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HOW STRONGLY PROGRAMMED IS A STRONG PROGRAMME BUILDING?:

A comparative analysis of outpatient clinics in two hospitals

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Abstract

Buildings are traditionally classified in Space Syntax theory as either strongly or weakly programmed. According to this theory, social life in strong programme buildings follows rules and requirements of the organisation, while space usage in weak programme buildings is assumed to follow spatial configuration. However, in recent studies it has been argued that weak programme buildings can show aspects of strong programming, too. This paper aims at a more detailed description of different levels of programming by identifying a set of criteria to differentiate between weak and strong programme. This is derived from early Space Syntax theories as well as from more recent contributions. These criteria are then applied to outpatient clinics in two hospitals using findings from an in-depth study of space usage as evidence. The main hypothesis to be tested is whether the two hospitals show different levels of programming, or are simply strongly programmed, as traditionally assumed in Space Syntax theory. Three different categories of users – physicians, nurses and clerks were observed and their work activities and interaction networks investigated.

Results show that none of the two hospitals show aspects of strong programming only, but rather change from strong to weak depending on the different criteria. Moreover, none of the two cases is consistently stronger programmed than the other suggesting that the same building as well as the same building type can show different degrees of programming. The study provides an elaborate analysis of programming in buildings and thus offers a starting point for a renewed debate on programme in order to devise ways of quantifying the level of programming of buildings in the future, which to date has only been done qualitatively. It suggests that other complex building types should be studied and added to the analysis. The paper enhances our current understanding of how space usage patterns in complex buildings evolve and contributes to the articulation of one of the key theoretical concepts in Space Syntax.

Keywords: *Strong and Weak Programme; Hospital Layout; Social Network Analysis; Workflow; Communication*

Theme: *Building Morphology and Performativity*

1. Introduction

The spatial layout of a building influences the social life of its users by creating different patterns of encounter and communication (Penn, Desyllas, and Vaughan 1999; Sailer and Penn 2009; Rashid et al. 2006; Sailer and Penn 2007). Space can bring people together or keep them apart. Depending on spatial configuration, Hillier et al. (1984) classify buildings in two categories – strongly and weakly programmed. This has become one of the key theoretical concepts of the analysis of buildings with Space Syntax. Since the origin of the theory, strongly programmed buildings were analysed, however less so than weak programme buildings. Moreover the theory was not much articulated with some notable and recent exceptions (Sailer 2007, 2010; Koch and Steen 2012a, 2012b; Lu, Peponis, and Zimring 2009; Heo et al. 2009; Cai and Zimring 2012).

Traditionally a specific building type was associated with either a strong or a weak programme. However, it was argued recently that weakly programmed buildings can show aspects of strong programming (Sailer 2007, 2010).

Ultimately, this raises a series of questions: What are the criteria for strong and weak programme buildings? Given the fact that weakly programmed buildings can show aspects of strong programming, can strongly programmed buildings also show aspects of weak programming? And if so, could our understanding of the social life of buildings be enhanced by a more detailed description of different levels or layers of programming?

To pursue this line of argument, hospitals as a building type were chosen since they are traditionally considered strongly programmed. Two different hospitals were studied in-depth to provide empirical evidence on space usage behaviours. The main hypothesis to be tested is whether Hospital A and Hospital B show different levels of programming.

The argument proceeds in the following steps: chapter 2 reviews the literature on strong and weak programme buildings and summarises a set of criteria to distinguish the two concepts. Chapter 3 presents the case studies; chapter 4 discusses the methodology. In the following three chapters the set of criteria are applied to the spatial configuration of the buildings (chapter 5); the workflow in the two hospitals (chapter 6); and communication patterns of caregivers (chapter 7). A final chapter 8 highlights the main findings, draws conclusions and suggests paths for further study.

2. The Theory of Strongly Programmed Buildings

The idea that buildings can be classified as strongly or weakly programmed was first discussed by Hillier, Hanson and Peponis (1984) and later developed by Hillier and Penn (1991). The theory originated from the Levi-Straussian concept of mechanical and statistical models. To illustrate the difference, Lévi-Strauss (1963) gives marriage laws in primitive and modern societies as an example. A mechanical model is characteristic for primitive societies, where social solidarities are formed based on predetermined rules i.e. who will marry who depends on kinship. The fewer rules exist, the more statistical the model becomes, therefore the choice whom to marry increases with certain matches being more likely to happen than others.

Three interrelated key theoretical concepts have been developed in relation to the theory of mechanical and statistical solidarities – the theory of long and short models, strong and weak programmes, and generative and conservative[1] buildings.

Hillier and Penn (1991) relate the mechanical and statistical models to 'short and long models'. This idea is based on simulations of how spatial systems grow (Hanson and Hillier 1984). In the experiments a closed cell with an entrance and an attached open cell was used. These units were then aggregated to form larger structures: either by applying local rules (e.g. joining closed cells on walls) or by applying global rules (e.g. to give preference to longer lines of sight). Whenever fewer and more local rules restrict the process the outcome is something new, while with more and global rules the outcome reflects the rule itself. Therefore short models correspond to Levi-Straussian statistical models and long models match mechanical ones.

This was then related to the concept of programme. The programme of a building represents the spatial dimension of an organisation. Its key element is the interface that a building constructs, i.e. the spatial relation between two categories of people – inhabitants and visitors. Inhabitants are those with access to and control of space and the social knowledge produced in the building. In contrast, visitors are temporary users without control. A building was defined as strongly programmed whenever the interface between different user groups is highly regulated in terms of space, specified in advance and space usage does not generatively follow the layout of the building but its programme (Hillier, Hanson, and Peponis 1984; Hillier and Penn 1991). Such a programme is complex, acts conservatively and follows a long model, based on varied global rules. In contrast, in weak programme buildings the layout acts generatively and thus optimises and structures dense and random pattern of encounter as shown in numerous case studies (Grajewski, Miller, and Xu 1992; Hillier and Grajewski 1990; Penn, Desyllas, and Vaughan 1999; Spiliopoulou and Penn 1999). Such programmes are based on short models with few and local rules and randomised processes.

To elaborate more on theory, a reference to Hanson and Hillier's (1984) models for correspondence and non-correspondence was also made. Those two models depend on the relationship between spatial and transpatial groupings. A spatial group is formed when people are brought together by space regardless of their labels, and a group is transpatial whenever it does not depend on spatial proximity but on labels such as age, gender, affiliation, hobbies etc. A correspondence model exists whenever the two groups correspond to each other, i.e. members of one spatial group are also members of a transpatial group. In the non-correspondence system spatial and transpatial groupings do not overlap or correspond, i.e. label groups are distributed among various spatial structures. In a correspondence system, physical encounters and encounters resulting from membership of the same transpatial group reinforce each other. Such a system then becomes locally very strong and to maintain its strength it acquires restrictions on encounters, strong rules, strong boundaries and an internal hierarchical organisation. A non-correspondence system succeeds if it works on the contrary principle. Therefore correspondence models reproduce themselves in strongly programmed buildings while non-correspondence models in weakly programmed buildings.

