Information seeking in the context of writing: a design psychology interpretation of the 'problematic situation'

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Abstract

Information seeking does not occur in a vacuum but invariably is motivated by some wider task. It is well accepted that to understand information seeking we must understand the task context within which it takes place. Writing is amongst the most common tasks within which information seeking is embedded. This paper considers how writing can be understood in order to account for embedded information seeking. Following Sharples (1996), we treat writing as a design activity and explore parallels between the psychology of design and information seeking. Significant parallels can be found and ideas from the psychology of design offer explanations for a number of information seeking phenomena. Next, we develop a design oriented representation of writing tasks as a means of providing an account of phenomena such as information seeking uncertainty and focus refinement. We illustrate the representation with scenarios describing the work of newspaper journalists.

Keywords: Information seeking, information behaviour, journalism, writing, design, uncertainty

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1. Introduction

Wersig has referred to the situations which motivate information seeking behaviour as the user's *'problematic situation'*s (Wersig, 1971). Within user-centred information seeking research it has been extensively argued that by understanding users' problematic situations, in which is included an understanding of their wider tasks, we will be better able to design more effective information systems (see for example, Ingwersen, 1992; Vakkari, 1999). This begs two questions: what is the nature of the information seeker's wider task? How can it best be represented and understood? In this paper we address these questions, taking writing (i.e. document authoring, possibly the most common tasks within which information seeking is embedded) as our focus. Central to our approach is the view that writing can usefully be conceptualised as a form of design activity and that, by taking this perspective, we are better able to interpret the information seeking behaviour of authors.

We are not the first to make the link between writing and design. For example, Goel and Pirolli (1992), in their analysis of design problem structures, identify writing as diverging only slightly from prototypical design tasks such as architecture and engineering. Moreover, Sharples (1996) has developed a model of writing, central to which is the idea of the writer as a creative designer. But the significance of this idea for information seeking research is that it can provide additional leverage for understanding the information seeking phenomena that arise in the context of writing tasks. This paper, then, follows an established approach to information seeking research in adapting concepts and ideas from related areas in order to enhance existing models (see for example, Kuhlthau, 1993; Wilson, 1996).

The aims of the paper are twofold: the first is to identify and explore parallels between the findings in the separate areas of the psychology of design and information seeking in the context of complex task performance[1]. In particular, the theories from the psychology of design that we consider have emerged from research into the performance of creative work such as architectural design. We show that significant parallels can be identified with this related, but perhaps unfamiliar, branch of research, and that the value in drawing these parallels is that explanations offered within the psychology of design literature can be applied to explain a number of information seeking phenomena. The second aim is to develop a design based representation of writing tasks as a means of providing a situated account of phenomena such as information seeking uncertainty, the progressive refinement of information seeking focus, and the reciprocal relationship between a user's evolving conception of their task and the information that they find.

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[1] Broadly, by 'complex task performance' we mean the performance of tasks whose complexity is such that they are not performed as a simple sequence of steps. This notion will become more clearly articulated in this paper through our review of Byström and Järvelin (1995).

Specifically, we use the idea of a constraint delimited problem space as the basis for a framework for representing the information seeker/writer's problematic situation.

To provide context for our later discussions, we begin the paper with a review of some important information seeking research relating information seeking to the process of addressing a wider task. Important themes in this work are uncertainty, its relationship with the formulation of a task focus, and the effect that this has on relevance judgments and query specificity. We then review some prominent conceptions of information seekers' wider tasks in which uncertainty (and its reduction) again provides an important connecting theme.

These reviews prepare the ground for the fourth section in which we discuss four features of design problems and design problem solving as observed within the design psychology literature, and relate these to concepts in information seeking. These features are: incomplete specification; primary generators; the analysis/synthesis dynamic; and multiple constraints and integrated solutions. We exemplify these and related concepts using observations from a study of the information seeking and use of national newspaper news reporters and feature writers (Attfield and Dowell, 2003a; Attfield and Dowell, 2003b); this paper is a development of that earlier work, explicitly relating the empirical findings to work on uncertainty in information seeking and to the nature of design problems. Finally, we use the design perspective to motivate a constraint-based framework for the representation of writing tasks which we claim offers a new explanatory framework for interpreting many information seeking phenomena.

2. From uncertainty to formulation

Over the last twenty years, uncertainty on the part of users engaged in information seeking has gained increasing prominence as an issue for user-centred information seeking research. It is argued that uncertainty is a particularly persistent characteristic of an information seeker's experience (Kuhlthau, 1993), underlying all aspects of information seeking and searching (Wilson, Ford, Ellis, Foster & Spink, 2002). It is often argued that, as an obstacle to task effectiveness, uncertainty should receive greater consideration in information retrieval (IR) system design (Belkin, Oddy, & Brooks, 1982; Kuhlthau, 1999). Hence Wilson (1999) has described uncertainty as the "ghost at the feast". Failing to accommodate user uncertainty is often cited as a shortcoming of the systems oriented approach in IR research which, it has been argued, is based on assumptions of certainty and order (Belkin, Oddy & Brooks, 1982; Kuhlthau, 1999).

One of the most frequently cited statements of uncertainty appears as part of Belkin, Oddy and Brooks' ASK hypothesis (1982). Belkin *et al.* argue that an information need arises from a recognised 'anomaly' in the user's state of knowledge concerning a topic or situation, and that, in general, the user is unable to specify precisely what is needed to resolve that 'anomaly'. According to Belkin *et al.*, there are times when a user is able to specify what information they require, but more usually the information that is required cannot be clearly specified in advance.

Some key work which has contributed to an understanding of the relationship between wider information tasks and uncertainty in information seeking has been performed by Kuhlthau and colleagues in relation to her Information Search Process (ISP) model

(Kuhlthau, 1993). The theoretical foundations of the ISP model draw upon the constructivist theories of Dewey, Kelly, and Bruner, according to whom forming new mental constructs, i.e. learning, is not simply a matter of the passive receipt of information, but rather a process of active mental reconstruction involving several stages and accompanied by varying levels of confusion and doubt.

