controlling for level-1 effects this would suggest that level-1 and level-2 variables are confounded.

The results indicate that effects of building-level variables may become very small or irrelevant when known effects of office and job design are controlled for in the study design and when variance is correctly partitioned to the adequate level as in multi-level modelling. Thus, no objective office building design variables can be identified as sources of influence on satisfaction, health, and performance. Rather, perceptions of the environments have explanatory power. This result corroborates previous research that identified stronger correlations between self-reported measures and strain as compared to objective measures of stressors (B. A. Greiner et al., 1998; B. A. Greiner et al., 1997).

Table 141. Summary of the step-3 models (γ-values)

	Work area satisfaction	Job satisfaction	Health	Self-assessed job performance	Self-assessed job performance based on feedback	Situational work performance	Dedication	Vigour
Gender	.07*	.08	-.21***	.06*	.08*	.11*	.01	-.03
Age	-.004*	.002	-.004	.004*	<.001	.01**	.005**	<.001
Tenure	.002	-.002	.002	<.001	-.003	.002	-.004*	-.003
Privacy	.11***	.04	.05	.04	-.008	.16**	.01	.05*
Office noise	-.01	.04	.04*	-.03	-.01	-.01	.06***	.02
Control	.10***	.11*	-.04	-.04	.02	-.07	.02	-.01
Indoor climate	.08***	.05*	.04*	-.003	-.006	.05	.005	.02
Lighting	.05**	.03	.02	-.03	.01	.04	.03*	.02
Social density	.01	.11	.11**	.04	.06	.07	.04	.10***
Workspace quality	.44***	.27***	.05*	.06**	.03	.07*	.05**	.03*
Workplace appropriateness		.03	-.06*	-.004	-.01	-.12*	-.05*	-.07**
Work and storage spaces	.30***	-.12	.16	-.04	-.13	.02	-.09	.13*
Distractions	.11***	.12***	.10***	.05**	.03	.07*	.02	.07***
Scope of action	-.002	.06	.11***	.01	.10***	.12**	.04**	.07***
Variety	.06*	.47***	.10***	.26***	.14***	.44***	.40***	.16***
Overload	.02	.14***	.13***	.04	.10***	.10**	.04*	.27***
ΔR^2 control variables	.02	.02	.03	0	0	.01	0	.04
ΔR^2 environment	.62	.30	.18	.8	.04	.09	.12	.13
ΔR^2 job characteristics	0	.11	.05	.12	.11	.14	.34	.22

The relationships between perceptions and outcomes show that factors of the ambient environment are more important for satisfaction and health than for work performance. Office noise is weakly associated with health and dedication but not with the other outcome measures. Compared to previous research, the effects of office noise are small. This finding can be explained through the consideration of qualities of office noise. As several studies summarised in chapter 6.2.1 show, the most disturbing aspect of office noise is speech. The impact of this aspect of office noise is captured in the significant effects of distractions in the workplace. Distraction is a significant coefficient for most of the outcome measures, including three of the five performance measures.
The other aspects of the socio-spatial environment have more specific effects: social density is positively associated with health and vigour, a result that indicates that proximity or accessibility to colleagues connected with social density may act as a resource for well-being. Privacy is a significant predictor for work area satisfaction, situational work performance, and vigour. This result confirms that privacy generally acts as a resource.
The material environment has not received much attention in research. In this study, the quality of the workspace appears as an important predictor of all outcome measures except one work performance measure. Work and storage spaces are strong predictors of work area satisfaction and are also correlated with vigour. Workplace appropriateness is negatively associated with health, situational work performance, and work engagement. This result is unexpected because workplace appropriateness is assumed to be a resource. The result may be due to the high intercorrelations with other aspects of the office environment and the low unique variability contributed by workplace appropriateness.
Control over the work environment is a significant predictor for both, work area and job satisfaction. This confirms results from previous research (Lee & Brand, 2005). However, the influences of control on performance reported by Leaman & Bordass (2005) are not confirmed.

From this pattern of results it can be concluded that socio-spatial and material aspects of the office environment are important job demands or resources for work performance while aspects of the ambient environment are important for work area satisfaction, job satisfaction, and health. Control over the office environment contributes to work area and job satisfaction.

12.3.1. Limitations of the second study

There are at least four limitations that must be mentioned for the evaluation of the second study.
While the second study uses a large dataset, the findings are limited by the cross-sectional nature of the data that does not allow the inference of causality. However, based on the theoretical framework and previous research, the direction of the effects can be assumed to be valid.
A second limitation is the reliance on self-reports in the outcome measures. In connection with self-reports of perceptions of the environment this causes a concern

for common method bias. Common-method bias refers to the fact that both, the independent and dependent variables are measured using the same method. This may result in common method variance, i.e. the increased proportion of variance attributable to the method of data collection (and not to the constructs the variables represent). While common method bias is a controversial issue (Podsakoff et al., 2003; Spector, 2006) the differences in the models for the different individual work performance measures indicate that participants give a differentiated, complete, and full account of their self-assessments.
The third limitation refers to the building-level data. These data were collected using a checklist and interviews. On the one hand differences may exist between average building features and local (e.g. floor-specific) conditions. Not all employees of a specific office building participated in the survey and therefore such differences may be of consequence. On the other hand the building-level data collected could be too abstract and of limited relevance for the employees. Previous research has shown that the immediate environment is more important for evaluations of work environments than more distant aspects (Donald, 1994; Marans & Spreckelmeyer, 1982). Therefore, objective measures of office and workspace quality may have more explanatory power than the variables analysed in this study.
The fourth limitation consists in the composition of the sample. The participants and participating organisations represent a convenience sample. Organisations were participated in the study on a voluntary basis. This sampling technique may threaten the external validity of the findings because the samples are not representative of the population and generalizing from the results obtained from a convenience sample may be erroneous (T. D. Cook et al., 1990). Due to the size of the sample both in terms of individual participants and participating organisations the threat of external validity is considered to be limited.

12.3.2. Conclusions and implications

The results of the second study show that objective measures of office building and design parameters generally explain little variability in individual level outcomes. Rather, variability in the outcome measures (work area satisfaction, job satisfaction, health, work performance) is explained by individual perceptions and assessments of the office environment and job characteristics. The influences of the perceived influence on the outcomes are therefore largely independent of building characteristics. However, the models with social density and building size measures increased overall model fit without contributing unique variability. The relationship between spatial density and building size and individual level outcomes deserves and requires further research. The perception and assessment of the amount of space available is an important factor for environmental satisfaction. However, the relation to objective parameters remains unclear and the satisfaction with available spaces may be affected by other factors than the actual measurable floor area.
While the overall fit of models including level-2 coefficients for spatial density and building size was better than for models without these variables, the effect size seems to be small when level-2 effects are taken into account. Especially office type, a common concept in office workplace research (Bodin Danielsson & Bodin, 2008;

Duffy, 1997; Oldham, Cummings & Zhou, 1995) seems be less important than some of the perceivable consequences such as distractions or privacy office types implicate. Designing offices and taking into account distraction and privacy issues may be more independent of office types than current discussions suggest. Ventilation type and operable windows, two important issues in sustainable building design and comfort research (e.g. Brager & Baker, 2009; Steemers & Manchanda, 2010; Wargocki, 2009) also may be less important than the actual implementation, use and control of ventilation systems and practices. Eventually, building age and time since last indoor refurbishment play a marginal role indicating that building adaptation (Brand, 1995) and modernisation contribute little to the outcomes analysed. The effects of such interventions are captured by the importance of workspace quality as an important level-1 variable.