These initial theoretical ideas on programme were articulated in due course by contributions of various scholars.

Sailer (2007, 2010) conducted studies in eight weakly programmed office buildings and found that movement flows did not always follow the spatial configuration of the building, but its programme in space and time. Sailer concluded that even if the organisation and its set of roles and relationships suggest weak programming, buildings can show aspects of strong

1 This is studied elsewhere (Sailer et al. 2012) and is therefore not explained further in this paper.

programming. Based on these extensive studies two new aspects could be added to the understanding of strong and weak programming. Firstly, the placement of attractors such as photocopiers, printers, tea points etc. can deflect movement and hence introduce a degree of programming to otherwise randomised usage behaviours. In this sense strong programming would occur in cases where attractors are positioned in segregated spaces, since activities then follow the programme, while attractors in integrated spaces would not interfere with the configurational logic of the building and hence allow weak programmes to come into play. Secondly, time was pointed out as a variable that influences the programme of a building by restricting certain activities to specified times of the day.

A whole range of recent contributions elaborated on the distinction of different roles and how behaviours of certain user groups were driven by spatial properties of strongly programmed buildings.

Lu, Peponis and Zimring (2009) conducted a study in an Intensive Care Unit investigating how visibility affected behavioural activities and communication of different roles and found out that nurses and doctors were tuned to different features of the environment. While doctors' patterns correlated better with generic visibility, nurses' activities were tuned to a new spatial measure introduced by the authors as 'targeted visibility'. This measure is based on selected critical locations e.g. in the ICU case study – patients' beds, compared to the generic visibility analysis that takes into account all visible locations. Again this points to a detailed layering of programming since various spatial factors affected behavioural patterns depending on the different roles of inhabitants.

In the same way, Heo et al. (2009) argued that the spatial layout could influence nurses' movement but at a finer scale. Instead of choosing the entire floor area of a nursing unit, the authors selected the set of rooms to which individual nurses were assigned to. They proved that three specific and local properties of space – axial integration, visual connectivity and path distance influenced the frequency of nurses' visits to patients' rooms.

Similarly to the above two studies, Cai and Zimring (2012) found a correlation between nurses' distribution, interaction and awareness with integration and two new spatial metrics they developed – team-based distance and peer distance. The authors found that shorter distances correlated with a higher ratio of interaction and greater awareness of patient conditions and peer location.

In studies conducted in a university hospital Koch and Steen (2012a, 2012b) used the concept of spatial practice, which represents the interplay between spatial configuration, organisational configuration and configuration of work processes and routes to 'de-compose' work programmes. What they added to the above arguments is the spatialisation of different tasks and roles. The authors chose cases with similar general workflow principles and argued that: 1) similar tasks and roles were realised in space differently; 2) similar tasks and roles were also realised in time (duration) differently. From this it can be inferred that a building is rather weakly programmed, if similar tasks and roles are realised in space and time differently, since that implies choice how and where to do things. On the contrary, if tasks and roles are always performed in exactly the same way, a stronger programme could be argued to be in place.

Table 1 below finally summarises criteria for a building to be classified as strongly or weakly programmed as derived from early Space Syntax theories (criteria 1-8) and recent contributions (10-13).

	STRONG PROGRAMME	WEAK PROGRAMME
THEORY ORIGIN (Hillier, Hanson, Peponis, Penn)	1. More complex and segregated layout 2. Low ratio of bounded spaces to convex space 3. Low ratio of axial lines to convex spaces 4. Smaller buildings 5. Strong control of inhabitant – visitor interface: 5.1 Separate non-interchangeable entrances 5.2 Easily controlled spaces for visitors, shallow in the building – close proximity to visitors 5.3 Independent routes 6. Strong control of inhabitant – inhabitant interface: 6.1 Strong division of categories of users by division of spaces used 7. Preserved professional status with more segregated spaces 8. Activities follow programme 9. Correspondence model Examples of building types: courts, prisons, hospitals, airports	1. Simpler and more integrated layout 2. High ratio of bounded spaces to convex space 3. High ratio of axial lines to convex spaces 4. Larger buildings 5. No control of inhabitant – visitor interface: 5.1 Same entrances for inhabitants and visitors 5.2 No control over visitors 5.3 Shared routes 6. No control of inhabitant – inhabitant interface: 6.1 No division of spaces, therefore categories of users are mixed 7. No status expressed with spatial properties 8. Activities follow configuration 9. Non-correspondence model Examples of building types: offices, museums, galleries
CONTRIBUTIONS (Sailer, Koch/Steen, Heo et al, Lu et al, Cai/Zimring)	10. Attractors placed in segregated areas without configurational logic (Sailer) 11. Time restrictions of space usage (Sailer) 12. Activities follow programme: no influence of a spatial factor on different roles and tasks 13. Spatial practices (tasks and roles) are realised in space and time (duration) similarly (Koch and Steen)	10. Attractors placed in integrated areas according to configurational logic (Sailer) 11. No time restrictions of space usage (Sailer) 12. Activities follow configuration: different spatial factors influence different roles and tasks 12.1 Targeted visibility (Lu, Peponis and Zimring) 12.2 Visual connectivity / generic visibility (Lu, Peponis and Zimring; Heo et al) 12.3 Axial integration (Heo et al) 12.4 Distance (Heo et al; Cai and Zimring) 13. Spatial practice (tasks and roles) are realised in space and time (duration) differently (Koch and Steen)

Table 1: Criteria for strong and weak programme buildings as derived from the literature

Two facts should be noted in addition to the above criteria. Firstly, referring to criterion 4, Hillier et al. (1984) argue that the larger a building becomes the more difficult it gets to maintain them as 'strongly programmed' because they change socially. As the number of people in a building increases, the number of spaces to accommodate these people also increases and therefore the amount of unprogrammed contact increases as a by-product of functionally defined movement. This is a property of large buildings in general rather than an issue associated with a particular building type. Secondly, some of the parallel requirements are inconsistent for instance the fact that to preserve a status requires segregation while at the same time to control others requires close proximity and this can produce discontinuity.

In summary this chapter outlined the origin of the theory of strong and weak programme buildings. It explained the differences between strong and weak programmes, and based on existing literature developed a list of criteria for programming. This set of criteria is now applied to the two case studies.