Influenced by these ideas, and based on a series of studies of students and other novice library users, Kuhlthau's ISP model identifies six stages of the information search process through which an information seeker moves on the path from uncertainty to a constructed understanding. Kuhlthau found that the information search process begins (initiation) with vague thoughts and associated feelings of uncertainty, followed by identification of possible information sources (selection). The feelings of uncertainty soon give way to a brief sense of optimism as the information seeker weighs prospective topics against criteria of personal interest. As the person explores general information on the chosen topic (exploration), feelings of uncertainty and confusion increase, and it is at this time that an inability to express precisely what information is required results in awkward communication between the user and the information system. The most critical part of the process is the point where the information seeker forms a focus for their task (formulation); this acts as a turning point. Following formulation thoughts become clearer, uncertainty gives way to confidence, and clarity and confidence increase as the user gathers information (collection). Finally, a sense of relief is experienced as the search is completed (presentation).

Kuhlthau's ISP model has been described as most applicable to the process of seeking information and associated learning in the pursuit of complex tasks (Kuhlthau & Tama, 2001). In a recent study, Kuhlthau and Tama (2001) investigated the applicability of the model to the information seeking processes of lawyers undertaking a range of tasks, including both complex and routine tasks. This study set out to assess, among other things, whether, in this task domain, higher levels of uncertainty and construction of new knowledge were associated with more complex tasks. The findings supported this relation and accorded closely with the ISP model.

In the case of lawyers, complex tasks (preparing a case for trial) required considerable thinking and formulation. Formulation corresponded with establishing a trial strategy and was described as a difficult but creative part of the process. Further, developing a strategy, as well as being associated with uncertainty about the wider task, was also associated with uncertainty concerning the information needed. As predicted by the ISP model, the lawyers initially sought overview and background information to assist formulating a strategy.

Following Kuhlthau's work, there has been growing acceptance that formulation, in respect of the wider task, represents a particularly significant point for information seeking. This is the point at which the information seeker has developed sufficient understanding to establish a focused perspective for solving their wider 'problem' and, as such, represents a turning point for the user. Prior to it, uncertainty wavers, but generally increases in intensity; after, uncertainty subsides and confidence increases.

Vakkari, who has adopted the ISP model as a framework for his own research, interprets formulation as follows:

"Formulation of a focus or a guiding idea is a critical, pivotal point in a search when a general topic becomes clearer and a particular perspective is formed as the user moves out of uncertainty to understanding". (Vakkari, 2001)

He compares formulating a focus to developing a *hypothesis* for accomplishing the wider task. Byström and Järvelin (1995) articulate formulation as creating a solution space and determining the information requirements of the task. As Vakkari (1999) has argued, after formulation, the information seeker has a problem that might be solved, and knows more clearly what information is relevant.

Several studies have explored the progressive reduction in uncertainty as observed through two phenomena of IR interaction: query specificity and the ability to make categorical and confident relevance judgments. Tang and Solomon (1998) present a case study of a single graduate student searching for documents in preparation for writing a term paper. In two observation sessions, she was asked to mark retrieved records and journal articles for relevance. During the first session, she evaluated an initial 16 items of a bibliographic results set and then asked if she could go back and re-evaluate the previously evaluated records. During her re-evaluation it became clear that her relevance criteria had become more focused. She commented that her original selections had been too general, and that she had now developed a better idea of what she was looking for. At the second observation session, which was conducted after the subject had read her selected papers, she commented that a new topic had emerged during her reading. Content analysis showed that the new topic reflected the content of the original retrieved set more closely than her previously chosen topic. It seemed that the subject had modified her topic in accordance with the opportunities presented by the available documents.

Yang (1997) reports a study of undergraduate students performing information seeking using a hypermedia database in order to write a class assignment. The system used (Perseus) permitted users to retain items for later use, and hence provided a valuable opportunity for observing relevance judgments. Yang notes that, on occasion, subjects were uncertain about the value of a piece of information and would sometimes defer judgment. Subjects made comments such as, *"I'll come back to this later"*, or *"I'll have to think about that"*. One subject said,

"Eventually…, this is the reconstruction of the Frieze…, is something I'm going to use… I'm pretty sure… I don't know at this point, so I think I'm going to think about it a little more… mmm…" (Yang, 1997)

This study supports the notion of a focus corresponding with a broad plan or goal, which is consistent with Vakkari's notion of a hypothesis for accomplishing the wider task and Byström and Järvelin's idea of narrowing the solution space. As Yang argues with respect to one subject's exploratory information seeking at an early stage of the task,

"It seemed that he [Eric] had no specific goal or coordinated plan in mind. He appeared to be exploring the database in hopes of hitting on something that might trigger an insight or idea" (Yang, 1997)

Like Yang's description of provisional relevance judgments, Attfield and Dowell (2003a) also found that information gathering by newspaper reporters and feature writers was often performed on a relatively provisional basis. Not all of the gathered information would be included and more may be required. All of these studies demonstrate

developing confidence and ability to make categorical relevance judgments as a wider task progresses. Similar results have been reported by Spink *et al* (2002).

In a larger, longitudinal study, Vakkari *et al.* (reported in Vakkari, 2000a; Vakkari & Hakala, 2000; Vakkari, 2000b; Vakkari & Pennanen, 2000; summarised in Vakkari, 2001) observed this same effect, and also demonstrated that obtaining a focus for a wider task facilitates greater query specificity. Adopting and refining Kuhlthau's ISP model, Vakkari *et al.* report the evolution of search tactics, search terms, relevance judgments and sources by a group of students engaged in the task of writing a research proposal for their masters theses. Vakkari *et al.* chose to condense Kuhlthau's original six stages into three: prefocus, focus and postfocus. Various data were captured over three search sessions evenly distributed across a four-month period. This study showed that, throughout the task, the students' problem stages (according to the three-stage model) could be systematically related to the use of increasingly more specific search terms and discriminating relevance judgments. In the later stages, broader terms were dropped and the students adopted an increasingly large and more specific vocabulary.