The relationship between objective parameters of office design and outcomes deserves more research. Objective data regarding stressors or resources in work environments remain an important scientific and pragmatic goal of research because it will allow for more effective design. However, the identification of informative objective parameters is difficult because such parameters may oversimplify the relationship between design parameters and human experience and behaviour. Therefore, a contingency-based approach may prove more fruitful. Such an approach should consider the joint adaptation of physical (office design), social (e.g. organisational culture), task, and information technology systems with workforce demographics and employee needs as implied in the socio-technical systems approach or suggested by the organisational ecology approach (Becker, 1990, 2007). While this study indicates that for evidence based design there is yet a long way to go, the findings support evidence-based reasoning for workplace design (Pullen, 2005) that combines the use of scientific evidence with individual design expertise and organisational choices (see also Sackett, Rosenberg, Muir Gray, Haynes & Richardson, 1996).

The results of this study show, that the outcome measures are in parts associated with different predictors, e.g. control is correlated with satisfaction but not performance and health and workplace appropriateness is correlated with work engagement and situational performance but not with satisfaction and health. On the basis of this evidence specific goals of workplace design therefore should focus on different elements.

In this study, the building related parameters examined proved of little informative value. This strengthens user-centred approaches to office and workplace design (Vischer, 2008) that stress the importance of analysing stakeholder and user needs as well as continuous evaluation and improvement of existing work settings.

13. Discussion

While many studies have investigated the motivational characteristics of job and work design (Humphrey et al., 2007; Parker & Wall, 1998) very few (Fried, Melamed & Ben-David, 2002; Oldham & Rotchford, 1983) have combined job and environmental characteristics. The work presented in this thesis shows that the design of office environments affects employee well-being (satisfaction and health), commitment, and individual work performance. The primary finding of the analyses is that influences of the office environment can be identified and that these effects persist even when job design and factors of the social environment are controlled. Thus, the office is associated with a unique contribution to variance explained in the outcomes. This confirms that job characteristic with their focus on motivational components, social characteristics with their focus on interactional components, and environmental characteristics with their focus on contextual components have largely nonredundant effects on reactions and behaviour of office occupants and incrementally predict outcomes.

Longitudinal research in the first study shows that changes in office environments are correlated with changes in employees' perceptions and assessments of the office environments and that job characteristics and the perceived social environment remain unaffected. This finding confirms that perceptions of the office environment are generally independent from job characteristics and the perceived social environment. Longitudinal regression analyses result in strong evidence for causal relationships of changes in the office environment and individual-level outcomes: office noise and privacy affect job satisfaction; workplace appropriateness influences environmental satisfaction, and privacy and work and storage spaces have an impact on individual work performance. Cross-sectional regression analyses in the first study are used to identify weaker effects by using a larger proportion of the study sample (as compared to the longitudinal sample) (Table 142). The results of these analyses are inconclusive because the statistical association between office environmental variables and outcomes are inconsistent across different models containing similar or the same set of variables. The results, however, confirm that in some cases (i.e. in some of the organisations studied) effects of the office environment on the outcomes could be identified. The difference between the organisations studied is also apparent in the repeated measures analyses where the magnitude and direction of changes in user perceptions follow different patterns. Thus, the relationship between office design and outcome seems to be co-determined by other organisational factors such as usage policies, change management processes, or aspects of work and office design not examined in my studies.

The results of the second study generally confirm the individual level findings from the first study. No effects from building-level office design elements could be identified in multi-level models although the models with social density and building size measures increased overall model fit in comparison to models containing only level 1 variables (i.e. perceptions).

The results of the two studies regarding effects of the office environment on the outcomes are summarised in Table 142. While result from the first study refer to effects in some models, results from the second study are based on a larger dataset containing 39 office buildings and 1373 survey participants. Together the two field studies cover 45 office buildings and about 2000 respondents in surveys and thus represent a very broad database. Although the database covers many different industries and professions it is not representative in a statistical sense for Swiss office buildings in general. However the size and composition of the sample can be assessed as a solid basis for a potential assessment of office environment effects on individual-level outcomes.

Table 142. Summary of empirically significant relationships between office design variables and outcomes from first and second study

	Outcomes									
	Job satisfaction		Environmental satisfaction		Organisational commitment	Health		Individual work performance		Work engagement
study	1st	2nd	1st	2nd	1st only	1st	2nd	1st	2nd	2nd only
Lighting			+	+	+					+
Indoor climate	+	+	+	+			-			
Office noise	-		-				-			-
Environmental stressors (1st study only)						-				
Work and storage space			+	+				+		+
Workplace appropriateness	+		+		+	+	-	+	-	-
Workspace quality	+	+	+	+	+	+	+		+	+
Distractions	-	-	-	-			-	-	-	-
Privacy	+		+	+				+	+	+
Crowding (1st study only)	-		-							
Control		+	+	+				+		
Social density							+	+		+

+	positive influence
-	negative influence
Empty	no evidence
Grey	Result from longitudinal regression

Taken together, the two studies show that job satisfaction is influenced by various aspects of perceived office environments such as privacy, office noise, distractions, crowding, workspace quality, workplace appropriateness, indoor climate, and control. Privacy and office noise appeared as significant predictors in one longitudinal regression model in the first study. However, the results were not confirmed in a second model that used a different subset of the data. In the second study workspace quality, distractions, control, and indoor climate (in order of the magnitude of their influence) are statistically significant predictors of job satisfaction. In some of the cross-sectional models in the first study privacy, distraction, crowding, workplace appropriateness, and workspace quality appear as significant predictors. Environmental satisfaction was predicted by privacy and indoor climate at time 2 in one model of the longitudinal regression analyses in the first study. The second model did not reveal any significant predictors although variance explanation substantially increased when time 2 aspects of the perceived office environment were entered into the model. In the second study, workspace quality, work and storage spaces, distraction, privacy, control, indoor climate, and lighting appear as significant predictors. In addition to these aspects, in some of the cross-sectional analyses in the first study office noise and crowding appear as significant predictors. Organisational commitment was only analysed in the first study. Workplace appropriateness, workspace quality, and lighting appeared as significant predictors in cross-sectional models.

Health status was not associated with any predictor in longitudinal models. However, in the second study social density, distraction, workplace appropriateness, workspace quality, office noise, and indoor climate appear as significant predictors. These results confirm and expand findings from the first study where workplace appropriateness and workspace quality appeared as significant predictors.
Individual work performance was predicted by privacy and work and storage spaces in the longitudinal analyses in the first study. Cross-sectional regression models in the first study indicate that control and distractions may contribute to self-assessed individual performance and in one out of three regression models workplace appropriateness appears as a significant predictor while social density is significant in one out of nine statistical models. In the second study privacy, workspace quality, distraction, and workplace appropriateness are statistically significant predictors of individual work performance. Furthermore, in the second study work and storage spaces, office noise, social density, workspace quality, workplace appropriateness, distractions, and lighting are statistically significant predictors of work engagement, an additional outcome measure related to job performance measured in the second study only.
The summary of empirical relationships in Table 142 shows that the effects identified in the longitudinal regression analyses in the first study are not completely confirmed in the second study. This indicates that these effects may depend on the selective awareness of some aspects of the office environment caused by changes of the environment rather than on the actual office environment. Changing office environments may raise employee's awareness for certain aspects of the work environment. These aspects then become temporarily more salient although they may not be highly important factors for satisfaction, health, and work performance.

The effect sizes of each class of influencing factors (office environment, job characteristics, social environment) can be captured by the variance each of these classes explain in the outcomes. The proportions of variance in the outcome measures explained by aspects of the office environment, job design, and social environment are summarised in Table 143. The comparison of the two studies shows that the magnitudes are similar for job satisfaction, environmental satisfaction, and health. The results show that similarly to job characteristics, the office environment has a stronger effect on attitudinal outcomes (satisfaction) than on behavioural ones (performance).

Comparing the two studies, differences can be noted: in the second study the proportion of variance explained in job satisfaction by job design is lower than in the first study. This difference can be attributed to a difference in job characteristics variables employed. In the second study no data on task identity (holistic job) were collected, a variable that turned out to be more informative in the first study that had been assumed based on theoretical models. Most theoretical approaches and empirical results tend to find autonomy (scope of action) the most important job characteristic (e.g. Frese & Zapf, 1994; Humphrey et al., 2007; Karasek, 1979; Karasek & Theorell, 1990). The neglect of task identity may explain the lower proportions of variance explanation in the second study. However, the difference in the job design variables employed in the two studies does not affect the results for the other outcome measures.