3. Case Studies: Outpatient Clinics in Two Hospitals

Two different hospitals were chosen for analysis and studied in-depth over the summer and autumn of 2012.

Hospital A is located at the outskirts of a small town in the Southeast of the Netherlands, not far from the German and Belgian borders and was opened in 2009. It is a new and large stand-alone building designed by the Dutch firm Bonnema Architecten. The hospital has one main entrance used both by patients and caregivers; it leads to a large atrium inside the building where receptions and waiting areas are situated. The clinics are located on the first two floors on both sides of the atrium. For the purpose of this study the focus was on five outpatient clinics: Internal Medicine, Cardiology, Pulmonology, Surgery and Orthopaedics. Figure 1a shows the layout of the Surgical Clinic as an example. The other clinics are similarly organised. In contrast to a traditional layout, several clinics share a 'Knowledge Centre', which accommodates open-plan workplaces with shared desks and facilities such as meeting rooms, quiet rooms, tea points and printing areas for caregivers. The Knowledge Centre is located on a half level in-between the two outpatient clinic floors and is connected to the clinic areas via two open staircases. It has separate staff entrances from the outside. Among the five selected clinics Internal Medicine, Surgery and Orthopaedics on the one hand and Pulmonology and Cardiology on the other share Knowledge Centres. The clinics have a common corridor, which connects their exam rooms. On both sides of the corridor charting galleys with shared computers used during exam hours are located.

Hospital B in contrast, is structured as a campus of several buildings, located in the centre of a big city on the West Coast of Canada. It was first opened in 1912 and after that built and refurbished in several stages. The following five outpatient clinics were studied: Rapid Access Clinic, Heart Clinic, Lung Clinic, Surgical Clinic and Immunodeficiency. The clinics are located in two adjacent buildings of the campus. The complex has three main public entrances, four staff entrances and links connect the two main buildings on the first four floors. The clinics are located on the fourth, fifth and eighth floor. The Surgical Clinic is shown in Figure 1b as an example of a traditionally structured layout with a system of corridors that connects the exam and consultation rooms, reception, waiting areas and physicians' offices, which are either single or shared between two to three people. Some of the clinics additionally have meeting rooms, small kitchens or break-out areas for staff, and common rooms for all staff with computers for charting.

Legend

Exam rooms; Corridor; Waiting area; Reception; Workspaces; Meeting rooms; Breakout areas (kitchen, tea point); Quiet rooms; Staircases and lifts; Supply, storage, clean Utilities; Clinic area; Knowledge centre

Figure 1a: Hospital A – Surgery

Figure 1b: Hospital B – Surgery

4. Methodology

Space Syntax was used as a methodology to compare and contrast the spatial layouts of the clinics. Axial and convex models of the clinics for both hospitals were done using Depthmap (Turner 2010; Varoudis 2012).

A staff survey including a Social Network Analysis was conducted in both hospitals to quantitatively assess communication patterns amongst caregivers. Physicians, nurses, clerks and residents and (in the case of Hospital B) allied professionals from the five clinics were invited to participate (n=177 and n=206 in Hospital A and Hospital B respectively). The return rate for Hospital A was 31% and for Hospital B 43%. Participants were asked to select up to 25 colleagues and to indicate on a scale from 1 to 7 how often they communicated face-to-face planned, face-to-face unplanned and electronically. Results were analysed with UCINET (Borgatti, Everett, and Freeman 2002). The structural match between all communication networks was tested using the Quadratic Assignment Procedure (QAP) (Krackhardt 1987) which correlates the value of a tie that connects each dyad (reported tie strength) across the different networks.

Observations were conducted by following 6 different caregivers each day for 10 working days in each hospital (two days dedicated to each clinic). In total 128 members of staff were observed (64 physicians, 33 nurses and 31 clerks), each for a period of 1.5-2 hours during examination hours. Sequences of activities and locations, durations and types of activities were digitally recorded. Pre-programmed PDAs (Personal Digital Assistants) were used for the data collection in the two hospitals. Differences in time spent in certain activities and locations between the two hospitals were analysed.

5. Spatial configuration

This chapter analyses the configuration of the clinics. It applies the relevant criteria for strong programming outlined above, i.e. criteria 1, 2, 3, 4, 5, 6 and 10.

Figures 2a and 2b show the axial models for Surgery in both hospitals, while table 2 reports related metrics including size of clinic area, number of bounded spaces, number of convex spaces, number of axial lines, and average mean depth for each clinic.

Criterion 1 states that the more complex and segregated a layout is the more strongly programmed the building is. It can be argued then that clinics in Hospital A are more programmed than in Hospital B with an average MD=4.27 and a range from 3.97 to 4.57 for clinics against an average MD=3.26 and a range of 3.01-3.39 for clinics in Hospital B.

In line with criteria 2 and 3 the higher the ratio of bounded spaces to convex spaces and axial lines to convex space the more strongly programmed a building is. Ratios can vary between 0 and 1 as the number of bounded spaces and axial lines is always smaller or equal to the number of convex spaces. In cases with a constant number of bounded spaces, a higher number of convex spaces results in a lower ratio, thus segregation is gained (Hillier et al, 1984). In cases with a constant number of convex spaces, an increase of bounded spaces means the building becomes more segregated, however the ratio shifts towards 1 instead of 0. In the presented case studies neither the convex nor the bounded spaces are constant across the 10 clinics therefore the above methods of analysis are not easily applied. These inconsistencies in the boundaries of the range indicate that the relationship between bounded / convex spaces and convex spaces / axial lines should be expressed differently in order to be used for a comparison. Additionally the metrics seem insufficient to describe levels of programming in the layout. What matters more than ratios is how elements are put together i.e. different arrangements of the same number of elements have different configurational properties. Therefore the two ratios on their own fail to describe a building layout sufficiently. The links between parts are the ones that additionally matter and this is what leads to metrics such as connectivity and integration describing the building layout in a more rigorous way. Hence the two criteria are excluded from further evaluations[2].

In accordance with criterion 4 the smaller the building is the more strongly programmed it is. The average area of clinics in Hospital A is 1421m2 with a range from 1013-1602m2. For Hospital B the average area is 963m2 with a range of 577-1517m2. On average clinics in Hospital A are larger in size than clinics in Hospital B. However, Surgery and Immunodeficiency in the latter are large enough to be considered as 'large' rather than 'small'. Therefore, Hospital B may be considered slightly more programmed than Hospital A, yet both are rather large structures and as such may tend towards weaker programming.

Figure 2a: Hospital A: Axial model of Surgery

Figure 2b: Hospital B: Axial model of Surgery

2 If the sums of bounded / convex spaces and convex spaces / axial lines are calculated they seem to overcome the inconsistencies in resulting ranges and with an increase of the sum integration decreases. However this metric still does not take connections between parts into account.