We can, then, understand two cognitive issues involved in formulation: first, the information seeker achieves a pivotal level of sufficiency in their understanding about a topic; second, that understanding is sufficient to support the formulation of a focus for a wider task. Like Vakkari's notion of formulation being comparable to the generation of a hypothesis for accomplishing the wider task, we interpret a focus as corresponding to the development of a cognitive construct resembling a broad plan. No doubt this plan lacks detail, but it is nevertheless more focused than any original statement of objectives—the goal that brought them to the information service in the first place.

By developing a focus, or guiding idea, a searcher creates a solution space i.e. clearer task goals (a reduction in task uncertainty), and so their information requirements become clearer (a reduction in information seeking uncertainty), and this manifests itself through the production of more specific queries and through the ability to make more confident and discriminating relevance judgements.

3. Information seeking models of the wider task

Within the emerging field of information seeking and use, two broad premises can be identified concerning contextual variations in information behaviour. The first, discussed above, is that different stages of tasks give rise to different kinds of information need and associated information seeking behaviours (such as query construction and relevance judgments). The second is that different kinds of task give rise to different kinds of information seeking. Research in information seeking has, either explicitly or implicitly, distinguished different classes of task. Many have focused on the information seeking of different professional groups such as Kuhlthau and Tama's (2001) study of lawyers, Ellis and Haugan's (1997) study of engineers and industrial research scientists, and Nicholas and Martin's (1997) studies of journalists. Evident too is a more fundamental distinction between complex and routine tasks. A number of researchers have attempted to characterise the properties of complex tasks. In this section we review two of the more prominent of these characterisations, the first by Byström and Järvelin (1995) and the second by Wilson (1999).

An emerging consensus within information seeking research is that users' wider tasks can usefully be framed as *problem-solving* (Kuhlthau, 1993; Yang, 1997; Byström and Järvelin, 1995; Wilson, 1999). Byström and Järvelin (1995) adopt a view of problem-solving based on the expert systems literature, according to which information can be categorized into domain information (*e.g.* known scientific facts), problem information (*i.e.* the problem characteristics) and problem-solving information (*i.e.* expertise in problem treatment).

They propose a framework for classifying tasks according to level of task complexity based on a review of a number of task dimensions that, in the past, have been identified as characterising task complexity: *a priori* determinability; receptivity; analysability; the number of alternative paths of task performance; outcome novelty; number of goals and conflicting dependencies among them; uncertainties between performance goals; number of inputs; cognitive and skill requirements; and time-varying conditions of task performance. In considering these, Byström and Järvelin judge them as belonging to one of two main groups: characteristics related to *a priori* determinability and characteristics related to the extent of tasks. Of these, the dimension they chose to operationalise as a measure of complexity was *a priori* determinability.

Byström and Järvelin define a lack of *a priori* determinability as uncertainty concerning task outcomes, process and information requirements. This is essentially an adaptation of a concept from Van de Ven and Ferry (1980) (also adopted by Tiamyu (1992)), which states that task complexity relates to uncertainty associated with the inputs, procedures and outcomes of a task. The adaptation is that Byström and Järvelin substitute 'information requirements' for 'inputs'. These features, as identifiers of task complexity, have been the most widely used in information seeking research (Vakkari, 1998; Vakkari, 1999).

Adopting the concept of *a priori* determinability to characterise complexity, Byström and Järvelin classify tasks as ranging from *automatic information processing tasks*, which are *a priori* completely determinable (and could, in principle be automated), to those they refer to as *genuine decision tasks*, which are:

> "…unexpected, new and unstructured. Thus neither the result, the process, nor the information requirements can be characterized in advance. The first concern is task structuring" (Byström & Järvelin, 1995)

Finally, Byström and Järvelin make the point that the level of complexity, or *a priori* determinability, is relative to the point of view of the user. Task complexity is not absolute for a given task, but concerns the relationship between the task and the user's knowledge and expertise. This intuitive point has been made by a number of researchers in information seeking and is reinforced by Ng (2002) in a study exploring the extent to which people plan information seeking interactions as opposed to adopting more situated responses. Ng found that, for subjects with higher system knowledge or higher subject matter knowledge, there was less observed deviation from preformed plans. Thus assignment uncertainty is a function of the relationship between the task and the user.

Byström and Järvelin frame the wider task as problem solving, and their classification characterises problem solving tasks in terms of features of the user-task relationship. In contrast, Wilson's (1999) model of the information behaviour focuses more on task

process; this was subsequently adopted as a framework by the Uncertainty Project (Wilson *et al*., 2002). Wilson's model places an emphasis on stages in the unfolding problem solving process. The aim of Wilson's model (reproduced in fig. 1) is to provide a means for conceptualising the stages of problem resolution within which information seeking is embedded and motivated. The model dissects problem solving into four consecutive process stages: problem identification (where the person asks, 'What kind of problem do I have?'), problem definition ('Exactly what is the nature of my problem?'), problem resolution ('How do I find the answer to my problem?') and, potentially, solution statement ('This is the answer to the problem.').

Uncertainty resolution through information seeking

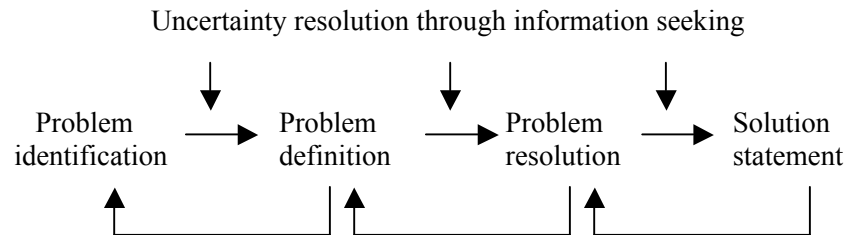Problem identification → Problem definition → Problem resolution → Solution statement

Figure 1. Wilson's (1999) problem solving model

According to the model, information seeking may be conducted at each stage of problem solving and may contribute to the resolution of uncertainty and transition to a subsequent stage. Wilson suggests that each stage in the model can subsume other well known models of information seeking, such as the Information Search Process (ISP) model (Kuhlthau, 1993) and Ellis and Haugan's (1997) search characteristics. The possibility of new information contributing to an increase in uncertainty and returning the problem solver to a previous problem stage, is represented by feedback arrows.