A second difference between the two studies concerns variance explanation by office environment variables in performance measures. Variance explanation for these measures is lower in the second study. The results from the second study are based on a larger dataset and therefore represent more of the heterogeneity of Swiss office buildings. Based on the findings from the second study, variance explanation by environmental factors in individual work performance is between four and nine per cent on average.

The results of the two studies suggest that office design can have an impact on employees' attitudes, well-being, and behaviour. Taking into account the amount and diversity of organisational and individual variables that affect employees, the proportions of variance accounted for by the office environment are considered as high. Thus, the analysis of physical work environments contributes to the understanding of results on employee-level that important for organisational performance.

The contribution to variance explanation in job satisfaction by factors of the office environment is about the same as the contribution by job design. This result may incorporate the impact of environmental satisfaction, i.e. environmental satisfaction may constitute an important facet of overall job satisfaction and as such mediate the effects of positive or negative assessments of office environmental elements (Newsham et al., 2009; Veitch et al., 2007). This relationship deserves more attention in further research.

The physical office environment accounts for fifteen to twenty-one per cent of variance in health symptom and therefore should be considered as an important factor for employee well-being. However, this result is based on a list of symptoms that may have only limited correlations with actual absenteeism figures, a relationship that should be examined in further research. Nevertheless, the results show that the office environment has a considerable effect on stress-associated symptoms and that this effect is higher than the impact of job design and the social environment.

Variance explanation of individual performance measures by factors of the office environment is lower than for the other outcomes and lower than the ratio of variance explained by job design. The value is comparable to previous studies (Brill et al., 2001) and of a size that makes the office environment a relevant contributor to organisational performance. The importance of office design may even be bigger when team-level performance is taken into account (Brill et al., 2001), a dimension of workplace research that has received little attention yet (Heerwagen et al., 2004).

Table 143. Summary of proportions of variance explained in outcomes by classes of influencing factors

	Study	Office environment	Job design	Social environment (1st study only)
Job satisfaction	1	12-37%	15-23%	0-7%
	2	30%	11%	
Environmental satisfaction	1	42-70%	0-1%	
	2	62%	0%	
Organisational commitment (1st study only)	1	12-23%	0-9%	0-5%
Health	1	16-26%	3-4%	0-5%
	2	18%	5%	
Self-assessed job performance	1	12-15%	12-13%	0%
	2	8%	12%	
Self-assessed job performance based on feedbacks	1	0-16%	12-24%	4-8%
	2	4%	11%	
Situational job performance	1	19-41%	4-12%	0%
	2	9%	14%	
Dedication (2nd study only)	2	12%	34%	
Vigour (2nd study only)	2	13%	22%	

The results summarised in Table 142 show that the office environment contains demands as well as stressors. Because the Job Demands-Resources framework defines demands and resource in function but not in content and due to the lack of conclusive evidence from previous research, the categorisation of office characteristics to demands and resources is not a priori given. Theoretical reasoning based on action-regulation theory led to the allocation of most office characteristics to job demands, with the exceptions of control over the physical environment, privacy, and environmental comfort (Figure 22). Thus, the factors considered relevant were regarded as requiring sustained physical or mental effort that is associated with physiological and psychological costs.

The two studies confirmed that overload acts as a job demand while the job characteristics scope of action, variety, holistic job, and social support act as resources. The results of the two studies indicate that some office environmental variables belong to job resources, i.e. represent aspects that are functional for achieving work goals, reduce demands and the costs associated with demands, and stimulate personal growth, learning, and development (Figure 61). The assumption, based on theoretical reasons and from previous research, that office noise, distractions, environmental stressors, and crowding act as demands while control over the physical environment and privacy act as resources could be confirmed. On the other hand, lighting, indoor climate, aspects of workspace design (work and storage space, workspace quality, and workplace appropriateness), and social density appear as resources rather than demands in the two studies.

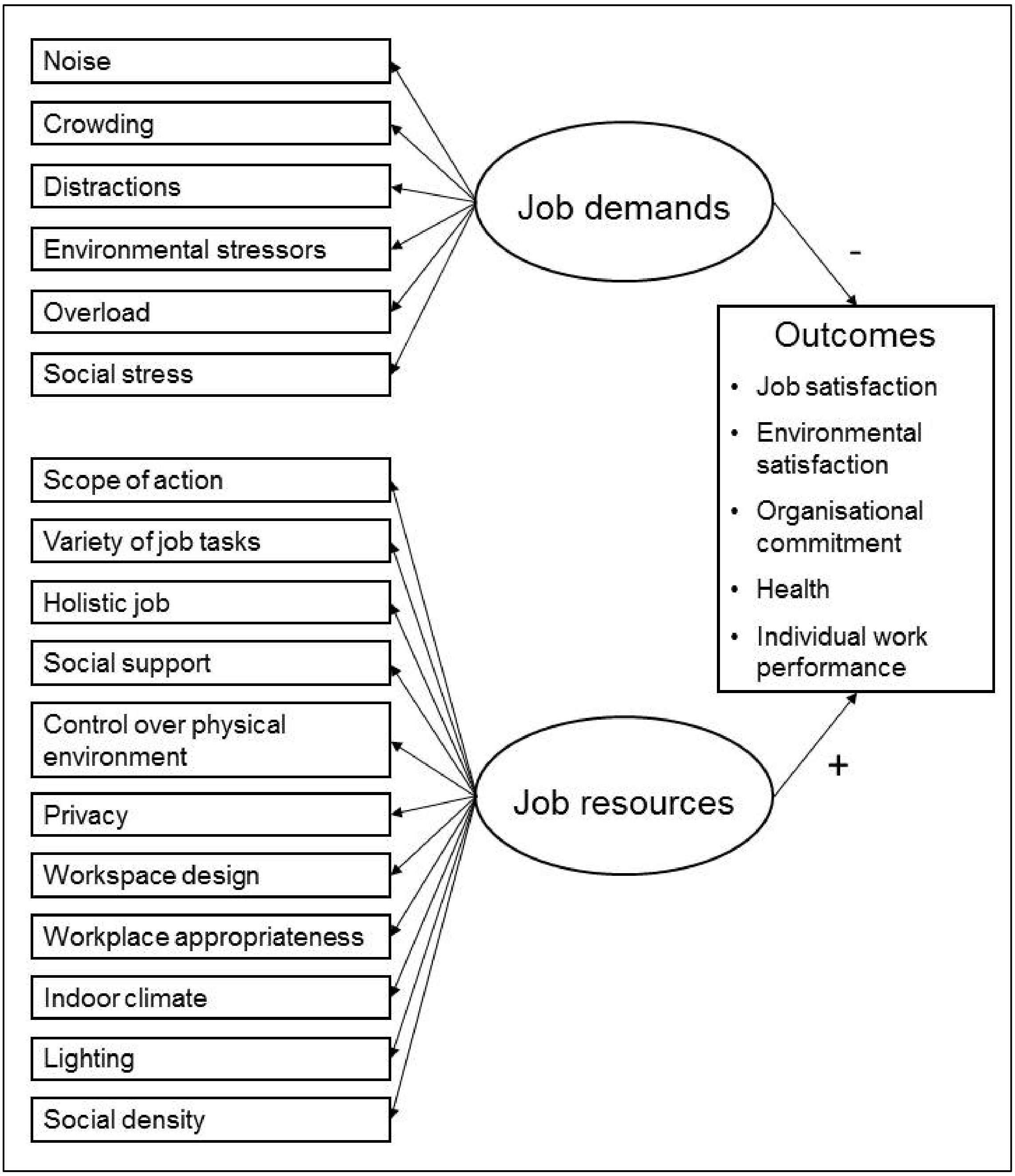


Figure 61. Job Demands-Resources model containing empirically found relationships between office environmental variables and outcomes

The Job Demands-Resources model has been developed in reaction to the limited perspective on negative effects in traditional stress models. The inclusion of resources and the positive effects associated with them proved fruitful for the research of office environment effects. Notably the discovery of workspace design and social density as resources may stimulate more research and influence office design in the future.