		Internal Medicine / Rapid Access Clinic		Cardiology / Heart Clinic		Pulmonology / Lung Clinic		Surgery Clinic		Orthopaedics / Immunodeficiency		Average	
Hospital		A	B	A	B	A	B	A	B	A	B	A	B
Area [sqm]		1013	577	1565	692	1376	776	1548	1252	1602	1517	1421	963
Bounded spaces [No]		39	35	41	31	37	40	34	69	33	81	37	51
Convex model [No]		63	52	79	51	71	54	57	88	56	102	65	69
Axial model	No	54	46	63	41	56	49	49	62	45	94	53	58
	MD	4.07	3.01	4.47	3.39	4.57	3.28	3.97	3.23	4.26	3.37	4.268	3.256

Table 2: Spatial metrics for each clinic in Hospital A and in Hospital B including average values

Criteria 5 and 6 relate to the strength of the control of interfaces between inhabitants and visitors, and among inhabitants. Principle 5.1 suggests that strong programme buildings have separate non-interchangeable entrances for inhabitants and visitors. Hospital A has one main entrance, which serves both patients and clinicians and smaller separate staff entrances to the Knowledge Centres, while Hospital B has three main public entrances and four separate entrances for staff. Therefore Hospital A is more weakly programmed than Hospital B, since it has a shared main entrance.

Criterion 5.2 refers to the location of and control over visitors' areas. When an outpatient enters Hospital A they find themselves in a spacious atrium – the heart of the building, where receptions and visitors' areas are located. In Hospital B the waiting areas for each clinic (see figure 1b) are situated shallow in relation to the clinic entrances but deep in relation to the main entrances. It is suggested here that criterion 5.2 should be split into two – visitors' area located shallow in relation to the main entrance of the building (global) and shallow in relation to other specific entrances (local). Hospital A hence provides shallow areas for visitors on both scales and is therefore more strongly programmed than Hospital B due to exercising more control over visitors.

Criteria 5.3 (independent routes) and 6.1 (control of interface) relate to the two major differences in the spatial layouts of the hospitals. While in Hospital A back- and front-of-house are strictly separated resulting in a clearly defined large and shared area for professionals only – the Knowledge Centre, in Hospital B caregivers and patients use a common corridor system leading directly to exam and small staff common rooms. Therefore, in Hospital A caregivers are brought together, yet mostly separated from patients, while in Hospital B caregivers are separated, but brought together with patients. Routes are mostly independent in Hospital A and mostly shared in Hospital B. Since the flexible open-plan work environment in the Knowledge Centre of Hospital A, where physicians, nurses, clerks, residents and other professionals have equal access to and control over space, this indicates no controlled interface and thus weak programming. Similarly, differentiating zones for clerks and nurses, private offices for doctors and allied professionals and separate rooms for residents, the layout of Hospital B shows aspects of strong programming. This is further discussed with data from direct observations in the next chapter together with criterion 7.

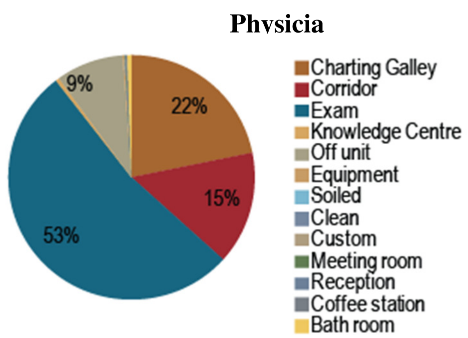
Considering criterion 10 (location of attractors) as shown in figure 1 and figure 2 it is obvious that attractors such as tea points and break-out areas are quite centrally located in Hospital A and thus accessible and integrated, while in Hospital B the break-out areas are in separate rooms located towards the periphery of the building and therefore more segregated. Movement in Hospital B then is more likely to be programmed in comparison with Hospital A.

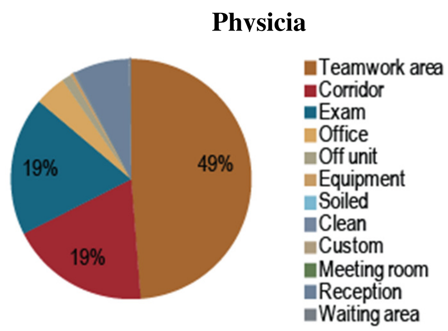
In summary, several of the criteria for the programme of buildings were applied to the selected case studies. Three of the criteria (1, 5.2a and 5.3) indicate that Hospital A is more strongly programmed than Hospital B; in the case of four criteria (4, 5.1, 6.1 and 10) Hospital B is more strongly programmed and according to one criteria (5.2b) the two hospitals are programmed relatively equally strong. The remaining criteria (2, 3) are excluded since they can not be applied to the two case studies.

6. Workflow

Data from direct observations of activities and their locations in each clinic was used to analyse the workflow in each hospital and thus test the relevant criteria 7, 11 and 13. To support the argument, a comparison was drawn between 1) the time physicians, nurses and clerks spent at certain locations e.g. exam rooms, corridor, charting galleys and teamwork areas in each hospital and 2) the time spent for certain activities that are an essential part of the working process such as patient care, communication, walking, charting, document management etc.

According to criterion 7 more segregated spaces are necessary to preserve the professional status of the inhabitants. The Knowledge Centre in Hospital A, as discussed in Chapter 5, is an open-plan work area shared among all caregivers and used flexibly. The areas of the Knowledge Centre are highly integrated and show high inter-visibility. Physicians do not ‘own’ their exam room either; instead they are shared, too, and not personalised. Therefore it could be argued that professional status is not preserved in a particularly pronounced way. This points towards a rather weak programme. In contrast, in Hospital B teamwork areas, break-out spaces and offices are designated to the different caregivers, and offices and exam rooms are owned by the physicians. Thus professional status is preserved through segregation, highlighting a predominantly strong programme. This difference is reflected in time spent by physicians, nurses and clerks in various locations in Hospital A and B, as shown in figures 3a and 3b. Physicians and nurses in Hospital A spent a relatively equal amount of time in observed locations – 53% and 63% in exam rooms, 22% and 25% in the charting galley and 15% and 9% in the corridor. In Hospital B though, there was a greater difference between the areas occupied. Physicians spent almost half of their time (49%) in the teamwork area while nurses only 30%; physicians spent 19% in the corridor and nurses only 6%, and physicians are 19% of their time in the exam rooms versus 62% for nurses. In both hospitals clerks show a completely different pattern of occupation as compared to physicians and nurses, since they spent their time predominantly in the charting galley for Hospital A (84%) and the reception area for Hospital B (55%).