We have reviewed two conceptualisations within the information seeking literature of the wider task, and of task complexity. The first proposes that a complex task is one in which, from the information worker's perspective, there is *a priori* indeterminability (hence uncertainty) associated with the information requirements, process and goals of the task. We then described a generic problem solving model (Wilson, 1999) which describes the user as passing though stages with transitions between stages being enabled by information seeking and corresponding reductions in task uncertainty. In the next section we consider the information seeker/writer as the designer of texts; we turn to the psychology of design to review a number of properties of design problems and design problem solving which relate closely to, and extend, our understanding of information seeking as embedded within the complex information task of writing. Following this we present a model of the writing problem which will act as a framework for explaining information seeking phenomena.

4. The author as a designer of text

Much research into information seeking in context is concerned with people whose wider task involves writing. This undoubtedly reflects the ubiquitous nature of writing and the frequent requirement writers have for information. Consequently, by better understanding

writing, we might be better able to understand the context for a broad set of information seeking behaviours.

In this section we adopt the view of writing not simply as a kind of problem solving but, specifically, as a form of designing. According to this view, the writer is seen as a designer of texts. Drawing on influential work in the psychology of design (Lawson, 1997; Darke, 1978; Goel and Pirolli, 1992; Schön, 1983), we review some characteristic features of design problems and design problem solving which we are able to relate to features of writing, extending earlier work by Sharples (1996), and also to features of information seeking as reported in the information science literature reviewed in sections 2 and 3 above. We illustrate many phenomena through findings from a previous study of the information seeking and use behaviours of news reporters and feature writers working at a national daily newspaper (Attfield and Dowell, 2003a; Attfield and Dowell, 2003b). The design problem features we focus on are: incomplete specification; primary generators; the analysis/synthesis dynamic; and multiple constraints and integrated solutions.

4.1 Incomplete specification

Incomplete specification as a feature of design problems was recognised initially by Reitman (1964) (under the label of ill-defined or ill-structured problems) and has subsequently been echoed throughout the psychology of design literature (see, for example, Goel & Pirolli, 1992; Lawson, 1997). Reitman noted that there exists a lack of information (i.e. there is ambiguity) in the three components that comprise design problems: the start state, the goal state, and the transformation function from the start to goal states. Similarly, Sharples (1996) relates this feature of design problems to writing tasks. Unlike the classic problems studied by cognitive psychologists, like chess or Towers of Hanoi, there is no fixed set of goals or sequence of steps for solving them (Sharples, 1996).

A clear relationship can be seen between the notion of incomplete specification in design and that of *a priori* indeterminability concerning information requirements, process and task outcomes used by Byström and Järvelin and others. Also, Byström and Järvelin argue that *a priori* determinability is relative to the point of view of the user, and the same view is expressed by design psychology researchers with respect to indeterminability. For example, Goel and Pirolli (1992) cite Simon (1973), who argued that a problem is not intrinsically unstructured, but that this is a function of the relationship between the problem solver, their available knowledge, and the problem to be solved. Lawson uses the example of igloo building, arguing that this is not a design problem at all for an Eskimo (i.e. an expert), but rather a traditional form of solution or "vernacular" with variations to suit different circumstances. And in the context of writing (understood as a design task), Sharples (1996) explains this relativity by saying that expert writers can call on a large stock of remembered plans and schemas built up through a long apprenticeship in the craft of writing, whereas inexpert writers have less pre-compiled knowledge and so must construct plans to order. Since our example domain, newspaper journalism, is a largely formulaic genre of writing, it is replete with such schemas determining either content or structure, often contingent on the type of story being reported. The following extracts from an interview with a senior health

correspondent (Attfield and Dowell, 2003b) indicates the existence of pre-compiled content schemas used in disaster reporting:

> MG: Well people, yeah, well people want explanations. They want to know why, why is there an outbreak of foot and mouth, why are we.. you know why are we getting CJD…

> …Yes, it is a rough rule of thumb. Certainly it is with natural disasters, earthquakes or things like that are always measured by the number of dead. I think it is true of medical disasters too.

Clearly, for the experienced journalist, schemas supplement the initial brief and reduce task indeterminacy. And since *a priori* indeterminacy corresponds with information need uncertainty, we can expect the experienced journalist to know better what information to search for than the novice.

Within the design literature this relationship between incomplete specification and information need uncertainty has been commented on by Lawson, who observes that, given incomplete specification, it is difficult for designers to know what problems are relevant and what information will be useful until a solution is attempted (Lawson, 1997). Moreover, Lawson regards the ability to live with this uncertainty as an important personal quality for a designer, and he criticises modern Computer Aided Design systems for failing to accommodate uncertainty, particularly during the early stages of the design process. This claim has a strong resonance with the ideas of Kuhlthau who has long argued that bibliographic information retrieval systems are ill-suited to users in a state of uncertainty (Kuhlthau, 1993).

Incomplete specification means that the problem itself is not apparent but must be found (Lawson, 1997). Consequently much of a designer's time is spent in identifying and refining the problem (Sharples, 1996). Goel and Pirolli (1992) argue that lack of specification in design problems means that extensive problem structuring must be performed. Byström and Järvelin (1995) echo this in the context of complex tasks with embedded information seeking.

In the next section we consider the relationship between problem structuring in design tasks through 'primary generators' and focus formulation as discussed within the information seeking literature.

4.2 Primary generators

The notion of a *primary generator* as a means of structuring design problems has become particularly important within the psychology of design literature. A *primary generator* is a simple but powerful idea or principle established by a designer early in the design process around which further design activities are subsequently organized. The idea is attributed to Darke (1978) who interviewed a series of architects about their intentions when designing local authority housing. Darke found that the architects latched on to a relatively simple idea early on, and that this idea would then narrow down the space of possible solutions by providing an initial focus *i.e.* by constraining and guiding the designer's development of a solution. Darke gives examples of primary generators,

including the idea of creating a mews type street, or the idea of leaving as much open space as possible. Lawson (1997) observed that some designers deliberately generate a series of alternative primary generators, followed by progressive refinement, testing and selection.