Previous research on workplace design has tended to focus on demands and theoretical approaches such as action-regulation theory emphasise resources less than demands. However, many of the variables employed in the studies can generally act either as demand or resource (see also Crouch & Nimran, 1989; Vink & De Looze, 2008) although little is known about the tipping point values or bandwidths. The results of the two studies show that aspects of the ambient, the material, and the socio-spatial environment may act as resources. This suggests that future research in office design should consider the function, contribution, and limits of resources related to the work environment. Additionally, organisations may be interested to know whether they are doing well or not in office design, i.e. whether their scores in a survey are high or not. Therefore the issue of cut-off scores needs to be integrated in further research e.g. by analysing odds ratios or validation studies (Demerouti & Bakker, 2011). Such cut-off scores, however, are not applicable to all variables of the office environment. Kim & de Dear (2012) present evidence that some factors of the office environment (such as temperature, noise, amount of space, privacy) have a predominantly negative influence on user satisfaction while other factors (such as lighting, comfort, or air quality) have a predominantly linear relationship with overall occupant satisfaction, i.e. these factors can reduce or increase satisfaction.

Crawford, LePine & Rich (2010) recently proposed an extension of the Job Demands-Resources model by taking into account appraisal of demands by employees. Their research suggests that there may be job demands that are appraised as challenges rather than hindrances by employee. These job demands require sustained effort but are not only related to negative outcomes such as exhaustion but also directly related to work engagement. Findings like these may lead to more refined JDR models in the future. They may also lead to further analyses concerning the function of office environment factors. For instance, certain variables may act as challenging demands rather than resources, i.e. they may have a positive impact on engagement as well as on exhaustion.

The results from the two studies imply that the theoretical approach of action-regulation theory may be incomplete because the predictions derived from this approach could not be confirmed completely. Especially, environmental comfort, a resource, contains some of the variables (e.g. density, lighting, indoor climate) that had been expected to belong to the demands category because they may overtax regulation. However, the positive statistical relationship between these variables and the outcomes studied suggests that they act as resources rather than demands. This implies that elements of office environments can support or facilitate action-regulation by providing material, ambient, or socio-spatial qualities that are functional for achieving work goals instead of only preventing hindrances. While action-regulation theory implies this possibility, it has been mainly applied to study workplace stress, regulation problems, and health (Frese & Zapf, 1994) and not to resources for action-regulation. Furthermore, action-regulation theory focuses on action execution. The design of office environments, however, may be less important for execution of actions than the motivation to dedicate oneself to a certain task. While action-regulation theory does acknowledge that motivation is an important concept, motivation is integrated in the concept of goals that are conceived as combining cognitive and motivational aspects of action (Frese & Zapf, 1994). The focus of the action-regulation approach is on the cognitive processes that constitute a better understanding of a job. The findings of the two studies suggest that for the study of office environments the focus could be extended to include motivational

processes of material, environmental, and socio-spatial resources for office occupants' work performance, satisfaction, and health. Such an extension would strengthen the connection between the action-theoretical approach and the JDR-framework that proposes dual processes (the chronic job demands-health impairment route and the resources-motivation route) but does not specify the psychological mechanisms.
Furthermore, for the study of human-environment interaction in work settings an extension of the theoretical approach is needed that encompasses aesthetic-emotional aspects and collective action regulation processes. This will lead to a better understanding of the effects of workspace design on office users. From the perspective of collective action regulation the role of social density as a resource becomes more plausible as compared to an individual action-regulation perspective.

The differentiation of office environment characteristics into demands and resources has implications for psychosocially supportive work design and workplace management. Demands and resources are treated differently: the focus in dealing with demands is on remedying weaknesses while with resources the preservation and development of strengths is the goal. Additionally, information collection for the two classes may be different. Demands are associated with hindrances of work processes and feelings of discomfort. They will therefore be uttered as complaints toward workplace or facilities managers. In contrast, information on resources must be deliberately searched or collected. This implies that data collection methods and procedures for evaluation, monitoring, and benchmarking of work environments must be developed and implemented in user organisations.

The material correlates of reported demands and resources proved to be difficult to find. In the second study the selected building-level variables proved to be uninformative. Self-reported data on well-being and work performance is better explained by individual perceptions of the office environment and job characteristics than by measurable parameters of office buildings. The situation may be different if outcomes can be measured with less dependence on self-reports of job incumbents. Generally, the results confirm that the perceived situation often has a greater effect on individuals than the objective situation does (Zalesny & Farace, 1987) and thus support the assumptions of the action-theoretical approach. Employees' perceptions and assessments of their work environment are affected by their expectations and perceptions of the spatial-physical reality shape the experience and behaviour in the office. The surroundings are therefore assessed in relation to work tasks and processes, individual needs, and other aspects of work life. This assessment is sometimes described as usability of an office environment (Windlinger et al., 2010). Office environment usability can be achieved in many ways, i.e. there is no "one best way" to design office workplaces. Rather, the potential of office design for desired outcomes can be utilised and therefore must be understood.
The objective parameters examined in the second study do not contribute to a better understanding of usability from a design point of view. Other objective parameters or indices may prove more informative. Based on the results of this research, objective parameters (that still dominate in many practical approaches to building evaluation)

should be complemented by subjective information provided by users of an office environment for benchmarking and further development of office environments (Preiser, 2002). The relationship between perceptions and building-level parameters (building design and building technology) remains an important issue, especially in the context of sustainable buildings because a focus on energy-efficiency in building and managing office buildings may result in negative or positive effects for office users (Windlinger, Janser, Feige & Wallbaum, 2012).

Offices, composed of the material, ambient, and socio-spatial environment, must be aligned with other organisational, technological, and management decisions. The two studies, demonstrate the importance of various aspects of office environments across different buildings. These aspects can be included in occupancy analyses in order to identify strengths and weaknesses of office environments; especially if the values can be compared to internal baseline or comparison measures or to external benchmarks. Results from occupancy analyses can then be used for further improvement of environments and/or for communication between workplace managers and office users. For instance, a theory-based set of measurements for a user-oriented assessment of office environments could support discussions among various stakeholder groups in change projects where the emotional nature of the workplace often becomes evident (see also Farshchi & Fisher, 2005).

The two studies have several limitations and implications for future research directions. A set of limitations is associated with field research: The studies rely on data from voluntarily participating organisations. These organisations imposed limitations on questionnaire size in the first study that proved to render the analyses difficult because different versions of the questionnaire had to be employed. Furthermore, access to office users was limited in both studies. This led to the impossibility to calculate a response rate in the second study. Convincing organisations of the usefulness of workplace research and establishing long-term relationships may remedy this kind of problem. The broad participation by more than twenty organisations in the second study shows that generally business organisations are interested in the study and improvement of their office workplaces.

A second set of limitations refers to methodological issues. The operationalizations of the concepts were based on literature and refined by principal components analyses. Some measures were skewed and had to be normalised. Furthermore, some variables are highly correlate, notably workplace appropriateness was strongly correlated with other variables pertaining to the office environment which may have led to inconclusive results regarding this variable. There is a need for a methodological development of the field. Many approaches to office building assessments are based on a design process framework (e.g. Mallory-Hill, Preiser, Watson, 2012; Preiser & Vischer, 2005) and do not elaborate theoretical background and measurement of perceptions of office users. The fundamental difference between technical and psychological quality of office environments (as framed in the socio-technical systems theory) needs further consideration. The JDR framework in connection with the action-regulation theory proved to be a valuable approach for the analysis of perceptions and their effects on outcomes. Further theoretical development should integrate both, motivational processes influenced by office environments and action execution. Such a development would contribute to a more detailed specification of the measurements and scales used. Mainly the function and interplay between privacy, distractions, noise, and control over the environment need to be developed from a theoretical and methodological point of view because they partially overlap and because they are consistently among the most important predictors for several outcomes. The same is true for workplace appropriateness, workspace quality, and environmental satisfaction.