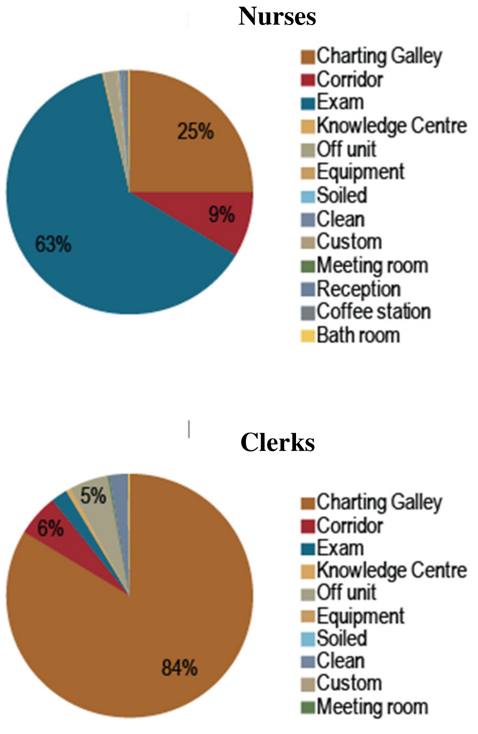


Figure 3a: Hospital A – percentage of time spent in various locations by physicians, nurses and clerks

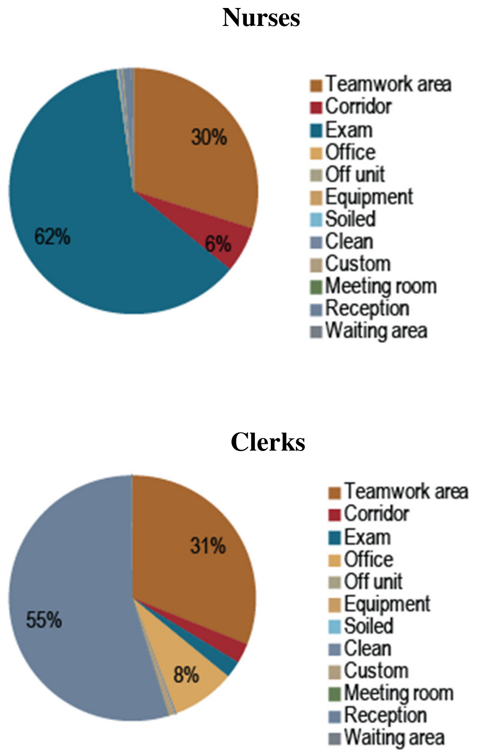


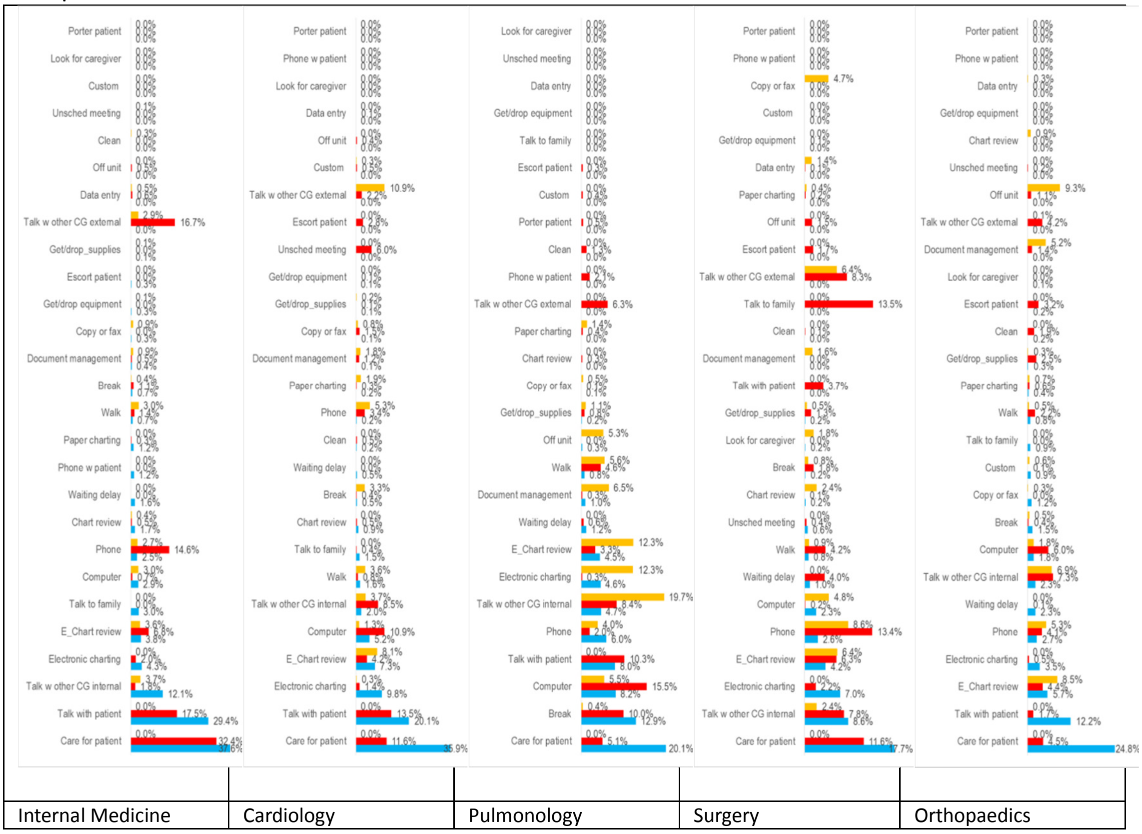
Figure 3b: Hosptial B – percentage of time spent in various locations by physicians, nurses and clerks

Criterion 11 states that time restrictions are imposed on space use in strong programme buildings. During observations it was noticed that for instance in Hospital A whenever there were no meetings, residents worked in meeting rooms or used them for private conversations or lunch. Also four exam rooms were allocated to Orthopaedics in the morning, but to Surgery in the afternoon. However our data is insufficient for a further discussion of this criterion and more detailed observations would be necessary to develop this argument.

Criterion 13 proposes that in strong programme buildings workflow defines one spatial practice, i.e. tasks and roles of inhabitants are realised similarly due to being defined by process and programme, while in weak programme buildings workflow leaves variations for differing spatial practices, i.e. tasks and roles of inhabitants are realised differently. If tasks are performed similarly the activities they consist of are also similar in terms of type and duration. This criterion is therefore applied to the duration of activities by comparing all individuals within one clinic and calculating the degree of difference[3] in time spent for each of the three different roles (physicians, nurses, clerks). Results are shown in figure 4. In Hospital A all three roles show relatively large variations in the most important activities (i.e. those with longest durations), for instance time spent in patient care shows a degree of difference from 18% to 38% for physicians. In Hospital B, differences are much smaller, ranging from 10% to 22% regarding the time physicians spent in patient care. This means both hospitals show aspects of weak programming, yet Hospital A clearly is more weakly programmed than Hospital B.