Sharples (1996) incorporated the idea of primary generators into his model of writing, noting that accomplished writers often describe specific concepts and ideas as initiating their writing. For example, he cites Garcia Marquez who explains that the writing of One Hundred Years of Solitude was organized around the adoption of a particular tone.

Turning to the newspaper journalism domain, Attfield and Dowell (2003a) report that all newspaper news assignments adopt an explicitly articulated approach or angle, usually communicated to the journalist by their editor during an initial assignment brief. An angle, perhaps contrary to popular perception, is not so much an emotive stance or value judgment, but rather takes the form of a proposition, or central factual claim that is to be made by the report. Where the claim involves some speculation, the angle takes the form of a working *hypothesis* or *conjecture.* It is then tested by information seeking to either confirm or refute it.

An angle is developed early on in a newspaper news assignment, after which it constrains and guides the journalist's development of the report; as such, it well illustrates the presence of a primary generator in writing. But also, as an early, focused perspective or guiding idea which determines both a solution space and the writer's information requirements, it similarly illustrates an assignment *focus* as discussed in the information seeking literature. Establishing a primary generator represents a form of focus formulation applicable to writing with and without embedded information seeking.

Findings related to the instability of the primary generator allow us to explore additional similarities. Both Lawson (1997) and Sharples (1996) point out that, as a design process progresses, designers can gain new insights into their problem, leading them to reject or modify an initial primary generator (the idea through which the insight was achieved). Similarly, in their case study of the graduate student searching for information in preparation for a term paper, Tang and Solomon (1998) observed a change in focus and concluded that "a search might trigger a competing or more compelling idea, enabling or enticing the subjects to change direction, set aside, forsake, or even forget the original focus of their search". Likewise, in his study of undergraduates' relevance judgements Yang reported that, "Although each subject established a framework to guide his or her problem-solving, these were treated as malleable and open to change". Finally, newspaper journalists in the Attfield and Dowell study (2003a) reported the process of information seeking and writing as sometimes enabling a better idea for an angle than the initial idea, and hence destabilising the process. Modifying an initial idea for a writing task, as a result of the information seeking that the initial idea motivated, represents part of the fluidity of writing with embedded information seeking and is one way in which such activities can usefully be considered as part of a design process. In the next section we continue to draw parallels between design problem solving and writing with embedded information seeking by describing a prominent conceptualisation of underlying cognitive processes which will contribute to an explanation of the instability discussed in the latter part of this section.

4.3 The analysis/synthesis dynamic

Given the fluid unpredictability of design, there has been a trend within the psychology of design literature away from models representing the design process at the macroscopic level as a linear sequence of activity phases, in favour of models akin to situated action which represent iterations between the more fundamental activities of analysis and synthesis. Analysis activities are characteristically reflective, such as investigating the problem, perhaps discovering previous solutions or solution components, and reviewing solution candidates. Synthesis activities, on the other hand, are generative, involving the creation of solutions. Schön, suggesting that a dynamic interplay between analysis and synthesis is at the heart of all design professions, characterises this two-way interaction of influence (designer-environment) as a dialogue, referring to it as "a conversation with the materials of the situation". The designer is engaged in a continual process of moving, looking at the situation to assess the result of the move, and moving again; and during a review they may form a new appreciation of their problem. Schön refers to this as the situation "talking-back" to the designer and the designer responding and frequently re-construing the problem; a process consisting of an interplay between exploration and commitment rather than a series of predetermined moves. Further, Schön identifies this process as occurring at different levels of granularity as the designer shifts focus backward and forward between the unit and the whole.

Lawson refers to the analysis/synthesis dynamic as "analysis through synthesis" (Lawson, 1997), and places particular emphasis on the idea of learning through experimentation. He describes a study to explore cognitive styles in solving design problems. Two groups of students, science students and architecture students, were given a problem that required them to create a structure from wooden blocks according to a set of specified constraints. An apparent difference between the two groups was that the science students attempted an *a priori* analysis of the problem in search of a rule for constructing an optimal solution. The architecture students, on the other hand, consistently used the strategy of learning about the problem through attempts to create solutions. The analysis through synthesis dynamic was also reported by Eastman (1970) as a result of observations of experienced designers redesigning a bathroom, and by Akin (1986), who observed a group of architects designing buildings. Akin found that the architects constantly generated new goals and redefined constraints, a process whereby the designer discovers more about the problem as they critically evaluate their own solutions (Lawson, 1997).

An analysis/synthesis dynamic is evident within Sharples' (1996) model of writing, which emphasises the interplay between text production (engagement) and reflection on the text produced (reflection). During engagement, the writer is devoted to the task of turning ideas into text. During reflection, the writer reads the text (reviewing), forms new ideas (contemplation), and makes decisions about what else to write and how to organise it (planning). Within reflection we can also locate information seeking as an analytic activity. As with the distinction between the science and architecture students observed by Lawson, however, different people may have different writing styles relating to the extent to which they pre-plan writing or make decisions as they go. The advantage of an analysis/synthesis model, as Sharples points out, is that it can account for such

differences through variations in the attention users devote to each process throughout the cycle

Writing is a dynamic and emergent activity. Notwithstanding pre-compiled schemas, the content and structure will not necessarily be decided in advance. Many decisions are made as the writer progresses towards a solution and understands better what it is they are writing. This was observed by Attfield and Dowell (2003a). Decision-making was found to be ongoing and reactive to the opportunities presented by the situation.

The significance of the analysis through synthesis dynamic for information seeking in the context of writing is that, through this dynamic, the writer engages in a continual process of making, reviewing and adjusting commitments. As each commitment is made, so this constrains and determines the nature of subsequent commitments which ultimately contribute to a coherent whole. Effectively, the problem emerges with the solution. As Dewey argued, "we know what the problem exactly is simultaneously with finding a way out and getting it resolved. Problem and solution stand out completely at the same time. Up to that point, our grasp of the problem has been more or less vague and tentative" (cited from Kuhlthau, 1993). And where a commitment, or decision, has implications for particular information requirements, so a new information need arises.