A second methodological limitation concerns the estimation of relative importance of influences which was estimated via regression weights and variance explanation in the two studies. Further research may benefit from recently developed relative weights analysis techniques (Krasikova, LeBreton, & Tonidandel, 2011; LeBreton & Tonidandel, 2008) to cope with intercorrelated predictors. Finally, the regression and multi-level analyses serve for prediction and explanation of association. However, they do not prove causality. Further experimental research is needed in order to establish causal relationships. The isolation of influencing variables in controlled laboratory studies can e.g. contribute to a better understanding of the material office environment (workspace quality and workplace appropriateness) that has been identified as an important source of influence.

Further limitations concern the contents of the research of this thesis: the focus of the two studies is on individual-level outcomes. This level of outcomes should be complemented by an inter-individual level of networks, social contexts (Grant & Parker, 2009; Kilduff & Brass, 2010), and corresponding knowledge work environments (Heerwagen et al., 2004) because this level of analysis can provide further knowledge on the factors of environment design that affect interaction, social relations, creativity, and innovation (Oseland, Marmot, Swaffer & Ceneda, 2011). When the level of outcomes is expanded, multi-level models can be used for a better understanding of the effects of office environments. Particularly the meaning of constructs across levels of analysis deserves more attention (see also Demerouti & Bakker, 2011). For example, distractions are a demand at individual level but verbal communications leading to individual distraction could prove to be a resource on team level. So the same construct could have different functions on different levels of analysis.
A further limitation regarding the content of the research consists in the consideration of employees’ physical mobility. Using diverse settings or zones within the same office building or in different buildings provides a degree of behavioural control that has not been covered by constructs of control over the individual office environment. Physical mobility of employees could also lead to short term variation in demands and resources, an issue that also needs further consideration.

The analysis of office workplaces from both perspectives, demands and resources, is a field of research that may result in more knowledge on interactions between parameters in the complex interplay of personal, social, and design factors for well-being and work performance of employees (see also Bluyssen, Aries & van Dommelen, 2011). While the two studies in this thesis show that the physical environment in offices has important unique effects on employees' well-being and performance, the mechanisms of these effects remain to be researched from an organisational ecology point of view that take into account reciprocal effects between personal, technical, organisational, and environment design factors.

14. Conclusions

The main goal of this thesis consists in clarifying the role of the physical work environment in offices for employee-level outcomes. In previous research satisfaction was the predominant outcome measure. In the two studies of this thesis job and environmental satisfaction measures were complemented with measures for health, organisational commitment, individual job performance, and work engagement. The relationship between the physical work environment and outcomes was studied based on the Job Demands-Resources framework that focuses not only on negative aspects (demands) but also on positive aspects (resources) of the work environment. The Job Demands-Resources framework allows the combined analysis of effects from the job design, physical, and social environment. The two empirical studies with large databases show that effects of the office environment on users' perceptions, assessments, and reactions can be identified and that these effects remain significant even when job characteristics or aspects of the social environment are entered into the statistical models.

The longitudinal analyses of office concept changes in four organisations show that the impacts of changes in the office environment are different in different organisations. These effects therefore are assumed to be dependent on organisational practices and change management procedures. Further research on effects of the work environment should control for these influences by more thorough descriptions of organisational characteristics and change management procedures.

The results of the multi-level models in the second study show that the impact of the office environment cannot be explained by characteristics of the office buildings. Rather, the variance in the outcomes (job and environmental satisfaction, health, job performance, and work engagement) is associated with employees' perceptions and assessments. Thus, the results from the two studies generally confirm findings from previous research carried out in different geographical-cultural and technological contexts. In general, the effects of office work environments therefore seem to be similar across region, time, and building construction contexts. There is one major difference, however, to previous research. In my studies social density appears as a resource rather than a demand, i.e. high social density is positively associated with health, performance, and work engagement.

The results from the two studies show that the facets of the ambient environment (office noise, lighting, and indoor climate) are predictors for affective-attitudinal outcomes (satisfaction and commitment). Effects of this class of environmental variables on health, performance, and work engagement are small and inconclusive. Similarly, control over the office environment seems to be mainly important for job and environmental satisfaction. The limited and inconclusive effects of the ambient environment are unsurprising because indoor environmental conditions are planned on the basis of laboratory research (reviewed in chapter 6). Laboratory research on the ambient environment has identified larger effect and helped to identify the bandwidths of optimal comfort. The conditions in the buildings studied seem to lie within the boundaries of these bandwidths.

Different aspects of the socio-spatial environment are captured with the following variables: privacy, distractions, crowding, and social density. Distractions appear to be a crucial variable in both studies. Distractions have a negative influence on job satisfaction, environmental satisfaction, health, work performance, and work engagement. Similarly, privacy affects environmental satisfaction, work performance, and work engagement. Crowding proved to reduce job and environmental satisfaction in the first study and social density is positively, but not consistently, associated with health, performance, and work engagement. These results regarding the socio-spatial environment confirm previous results on the importance of privacy. However, distractions appear as a more consistent and stronger predictor. In contrast to previous research, social density appears as a resource in the studies of this thesis and has positive associations with health, performance, and work engagement. These positive relations are found when several variables are studied at the same time. Thus, the positive effect of social density appears when the effects of crowding, privacy, and distractions are taken into account. This finding stresses the importance of multivariate methods in research of work environments. Furthermore, it points to the need for more research on the relationship between the different aspects of the socio-spatial environment. The positive associations between social density and health, performance, and work engagement seem to be suppressed by privacy and distractions and their nature remains to be researched. The practical implications, however, are important: it is more important to deal with distractions than with size and structure of office rooms. Large and openly structured office rooms seem to work well for employees if distractions are minimized by technology (e.g. sound masking), design of circulation paths, and behaviour of office users. An important measure for reduction of distractions and regulation of privacy is the provision of spaces for retreat and concentrated work in offices with high social density.
The findings of the two studies therefore contribute to the open vs. closed offices debate by specifying the relevant variables and their effect in a larger context. Further discussions on office structures should not continue to revolve around open vs. closed offices but focus on distraction-rich and distraction-poor open space offices.

The material environment has not received much attention in workplace research and has been studied only in context with control (Lee & Brand, 2005; O'Neill, 2010). In the two studies of this thesis, the material environment – described with three variables: workspace quality (referring to the furniture), workplace appropriateness (referring to the functional quality of the workplace), and work and storage spaces – acts as an important resource for the employees. Workspace quality is consistently positively related to all outcomes whereas workplace appropriateness is less positively associated with job and environmental satisfaction and organisational commitment, but less consistently associated with health and performance. Assessments of work and storage spaces are positively related to environmental satisfaction, work performance, and work engagement.