[3] This was done by calculating the mean values of percentage of time spent in each activity across all individuals that were observed in each clinic (separately for each role, i.e. physician, nurse, clerk), then aggregating the absolute of the differences between each percentage and the mean value, and then dividing by the number of caregivers observed. Thus degree of difference varies between 0% and 100% for each category of activity.

Hospital A



Hospital B

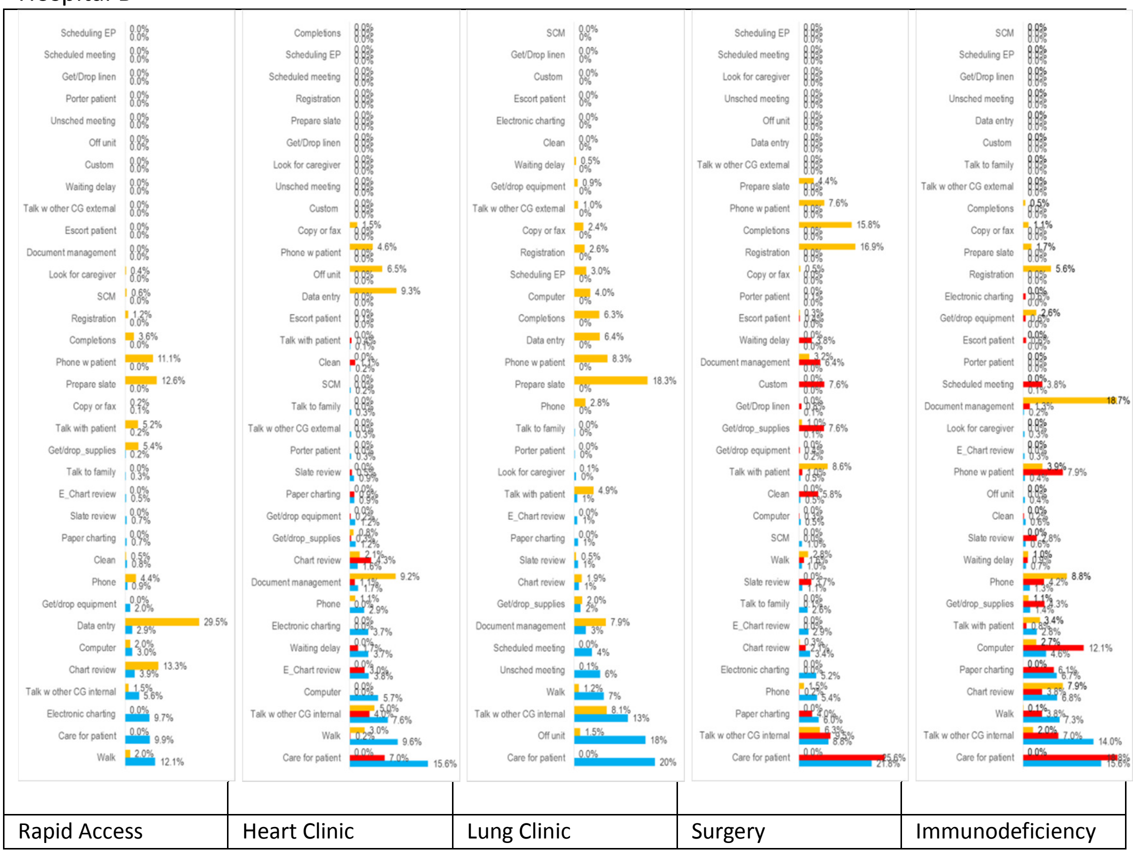


Figure 4: Degree of difference between percentages of time spent in certain activities within each clinic of Hospital A and B calculated separately for each group of inhabitants; activities were ordered from bottom to top according to importance (i.e. longer durations); Legend: physicians: nurses: clerks

In this chapter three of the criteria for strong and weak programming were discussed. In two cases (criterion 7 and 13) Hospital B was more strongly programmed than Hospital A; one criterion could not be applied sufficiently with the evidence at hand (criterion 11).

7. Communication and encounter patterns

In this chapter the remaining criteria 8, 9 and 12 are discussed. Communication was chosen as an activity to be analysed because studies have highlighted that interaction is one of the main activities to be directly influenced by the spatial configuration of weakly programmed buildings.

To investigate whether activities follow programme or configuration (criterion 8) various communication networks were compared in their structures, i.e. planned communication (f2f_planned_all), unplanned communication(f2f_unplanned_all) and electronic communication (electronic_all). Planned communication comprises intentional interactions or meetings, which are programmed and are not affected by the building layout. Unplanned communication include unintentional interactions, which arise from the opportunities the physical space provides e.g. bumping into each other in the corridor. Phone and email conversations are considered electronic communication. The three networks were constructed based on self-reports of caregivers in an online survey, indicating who they communicated with and how often this happened (monthly, weekly, several times a week, daily, several times a day). Therefore, valued directed networks were analysed with frequency of communication as associated tie strength. To test the association between these networks, for instance how much someone's planned communication patterns coincided with unplanned patterns, a QAP correlation analysis was used. Table 4 lists the results from the correlation analysis of the three networks in the two hospitals.

The correlations between all networks in Hospital A were all very strong and highly significant with correlation coefficients between $R^2=0.87$ and $R^2=0.91$. On the contrary, in Hospital B the networks correlated less strongly and with lower significance as coefficients ranged from $R^2=0.29$ to $R^2=0.49$. This implies that caregivers in Hospital A communicated with the same people in the same frequency across all different means of communication, i.e. those that someone saw regularly face-to-face in planned and scheduled meetings were also those they saw in an unplanned way or contacted electronically. This reveals a clear spatial correspondence between planned and unplanned communication in Hospital A. This is insightful, since unplanned communication clearly is a result of the spatial layout of a building. Therefore it could be argued that Hospital A is rather weakly programmed, where communication behaviours follow a spatial logic (possibly as a result of the open-plan work area of the Knowledge Centre), while Hospital B is more strongly than weakly programmed, since there is a much weaker correspondence between the different modes of communication, suggesting parts of the communication behaviour of caregivers in Hospital B are driven by programme rather than spatial configuration.