Some models of information seeking and information behaviour, including Kuhlthau's ISP model and Wilson's problem solving model, have adopted a representation depicting a linear sequence of activities in which the user progresses from establishing a problem, to refining a solution. Others have avoided commitments to linearity (see for example Ellis & Haugan, 1997). Linear models, we argue, run the risk of under-representing the indeterminate nature of complex problems and the consequent twists and turns of human exploration and creativity; this risk is perhaps what underlies the feedback loops shown in Wilson's model.

So far we have reviewed three features of design problems and design problem solving: incomplete specification, primary generators, and the analysis/synthesis dynamic, and we have related these ideas in particular to information seeking uncertainty and focus formulation. A primary generator acts as a constraint to reduce the problem space, but there are many other constraints that collectively structure a design problem. A primary generator, albeit a constraint that is psychologically significant to the design process, is nevertheless one of many constraints. In the next section we complete our review of design problem features by discussing the issue that research and writing tasks, as a class of design problem, require integrated solutions to multiple constraints. Indeed, a design problem *is* the sum total of its constraints and this has important implications for the representation of the information seeker/writers problematic situation.

4.4 Multiple Constraints and Integrated Solutions

According to Lawson (1997), a constraint is an issue that must be taken into account when forming a solution to a problem, and good design is frequently an integrated solution to a whole cluster of constraints. He describes design problems as essentially being "built up" of constraints. In an exploration of the types of constraint that can constitute a design problem, he proposes a three dimensional model on which all constraints can be classified, which together provides a general framework for

differentiating design problems. For example, one of Lawson's dimensions, which is also discussed by Goel and Pirolli (1992), corresponds with the extent to which a constraint is *hard* or *soft*. Hard constraints are rigid and must be satisfied, but design problems are frequently constituted mostly from *soft* constraints; these are less rigid and render the problem more as one of constraint optimisation rather than constraint satisfaction. Although we will only reference this model in passing here, such an endeavour is clearly underpinned by the premise that a design problem *is* the aggregate of its constraints, and that constraints provide the designer with a problem space within which one or more solutions lie. However, to complicate the matter, the requirement for an integrated solution often leads to constraints acting against each other, so that trade-offs must be made.

Writing *is* such a multiple-constraint problem, as noted by Sharples (1996). The constraints of writing are complex and operate at many levels, ranging from issues of surface level structure to social and political implications; they may include: avoiding libel; corresponding with known facts; ensuring comprehensiveness of the information cited (within the terms of the assignment); organising information appropriately; presenting valid argumentation; using humour appropriately; ensuring the aesthetics of the prose; using appropriate grammar, register (*i.e.* genre specific stylistic requirements or expectations) and spelling; and satisfying word count limitations. However, the constraints at play in writing characteristically vary between types of task, and therefore differentiate one task from another. Since constraints constitute the task, constraint differences differentiate one task from another.

Within the domain of newspaper journalism, as well as the angle (which typically serves as both a primary generator and a constraint), there are other common constraints. These include constraints concerning the content—notably originality (that the story angle should not repeat an angle taken in any previous article), newsworthiness (that it should be interesting) and correspondence with known facts. They also include constraints concerning the structure—for example, that the key points of the story should be communicated in the first sentence or two, that important information should appear before less important information, and that the article should be of a specified length. These multiple constraints are satisfied in the design of a good integrated solution—namely, the writing of a publishable newspaper article.

In elaborating constraint types in writing, Sharples makes a further distinction (adopted from Lawson (1990)) between constraints which are *external* to the writer, such as an essay topic, previously written material, or a set of publisher's guidelines, and those which are *internal* to the writer, such as schemas, inter-related concepts, genres and knowledge of language. Like Lawson, Sharples identifies the resources a writer uses as constraining the writing process. "The designer, the artefacts, and the setting form a rich interoperative system. Each artifact conditions the activity, assisting certain operations while restricting others"; it is in this context that he makes passing reference to information seeking from external resources.

One important observation by Sharples (1996) is the apparent paradox that constraints are, simultaneously, limiting and facilitating. They are limiting in that they define the space of acceptable solutions, and yet they are facilitating insofar as they enable the creative process by "constraining the generative system into an appropriate conceptual

space". The way that a writer generates new material, and also manages the proliferation of possible next actions, is by imposing appropriate constraints. Put simply, constraints, as well as limiting the design process, guide the designer.

5. An Account of Embedded Information Seeking in Terms of a Constraint Delimited Problem Space

Where information seeking is embedded within writing, a reciprocal relationship occurs between the two – *i.e.* information needs are determined by the needs of the task, and yet the evolving task is shaped by the information found; this is an aspect of the analysis/synthesis dynamic. Consequently, a representation of the wider task which reflects this view should explain how tasks give rise to information needs and also how found information affects the structure of tasks. Further, on the view that a design problem *is* the totality of its constraints, a representation of the wider task should use constraints as its conceptual basis. And, since design problems feature multiple constraints and require integrated solutions, it should also show that successful solutions do just this. We use these requirements as the start point for a representation of writing tasks.