The effect sizes of the identified relationships are substantial. Compared to the effects of job design, the effects of the office environment are larger for job satisfaction, somewhat smaller for job performance and clearly smaller but still substantial work engagement. Furthermore, the results indicate that the effect of the office environment on health is clearly stronger than the effect of job design. Taken together, these results show that office environments contain factors in organisational behaviour that deserve attention from researchers, business management and facilities management alike.
The ranking of influencing factors based on significant γ-values of the second study (Table 144) shows that variety and overload, two job characteristics, are the most consistent and important predictors for all outcomes except work area satisfaction and health. Among the work environment characteristics the variables referring to the material environment (workspace quality, workplace appropriateness, and work and storage spaces) and variables referring to the socio-spatial environment (distractions, privacy, social density, and to a lesser degree office noise) are the most important predictors. Variables pertaining to the ambient environment (indoor climate and lighting) are less important and mainly affect satisfaction. Individual control over these aspects is more important than the assessment of these dimensions itself. In addition to these factors, gender is an important predictor for health and performance measures.
The analyses show that office environment factors contribute uniquely to variance explained in the outcomes. The results therefore imply that leveraging office design and management workplace / facilities managers can promote satisfaction, health, job performance, and work engagement. Thus, the results from the two studies have several implications for business managers, workspace designers, and workplace / facilities managers. Results regarding the building sample in the second study show that the average period for office refurbishments is about four years. This short cycle of changes in the office environment produces opportunities to implement office designs that take up the results from the two studies presented in this thesis.
Business managers are well advised to raise their awareness of effects of work environments. Office environments can have substantial impacts on employees' satisfaction, commitment, health, job performance, and work engagement. Work environments should therefore be aligned with strategic goals, organisational practices and employees' work activities. Furthermore, the effects of work environments on employees should be monitored by periodical analyses for management decisions.

Workplace designers are confirmed in their service offerings that workplace quality is an important factor for employee-related outcomes. The results from the two studies, based on a large sample of individual participants and organisation-building units, capture the situational factors that engender a certain degree of stability of reactions and behaviour over time and offices. The results thus help to identify the relevant variables and provide information on their impact. The actual design and reason for a favourable or unfavourable assessment by office users is not comprehensively examined.

Table 144. Ranking of influencing factors for all outcome variables

Rank	*Work area satisfaction*	*Job satisfaction*	*Health*	*Self-assessed job performance*	*Self-assessed job performance based on feedback*	*Situational work performance*	*Dedication*	*Vigour*
1	**Workspace quality**	**Variety**	**Gender**	**Variety**	**Variety**	**Variety**	**Variety**	**Overload**
2	**Work and storage spaces**	**Workspace quality**	**Overload**	Workspace quality	**Scope of action**	**Privacy**	Office noise	**Variety**
3	**Distractions**	**Overload**	**Social density**	Gender	**Overload**	**Scope of action**	Workspace quality	**Work and storage spaces**
4	**Privacy**	**Distractions**	**Scope of action**	Distractions	Gender	**Workplace appropriateness**	Workplace appropriateness	**Social density**
5	**Control**	**Control**	**Distractions**	Age		**Gender**	Scope of action	Distractions
6	Indoor climate	Indoor climate	Workplace appropriateness			**Overload**	Overload	Scope of action
7	Gender		Workspace quality			Workspace quality	Lighting	Workplace appropriateness
8	Variety		Office noise			Distractions	Age	Privacy
9			Indoor climate			Age		

Note: Ranking is based on values are significant γ-values in second study; coefficients for factors printed in bold are >.10

In order to complement the findings, building-specific qualitative information would have to be collected (see also McCoy, 2002). While office environments generally may exert effects, the results are at least partially influenced by interactions between users and their environment (Vischer, 2008). Such interactions are captured by the rather high variation in correlations, e.g. between satisfaction and performance (Windlinger, 2009). Thus, as long as changes in desired outcomes are not attributable to objective design parameters, the successful management of office workplaces will rely on continuous improvement processes with pilot projects and monitoring of changes using post-occupancy evaluations (Hadjri & Crozier, 2009; Palmer, 2009; Preiser, 2002). The two studies imply that a user-centred design process may prove most fruitful. Strengths and weaknesses of new workplace concepts and design can be assessed in pilot projects or mock-up scenarios and should be carefully evaluated on the dimensions of the ambient, material, and socio-spatial environment.

Facilities / workplace managers can raise the value of their activities by continuously monitoring and improving work environments. To do so, measures of perceived office quality must be developed and aligned with strategic goals. Qualitative information from observations and interviews may complete the picture and provide further information in the context of recurring post-occupancy evaluations. Information from such analyses may contribute to the justification of costs in facilities / workplace management and to complete a cost-oriented perspective with employee and business related benefits (such as increased job performance) (see also Keable & Marmot, 2011).

All three stakeholder groups benefit from monitoring of effects of the office environment and continuous improvement through periodic post-occupancy evaluations (Preiser, 2002). To fully leverage the potential of periodic post-occupancy evaluations strategic approaches to workplace management need to be developed and adopted (Turnbull et al., 2011). Such an approach implies that goals of designing and managing workplaces are aligned with higher-level organisational goals and strategies as well as with activities of other support units, namely HR and ICT departments. The Job Demands-Resources framework provides a theoretical framework for the dimensions of post-occupancy evaluations and the model developed from the results of the two studies describes the content (Figure 61) and importance (Table 144) of job and work environment demands and resources. Thus the results contribute to the development of user-centred office design and workplace management. In addition to informing post-occupancy evaluations, the model can also be used for the development of workplace concepts, office planning, and allocation of resources in renovation. Based on the model, analyses of strength and weaknesses can inform such decisions, especially if strategic goals and (internal) benchmarks are available. In a combination of post-occupancy evaluations with interventions in the office environment, the model may serve as a basis for continuous improvement. A further application of the model lies in the use of the information it provides for adjusting the work environment to the needs and activities of individuals and groups. Thus the model could be used to identify and promote the potential of job resources in order to achieve better work results and deal with inevitable job demands.

These applications of the Job Demands-Resources model can be supported by further research on objective characteristics of indoor environment / office design as well as perceptions of the environments. Both aspects need more theoretical development, however. The contents and role of environmental satisfaction, privacy, distractions, and interruptions and their relations to objective parameters of office design deserve further research. The findings from the two studies have indirect economic consequences for work organisations through work performance, absenteeism or employee commitment. These links remain to be quantified and the development of estimation models may build upon the findings from the two studies.

More research is needed to support workplace design, strategy, and management. Extensions of office workplace research concern the physico-chemical pathway of work environment design and analysis (Cox & Cox, 1993; Cox et al., 2000) to include aspects of the environment that exert an effect on humans without mediation through perception, i.e. biological, chemical, and physical hazards in the office environment (Mendell & Fisk, 2007). An additional aspect of the office environment that deserves attention in future research is the availability and use of information and communication technology (ICT). Contemporary ICT allows for more control over time and location of work than ever before (O'Neill, 2010) and is contributing to changes in the way office work is performed (Blok, Groenesteijn, van den Berg & Vink, 2011; Fogarty, Scott & Williams, 2011). A promising approach to capture the effects of different sources of influence such as the perceived environment in combination with biological, chemical, and physical measures of indoor air quality and the use of ICT is the cumulative risk assessment (G. W. Evans et al., 2012), an approach that focuses on hazards and does not account for positive effects of the design and management of the physical work environment, though. A cumulative risk approach therefore should be complemented with an analysis of supportive elements of work environments such as facility services and symbolic and aesthetic qualities of offices (Vilnai-Yavetz, Rafaeli & Schneider Yaacov, 2005). Research in these topics may provide more detailed information about the character of office environmental facets as demands or resources.
While there is a need for more research, the findings from this thesis show that the role of the physical work environment in offices is an important one and should be taken up in organisational research and practices.

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16. Appendix: Detailed description of scales

The following table describes the scales and questions used in the first study. Elements highlighted (light grey) are also used in the second study.