Hospital A

	Electronic_all	F2Fplanned_all	F2Funplanned_all
Electronic_all	---	---	---
F2Fplanned_all	.87**	---	---
F2Funplanned_all	.91**	.90**	---

Hospital B

	Electronic_all	F2Fplanned_all	F2Funplanned_all
Electronic_all	---	---	---
F2Fplanned_all	0.35*	---	---
F2Funplanned_all	0.29*	0.49**	---

Table 4: Correlation matrices with coefficients for QAP analysis of all networks; R^2<0.5 are shown in light grey; 0.5<R2<0.8 are shown in bold dark grey; R2>0.8 are shown in bold black; only significant correlations are shown and significance levels are indicated by * (p<0.05) and ** (p<0.01).

According to Criterion 9 spatial and transpatial solidarities correspond to each other in strongly programmed buildings compared to weakly programmed buildings, where such a correspondence is not present. In order to be realised, face-to-face communication needs space, thus it represents spatial groupings, while electronic communication connects people across the boundaries of space and thus allows the formation of transpatial groupings. The strong and highly significant correlation between electronic and face-to-face communication (R^2=0.87 and R^2=0.91) in Hospital A suggests that a strong correspondence model exists in this hospital. On the other hand the lower correlation coefficients for Hospital B (R^2=0.35 and R^2=0.29) may indicate the presence of a non-correspondence model. If this logic is applied, then Hospital A shows stronger programming than Hospital B.

Criterion 12 is similar to criterion 8 in that it considers the influence of configuration versus programme on task performance and role behaviours. Various spatial metrics were discussed in the literature, among them distances between nurse stations. To assess whether distances have an impact on communication behaviours in the two hospitals presented in this paper (which would point towards a weak programme), or whether distances do not matter for communication (which would indicate a strong programme), we investigate distance and communication intensity across clinics rather than within clinics. This provides more differentiation, since the clinic layouts within a hospital are too similar to provide a broader range of configurations. Whole axial models of the two hospitals were used to calculate distance as axial step depths between clinics. Table 5 summarises the number of steps from each clinic to every other clinic in the two hospitals. The distances between clinics in Hospital A vary from one to maximally eight steps as a result of a compact spatial structure, where clinics are located in close proximity. The range in Hospital B is twice as big ranging from one to sixteen axial steps derived from the distant location of the clinics and their physical vertical separation. Communication intensity, a metric for the number of ties in the communication networks (planned, unplanned, electronic) reaching across clinics, indicated how many people from each clinic communicated with people from every other clinic more than once per week on average in each of the three categories[4].

[4] In detail, each tie could take a value between 2 (monthly contact) and 7 (contact 4 or more times a day). Tie strengths were summed up across all three networks and a threshold of 10 was applied, which represents at least weekly contact (tie strength of 3) in each of the networks.

Hospital A	Surgery	Int. Medicine	Cardiology	Pulmonology	Orthopaedics
Surgery	-	-	-	-	-
Int. Medicine	6	-	-	-	-
Cardiology	8	4	-	-	-
Pulmonology	8	4	1	-	-
Orthopaedics	1	6	8	8	-

Table 5a: Number of axial steps from each clinic to every other clinic in Hospital A.

Hospital B	Surgery	Rapid Access	Heart Clinic	Lung Clinic	Immunodeficiency
Surgery	-	-	-	-	-
Rapid Access	7	-	-	-	-
Heart Clinic	12	13	-	-	-
Lung Clinic	12	15	10	-	-
Immunodeficiency	6	1	14	16	-

Table 5b: Number of axial steps from each clinic to every other clinic in Hospital B.

Figure 5a and 5b show the correlation between axial step depth and communication intensity for Hospitals A and B. For Hospital A the correlation is highly significant ($p<0.0022$) with a high coefficient of $R^2=0.76$ (see figure 5a), yet only if an outlier case (encircled in a red dotted line representing the relation between Cardiology and Pulmonology) is excluded. The relation is not linear, but logarithmic. This means that in very close proximity small increases in distance make a bigger difference than for larger distances. Cardiology and Pulmonology are an outlier, since they are only one step away from each other, yet do not communicate very often. This shows that space is not the only factor in driving communicative patterns. However, since a spatial influence could be found, this means a weak programme is in place to some degree. In the case of Hospital B no significant correlation can be obtained (see figure 5b), even if a similar outlier (representing the relation between Immunodeficiency and Rapid Access Clinic) is excluded, where again distances are very low, but communication is not intense. Since no spatial influence is found, this suggests that a strong programme is in place, which drives communication intensity independently of spatial distances.

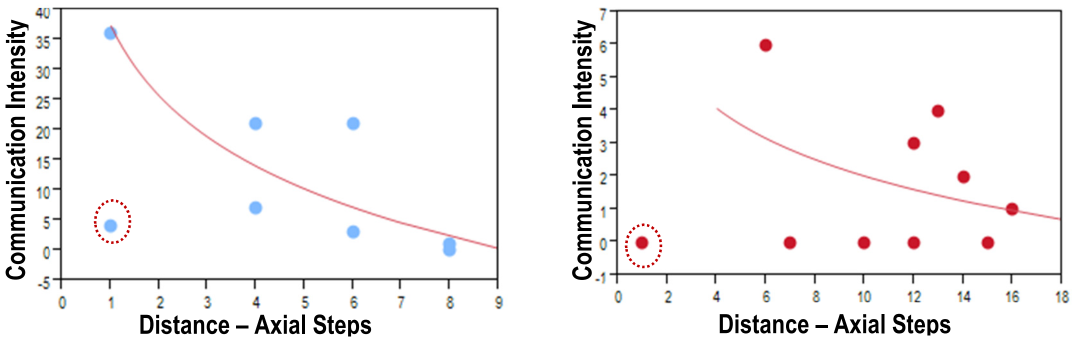


Figure 5a and b: Relationship between communication intensity and spatial distance in hospitals A and B

To conclude, three more criteria were applied in this section using data on communication patterns in the two hospitals. In one case (criterion 9) Hospital A was found to be stronger programmed than Hospital B, while for the other two criteria (8, 12) Hospital B was argued to operate on a stronger programme.

8. Conclusion: How Strongly Programmed is a Strong Programme Building?

This paper has discussed the theory of strong and weak programme in buildings by summarising various criteria from existing literature and applying evidence from two hospital buildings. Hospitals as a building type were traditionally assumed to be strongly programmed buildings, yet recent contributions highlighted the fact that the dichotomy of strong and weak may be inappropriate as a fixed label. Therefore this paper has aimed at articulating a more fine-grained description of the different layers and aspects of programme.

The main findings of this study are summarised in Figure 6. All criteria to distinguish between strong and weak programme buildings are listed and a scale from 'strong programme only' via 'predominantly strong', 'more strong than weak', 'average', 'more weak than strong', 'predominantly weak' and up to 'weak only' was devised to plot the position of each of the two hospitals based on the evidence found. This mapping process was done qualitatively.