As summarised above, Attfield and Dowell (2003a) identified three important constraints applicable to the determination of a story idea or angle in newspaper news writing. These were: originality; correspondence with fact; and newsworthiness. There may be others at this stage, such as the paper's political perspective, but these three will suffice to illustrate our account. We use them to illustrate a constraint delimited problem space as shown in figure 2. Figure 2 represents the idea that each constraint independently defines its own space of satisfactory solutions. For example, the originality constraint defines news reports that are new. However, these reports will not necessarily be *true* or *interesting* since they may fall outside the requirements of correspondence and newsworthiness. Since, for a good solution, all three constraints should be optimised, integrated solutions lie at the intersection of all constraints. In effect, any idea falling within this intersection represents a viable assignment opportunity. Also, for the sake of ease of representation and clarity, we have shown each of the constraints as having clearly defined boundaries, *i.e.* they are represented as *hard* constraints, ignoring the fact that any of them may be *soft*.
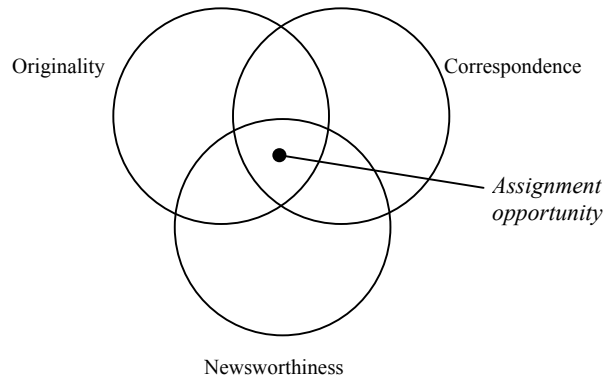
Figure 2. For journalists, a good angle lies at the intersection of the constraints
of *originality*, *correspondence* and *newsworthiness*.

Given this framework, we will explore the initiation and effects of information seeking through two scenarios using journalistic writing as our example. We use this domain since it is one with which we are familiar, although we believe that such an analysis can easily be extended to account for information seeking and writing as it occurs in other domains.

Consider a journalist at the very earliest stage of an assignment—before an angle (the 'primary generator' of a story) has been established. Indeed, at this point it is reasonable to say that an assignment does not yet exist. Let us say that our journalist is a senior, specialist journalist who has the authority to source her own stories. Information seeking at this stage might typically be broad-based with unspecified, or difficult to specify, needs, and might typically feature monitoring activities such as reading incoming newswires and emails, and receiving telephone calls. She may even use more proactive means such as contacting specific agencies to see whether anything interesting is in the offing, but at the moment a story does not exist. Our first scenario starts here.

Although she is aware of the constraints represented in figure 2, at present, our journalist has no idea for a story that will meet them. Through monitoring, however, some information comes to her attention which triggers an idea (*i.e.* an angle, or primary generator) for a solution which might optimise the constraints. The concept for the story may not simply be reporting the information received – it might involve an inference drawn from that information – but, whichever the case, she judges that the resulting story angle is newsworthy. However, some doubt exists in her mind about how close to the truth the central claim, or angle, of the story would be. Uncertainty also exists about the originality of the idea. Consequently, she engages in information seeking in order to resolve these (and other) issues.

Figure 3 represents these developments in terms of the problem space understood from the journalist's perspective. In the initial state (left), the journalist has a problem space but no competing solutions. When the new information arrives, it triggers a primary generator for a story and, as a proposed solution, this can be located within the problem space (shown right). This idea (marked 'S') represents an opportunity and so provides the journalist with focus. However, although the journalist judges the proposal newsworthy,

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and hence it is shown within the boundary of the *newsworthiness* constraint, she is unsure about where it is located in relation to the boundaries of the *originality* and *correspondence* constraints. She is unsure of the constraint boundaries. In Figure 3 this situation is represented (right) by showing the *originality* and *correspondence* constraints with two alternative perimeters (dashed lines). The proposed solution is located within the problem space, but its position in relation to the *originality* and *correspondence* constraints is indeterminate.
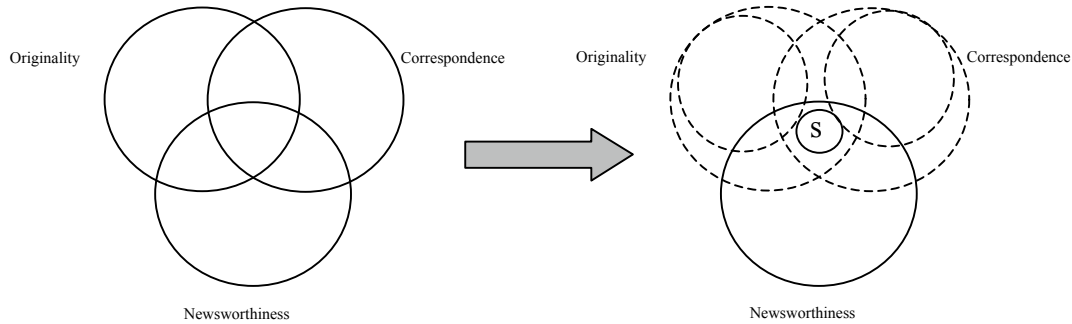

Figure 3. A solution space representation of the transition from no story concept to a story concept with originality and correspondence uncertainty.

Our reason for showing the story idea in figure 3 as a circle is to indicate that, whilst this idea is in embryonic form (*i.e.* as an initial focus, angle or primary generator), rather than representing a single solution, it represents a class of solutions, *i.e.* all those solutions that adopt the given primary generator. Hence, the idea itself constrains (or focuses) the problem space. By providing focus, it has the effect of narrowing the space of possible solutions, by "constraining the generative system into an appropriate conceptual space" (Sharples, 1996). Adopting a primary generator, however, is only the first step in narrowing the problem space. With each subsequent commitment the journalist will further reduce the size of the available solution class, until ultimately it consists of a single solution.

Our second scenario features the same journalist at a later stage in her assignment, where she has nearly finished writing. Her writing has been occasionally interrupted by information seeking. During cycles of reflection (analysis) on what she has been writing (synthesis) she has identified new information needs and has interrupted writing to resolve them. Occasionally she writes something, thinks, and then changes her mind. During one such cycle, she realises that, given what she has written already, she ought to provide the reader with a date as part of the background information. She believes she knows this information and has written it, but on reflection she is not entirely confident. We will refer to this piece of information as proposition *p*. The journalist directs a request to an information channel that she considers sufficiently reliable, and awaits a response.