Construct (questionnaire Codes)	**Subscales**	**Items**	**Scale type**	**Internal consistency (Cronbach's alpha)**[31]	**Source**
General information (D1-D9)		➢ Job title ➢ Location[32] ➢ Highest completed education ➢ Age (years) ➢ Gender ➢ Job tenure (years) ➢ Degree of employment (percentage) ➢ Rate of time you spend at your office workspace ➢ How many colleagues are working in the same office space with you? (Please give a number, including you)		Not applicable	Own (original German)
Job Characteristics					
Job characteristics (KFZA1-KFZA26)[33]	• Scope of action (KFZA1-KFZA3)	➢ If you consider all your activities, to what extent can you determine their order yourself? ➢ How much influence do you have on the work that is assigned to you? ➢ Are you able to plan and organise your work autonomously?	1 = very little, 2 = rather little, 3 = somewhat, 4 = rather much, 5 = very much	0.70	Prümper, Hartmannsgruber & Frese, 1995 (original German)

[31] As indicated in source
[32] Only in pre-change questionnaires if a relocation from different buildings into one (centralisation) was part of the change
[33] KFZA 25 und KFZA 26 under heading "Satisfaction with work environment"

	• Variety (KFZA4-KFZA6)	➢ Are you able to learn new things at your work? ➢ Are you able to fully utilise your knowledge and your skills at work? ➢ Generally speaking, I have frequently changing and varied tasks at my work.	1 = very little, 2 = rather little, 3 = somewhat, 4 = rather much, 5 = very much	0.73
	• Holistic job (KFZA7-KFZA8)	➢ At work I can see from the results whether or not my work is good. ➢ My work is designed in a way that allows me to produce a complete product from beginning to end.	1 = not at all, 5 = very much so	0.51
	• Social support (KFZA9-KFZA11)	➢ I can rely on my colleagues, if work becomes difficult. ➢ I can rely on my direct superior, if work becomes difficult. ➢ We work well together in our department.	1 = not at all, 5 = very much so	0.76
	• Co-operation (KFZA12-KFZA14)	➢ Work requires close co-operation with other people in the organisation. ➢ While at work, I can discuss official and private matters with several colleagues ➢ I always receive feedback about the quality of my work from superiors and colleagues.	1 = not at all, 5 = very much so	0.64
	• Cognitive demand at work (KFZA15-KFZA16)	➢ There are things in this job which are too complicated. ➢ My ability to concentrate is overstretched.	1 = not at all, 5 = very much so	0.40
	• Quantitative overload at work (KFZA17-KFZA18)	➢ I am frequently under time pressure. ➢ I have too much work.	1 = not at all, 5 = very much so	0.70
	• Interruptions (KFZA19-KFZA20)	➢ Often the necessary information, materials and equipment (e.g. computers) are not at my disposal.	1 = not at all, 5 = very much so	0.44

		➢ I am repeatedly interrupted (e.g. by the telephone) when I am trying to get my work done.			
	• Information and participation (KFZA21-KFZA22)	➢ In our organisation we receive sufficient information about important matters and procedures. ➢ Management is willing to consider employees' ideas and suggestions.	1 = not at all, 5 = very much so	0.70	
	• Benefits (KFZA23-KFZA24)	➢ Our organisation offers good opportunities for professional development. ➢ There are good opportunities for advancement in our organisation.	1 = not at all, 5 = very much so	0.61	
Environmental Characteristics					
Rating of work environment (AZU4-AZU5; KFZA25, KFZA26; AU1-AU3; EFR1-EFR18; P2, P3)	• Environmental stressors (KFZA25-KFZA26)	➢ In my workplace there are adverse environmental conditions such as noise, air conditioning and dust. ➢ In my workplace, the rooms and fittings are inadequate.	1 = disagree strongly; 5 = agree strongly	0.60	Prümper et al., 1995
	• Work and storage spaces (AZU4-AZU5)	➢ I have enough storage space at my workspace ➢ I have enough work surface area at my workspace	1 = disagree strongly; 7 = agree strongly	0.76	Brennan, Chugh & Kline, 2002
	• Workspace quality (AU1-AU3)	➢ Overall, my work area is appropriate for my work. ➢ I like the style/quality of my furniture. ➢ Overall, I like my furniture.	1 = disagree strongly; 7 = agree strongly	0.85	Lee & Brand, 2005
	• Environmental Features Rating (EFR1-EFR18)	➢ Amount of lighting on the desktop ➢ Overall air quality in your work area ➢ Temperature in your work area ➢ Aesthetic appearance of your office ➢ Size of your personal workspace to	7-point scale: from "very poor" to "excellent" (original: "very	Not specified; Authors identified three subscales (ventilation, lighting,	Charles, Veitch, Farley & Newsham, 2003

		accommodate your work, materials, and visitors ➢ Amount of background noise (i.e. not speech) you hear at your workstation ➢ Amount of light for computer work ➢ Amount of reflected light or glare in the computer screen ➢ Air movement in your work area ➢ Your ability to alter physical conditions in your work area ➢ Your access to a view of outside from where you sit ➢ Distance between you and other people you work with ➢ Quality of lighting in your work area ➢ Frequency of distractions from other people ➢ Degree of enclosure of your work area by walls, screens or furniture	unsatisfactory" to "very satisfactory")	privacy) using factor analysis	
	• Privacy (P2, P3, correspond to EFR5 and EFR6)	➢ Level of privacy for conversations in your office ➢ Level of visual privacy within your office		Not specified	Charles et al., 2003
Distraction[34] (AS1-AS3)		➢ I find it difficult to concentrate on my work. ➢ I experience auditory distractions in my work area. ➢ I experience visual distractions in my work area.	Yes, all the time = 1; No, never = 7	0.80	Lee & Brand, 2005
Office noise (L1-L6)		Which elements does the noise include that disturb you? ➢ Air condition ➢ Telephone calls of colleagues ➢ Office machines (incl. Computers) ➢ Exterior noise	1 = does never disturb; 7 = continuously disturbs	Not applicable	Leather, Beale & Sullivan, 2002

[34] Two questions of the original 5-item scale were omitted because they focus visual/acoustic privacy.

		➢ Conversations of colleagues ➢ Other			
Privacy (TP1-TP3; CP1-CP3; P1)	• Task Privacy (TP1-TP3)	➢ I am able to concentrate fully on my job while at work ➢ While at my workstation, I can work with few distractions or interruptions ➢ Interruptions at work often prevent me from giving my full attention to my job*.	1 = very inaccurate, 5 = very accurate	0.64 to 0.69	Oldham, 1988
	• Communication Privacy (CP1-CP3)	➢ I can talk with my co-workers in confidence while at my workstation ➢ It's difficult to work at my station because I have to worry about disturbing others* ➢ I am unable to have a personal or private discussion while at work*	1 = very inaccurate, 5 = very accurate	0.65 to 0.67	Oldham, 1988
	• Distraction through people (P1)	➢ Sometimes I'm disturbed by colleagues who walk by my workplace.*	1 = very inaccurate, 5 = very accurate		Zalesny & Farace, 1987
Crowding (CR1-CR4)		➢ My work area has an adequate amount of space for the number of employees who work in it.* ➢ I often feel 'crowded' while at work ➢ My work area does not have enough space for the number of employees currently working in it ➢ Employees must work too closely together in my work area	1 = disagree strongly; 7 = agree strongly	0.92	May, Oldham & Rathert, 2005
Control (K1-K6)		➢ I determine the organization/appearance of my work area. ➢ I can personalize my workspace. ➢ I feel my work life is under my personal control. ➢ I can adjust, re-arrange, and re-organize my furniture as needed. ➢ The variety of work environments needed for my job is available to me. ➢ I can hold small, impromptu meetings in my	Yes, very much so = 1; No, not at all = 7	0.71	Lee & Brand, 2005

		office or work area as needed.			
Preference for enclosed area (IA1, IA2)		➢ I prefer a completely open office (no partitions) to cell offices. (Yes, very much so = 1; No, not at all = 7) * ➢ I am most effective in _____ kind of work space.(Private, enclosed = 1; Open, barrier-free = 7)		0.77	Lee & Brand, 2005
Outcomes					
Job satisfaction (AZ0-AZ7)	• Job satisfaction (AZ0, AZ1, AZ4, AZ5)	➢ How satisfied are you with your work in general? ➢ I hope my work situation will always stay as good as it is now. ➢ I really look forward to going back to work after days off. ➢ If some things at my work don't change soon, I'm going to look for a new job.*	What do you think about your work these days? 1 (never) through 7 (always); first question is rated using a 7-point Kunin scale	0.73	Baillod & Semmer, 1994 (original German)
Environmental satisfaction (AZU1-AZU3; OES2)	• Work area satisfaction (AZU1-AZU3)	➢ I am satisfied with my work setting as a whole. ➢ In general, my work area provides a good setting in which to work. ➢ Overall, I feel comfortable in my work area.	1 = disagree strongly; 7 = agree strongly	0.88	May et al., 2005; Oldham, 1988
	• Overall environmental satisfaction (OES2)	➢ Indoor environment in your workstation as a whole	7-point scale: from “very poor” to “excellent“	Not applicable	Charles et al., 2003
Commitment (C1-C9)	• Organisational identification (C1, C5, C8)	➢ I am quite proud to be able to tell people who it is I work for. ➢ I feel myself to be part of the organization. ➢ I would not recommend a close friend to join our staff.*	1 = disagree strongly; 7 = agree strongly	0.74	Cook & Wall, 1980; cf. also Stride, Wall & Catley, 2007
	• Organisational Involvement	➢ I'm not willing to put myself out just to help the organization.*		0.87	