In general it can be concluded that neither of the two hospitals is easily assigned the label of a strong programme building. It is rather the case that the two buildings fluctuate from strong to weak highlighting the fact that strong programme buildings can show aspects of weak programming. This has already been suggested by existing literature on hospitals, since previous studies have found an impact of spatial configuration on behaviours (which is a feature of weak programme buildings), however, this was not articulated as clearly. It is also interesting to see that none of the two hospital buildings is consistently stronger programmed than the other. Depending on each criterion, Hospital A or Hospital B is argued to operate a stronger programme. The findings therefore suggest that the same building as well as the same building type can show different levels and degrees of programming.

This has implications for the future study of strong programme buildings. Spatial configuration needs to be investigated as an influential factor on behaviour in parallel to a systematic analysis of the logistical pathways taken by professionals or other building inhabitants. The entangled nature of programme and space can only be understood in combination.

Although very rich data was gathered for the present study some limitations should be noted. First, observations were done during exam hours in outpatient clinics only and no data on patients' activities was collected. Therefore the social behaviour in some interesting areas such as the Knowledge Centre or the public areas was not captured and the argument of this study could not be extended further. A stronger focus on the various interfaces could form an interesting further research study. Second, the return rates from the online survey were relatively low – 31% for Hospital A and 43% for Hospital B, which weaken our multi-layered data. Third, more cases and other types of strong programme or mixed programme buildings such as transport buildings, shopping malls, airports or courts could be analysed and plotted on the scale to extend the argument further. It would be interesting to assess whether trends appear according to building typology. Last but not least, the criteria could be further developed and tested with a particularly designed research study.

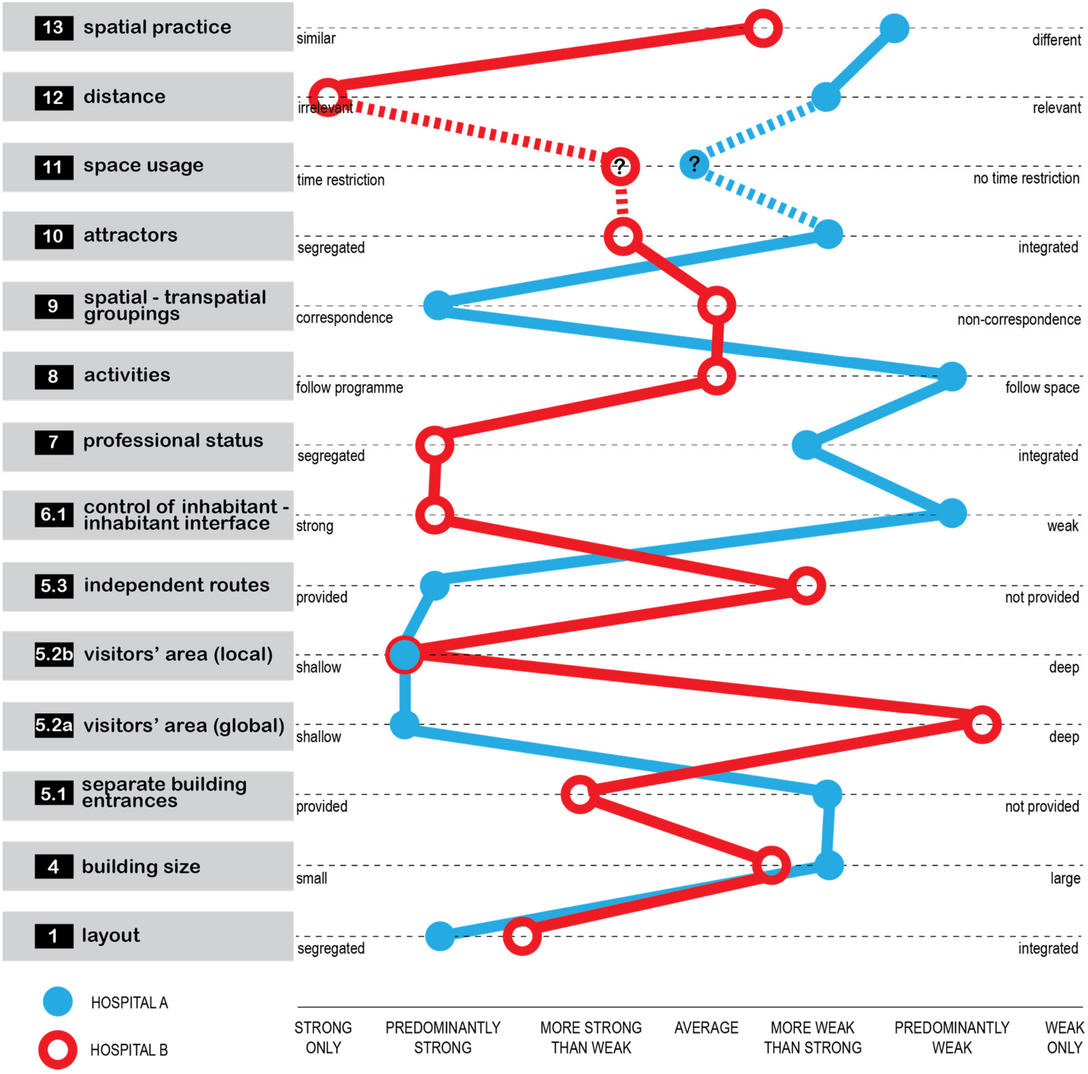


Figure 6: A multi-layered scale for strong and weak programme buildings. Hospital A is plotted in blue and Hospital B in red. Circles with a question mark indicate that data was not sufficient enough to support the criterion and circles were plotted on the scale qualitatively.

To conclude, this paper has contributed to a better understanding of social life in buildings by articulating an important Space Syntax theory of complex buildings, which to date has not received much attention – with the exception of some of the most recent papers discussed in the literature review. In most studies of building types, a hospital or gallery or an office was automatically related to either strong or weak programming. With the multi-layered scale developed in this study a more precise description and understanding of a building, its configuration and the space usage behaviours of its occupants could be obtained. While this paper has continued the line of enquiry of other scholars, a lot of questions remain that can only be addressed once more data and more types of buildings are analysed. These questions include: How small is small? How integrated is integrated? How controlled is controlled? And how strong is strong?

Still this paper has provided a starting point for the renewed discussion on the strength of strong programmes. It is hoped that this important debate continues by building on the foundations laid in this paper. A particularly important contribution would be to start quantifying the level of programming of buildings, which to date has only been done qualitatively.

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