	(C3, C6, C9)	➢ In my work I like to feel I am making some effort, not just for myself but for the organization as well. ➢ To know that my own work had made a contribution to the good of the organization would please me.			
	• Organisational Loyalty (C2, C4, C7)	➢ I sometimes feel like leaving this employment for good.* ➢ Even if the firm were not doing too well financially, I would be reluctant to change to another employer. ➢ The offer of a bit more money with another employer would not seriously make me think of changing my job.		0.82	
Health symptoms (BF1-BF17)		➢ Circulation / blood circulation problems ➢ Stomach trouble / intestinal problems ➢ Headache ➢ Restlessness / nervousness ➢ Difficulty in concentrating ➢ Backaches / lower back pain ➢ Neck / shoulder pain ➢ Dizziness ➢ Eating disorders / weight problems (excessive / too little) ➢ Insomnia (difficulty getting to sleep, difficulty in staying asleep) ➢ Heart palpitations ➢ Tiredness ➢ Aching, heavy, tired legs ➢ Eye Problems (burning, itching eyes; pressure, pain) ➢ Uncomfortable feeling of fullness ➢ Heartburn	1 = hardly ever / never 2 = every few months 3 = every few week 4 = every few days 5 = nearly every day		Mohr, 1986, 1991 (original German)

Self-assessed job performance (PR1-PR18)	PR1-PR13: self-assessed job performance	➢ The general office layout facilitates team work. ➢ I am able to stay focused and „on task“ at work ➢ Formal client (including internal employee) feedback about my work is positive. ➢ I have easy access to information that I need to do my work. ➢ I am able to be productive at my present workspace. ➢ I am able to meet my personal performance goals and objectives. ➢ Peer feedback about my work is positive. ➢ I can easily accommodate a drop-in visitor at my workspace. ➢ I am able to deal efficiently with unanticipated problems. ➢ Informal client (including internal employee) feedback about my work is positive. ➢ It is easy to have a one-to-one conversation at my workspace. ➢ I am located closely to people I need to talk with in my job. ➢ Leader and/or supervisor feedback about my work is positive	1 = strongly agree, 7 = strongly disagree	0.89	Brennan et al., 2002
	PR14-PR18: self-assessed job performance based on feedbacks	➢ I put a lot of effort and energy into my work. ➢ My work is of high quality. ➢ I rarely make mistakes or errors. ➢ I can accomplish a great deal each day. ➢ I do a large amount of work each day.	1 = strongly agree, 7 = strongly disagree	0.76 to 0.78	Oldham, 1988
Situational job performance (PR19-PR21)		➢ Compared to my typical performance, right now I would rate my job performance as (Very creative = 1; Not at all creative = 7) ➢ Compared to my typical work, right now I would rate the quality of my work as (Very good = 1; Very bad = 7)		0.76	Lee & Brand, 2005

		➢ Compared to my typical work, right now I would rate the quantity of my work as (Very good = 1; Very bad = 7)			
Work climate BK1-BK13, without BK7)		➢ The atmosphere at work is impersonal. ➢ If someone is having difficulties with his/her work, there's always a colleague who can help.* ➢ We are lacking a sense of community; here everyone only thinks of themselves. ➢ If any of us is having personal difficulties, she/he can expect understanding and assistance from her/his colleagues.* ➢ The mutual confidence in our team is so great that we can talk openly about everything, even about completely personal matters.* ➢ In our organisation it's advisable to keep one's personal opinion about intra-organisational procedures private: you never know how people may interpret your ideas.* ➢ To protect yourself against intrigues, the best thing is to hold your tongue. ➢ Everything that goes wrong here is covered up by polite empty phrases and compliments. ➢ In our organisation there's a lot of tension between older and younger colleagues. ➢ In our organisation everybody is free to express her/his opinion and feelings.* ➢ There are sometimes significant conflicts between myself and my colleagues, but they are glossed over and hushed up: to outsiders and our superiors everything seems as right as a trivet. ➢ My colleagues and I never criticise each other in a personally offensive way.*	1 = very inaccurate, 7 = very accurate	Not specified	Rosenstiel & Bögel, 1992 (original German)
Social Climate (ST1-ST10)	• Social stressors (ST1-ST10)	➢ Some of my colleagues are unpleasant to have as co-workers. ➢ In this organisation you get severely criticised for every little thing.	(Yes, very much so =1; No, not at all = 7)	0.86	Frese & Zapf, 1987 (original German)

		➢ You have to work with unfriendly people. ➢ My line manager expects a lot from us. ➢ My line manager plays us off against each other. ➢ If a mistake is made, our superior always blames us and never himself/herself. ➢ There are difficulties in coordinating with colleagues. ➢ It is unclear what our superiors want from us. ➢ We have to carry the can for others' mistakes. ➢ Our superior makes our work more difficult with his instructions.			
Note: items with an asterisk are reverse scored; originally German questions are translated for this description by L.W. for this table					

Table 145. Description of all constructs, scales, subscales and items

Construct (questionnaire Codes)	**Subscales**	**Items**	**Scale type**	**Internal consistency (Cronbach's alpha)**	**Source**
Work engagement (OLBI1-16)	vigour (OLBI2, 4, 5, 8, 10, 12, 14, 16)	➢ There are days when I feel tired before I arrive at work.* ➢ After work, I tend to need more time than in the past in order to relax and feel better.* ➢ I can tolerate the pressure of my work very well. ➢ During my work, I often feel emotionally drained. * ➢ After working, I have enough energy for my leisure activities. ➢ After my work, I usually feel worn out and weary. * ➢ Usually, I can manage the amount of my work	1 = completely disagree, 4 = completely agree	.73 (Demerouti, Bakker, Vardakou & Kantas, 2003)	Demerouti, 1999 (original German; English version: Demerouti, Mostert & Bakker, 2010; Halbesleben & Demerouti, 2005)

		well. ➢ When I work, I usually feel energized.			
	dedication (OLBI1, 3, 6, 7, 9, 11, 13, 15)	➢ I always find new and interesting aspects in my work. ➢ It happens more and more often that I talk about my work in a negative way. * ➢ Lately, I tend to think less at work and do my job almost mechanically. * ➢ I find my work a positive challenge. ➢ Over time, one can become disconnected from this type of work. * ➢ Sometimes I feel sickened by my work tasks.* ➢ This is the only type of work that I can imagine myself doing. ➢ I feel more and more engaged in my work.	1 = completely disagree, 4 = completely agree	.83 (Demerouti et al., 2003)	Demerouti, 1999 (original German; English version: Demerouti et al., 2010; Halbesleben & Demerouti, 2005)
Note: items with an asterisk are reverse scored					

Table 146. Description of additional constructs, subscales, and items for the second study

References (Appendix)

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