This information need has arisen because the journalist is proposing a particular solution to her assignment, *viz.* one that incorporates proposition *p,* but she is unsure that *p* is true. In terms of the constraint delimited problem space, she is fairly confident where the

solution lies in relation to the *originality* and *newsworthiness* constraints, but she is unsure of its relationship with the boundary of the *correspondence* constraint. We represent this uncertainty in figure 4 as the *correspondence* constraint having two alternative perimeters (dashed lines) with one possibility incorporating the solution and one not. Also, since at this point in the assignment the proposed solution is far more refined than the solution class of the previous example, we show it now as a single point.
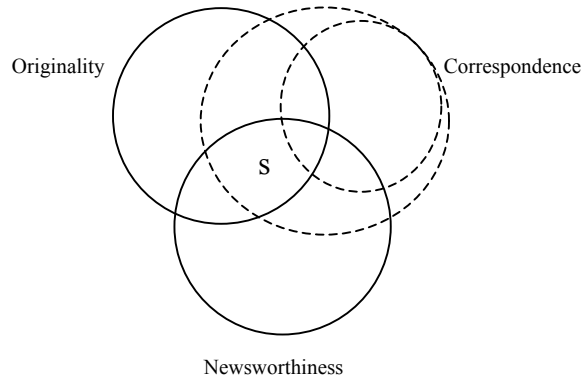

Originality

Correspondence

S

Newsworthiness

Figure 4. Correspondence uncertainty represented within a
news assignment constraint space

By confirming or disconfirming *p*, the journalist resolves this uncertainty. To confirm *p* is to establish that the contribution of *p* is not to render the solution outside the constraints. To find that *p* is false is to establish that the solution falls beyond the space of acceptable solutions. In this case, *p* would need to be modified or dropped altogether, and where the journalist fails to find out either way, the uncertainty remains. A response to this situation can be to dilute the claim and, in doing so, raise the certainty that the solution falls within the intersection of all the constraints, although this might reduce the value of the report in terms of other constraints, such as newsworthiness.

These two examples illustrate not only how information seeking can change a writer's understanding of the constraints that define their task, but also how framing a writing task in terms of a constraint delimited problem space can account for information seeking in the first place. Hence, the model implies the cycle of a task giving rise to information seeking and the information found changing the nature of the task *etc*. The examples intentionally demonstrate two contrasting information need types: a broad need specified at a general level, and a well specified fact-checking need. In the first case, the broad need arises from a requirement for a focus or primary generator; the writer is in a state of uncertainty. This state is represented as a problem space with no candidate solutions. Information seeking then provides the writer with an *opportunity* by triggering a solution idea or, rather, an idea of a class of solutions which, it is hoped, fall within the optimal area of the problem space. Subsequent information seeking can then resolve uncertainty with respect to the relationship between the proposed solution class and other constraint boundaries. In the second scenario, a well developed solution gives rise to a well

specified need – again, in order to resolve uncertainty with regard to the relative location of solution and the boundary of the correspondence constraint.

Hence, information seeking can give shape to the problem space in (at least) two ways. On the one hand, it can reshape the problem space by enabling the information seeker to identify an opportunity, which, in turn, better defines their problem and so establishes new constraints. On the other hand, it can reveal the shape of existing constraints and, in particular, how their boundaries correspond with different solution proposals. Design problems are typically under-specified at the outset, becoming better specified as solutions are attempted. The idea of constraints emerging during and through task performance is characteristic of design problem solving and, in particular, of the analysis/synthesis dynamic. Since the constraints *are* the problem, commitments which change the constraints effectively change what the problem is. Efforts to explore the existing constraints in relation to a given solution proposal change the structure of the constraints as understood by the problem solver.

6. Summary and Discussion

The first aim of this paper was to identify and explore parallels between what researchers studying the psychology of design have found and what information scientists have found in studies of information seeking in the context of complex information tasks, with a particular focus on the task of writing. We reviewed four features of design problems and design problem solving taken from the psychology of design literature, and related these to existing theories and empirical findings in information seeking.

In section 4.1, we argued that the idea of design problems being radically under-specified, and therefore requiring significant structuring, corresponds with Byström and Järvelin's notion of *genuine decision tasks*. Byström and Järvelin (1995) argue that *a priori* indeterminability is relative to the point of view of the user, and we find the same idea within the psychology of design in relation to user expertise. We reviewed an explanation of this from the psychology of design literature made in terms of learned plans and schemas.

In section 4.2, we argued that structuring a problem by establishing a primary generator, as identified in the psychology of design literature, corresponds with the idea of finding a focus in complex information tasks as explored in the work of Kuhlthau, Vakkari, Byström and Järvelin and others; a primary generator being an imposed constraint that narrows the space of potential solutions and, in doing so, focuses and guides the user's concept of what information is and is not relevant to the task. We also related instability of the primary generator to focus reformulation.

In section 4.3, we described a conception of process prominent within the psychology of design literature which we termed the analysis/synthesis dynamic and which offers an intuitive design oriented explanation for changes in focus. We argued that the analysis/synthesis dynamic provides an account of the dynamic nature of human exploration and creativity more adequately than linear activity sequence models. Analysis and synthesis, when applied to writing, implies that users frequently evaluate their situation and reframe the problem accordingly, hence re-appraising the constraints. In addition to the primary generator, writing tasks are driven by a need to optimise multiple

external and internal constraints, and in section 4.4 we related the idea of design problems being constituted from constraints to writing with embedded information seeking.

The second aim of this paper was to explore the extent to which the ideas reviewed in section 4 offer leverage towards representing the information seeker's 'problematic situation' and explaining various aspects of information seeking behaviour. In section 5, we developed a framework for representing writing tasks in terms of a constraint delimited problem space, illustrated using scenarios from journalism. We used the constraint based framework to illustrate the occurrence and effects of two different kinds of information need: a broad-based need resulting in opportunistic search behaviour, and a more specific fact-checking need resulting in goal-driven search. In each case, we were able to show how information seeking is driven by the wider task, and also how found information changes or reveals the shape of the wider task as understood by the information seeker/writer.

In terms of the problem space, a broad-based need arose when the information seeker had no candidate solutions to meet her wider goal. At this point she was unable to say what information would trigger a solution proposal, and hence was in a state of uncertainty. Information seeking at this point can at best be exploratory. When she found information to trigger an idea, this was represented as a new constraint defining a solution sub-class, and hence reshaping the problem space. Information seeking then focused on testing the class of solutions against other constraints to assess its viability. In the second example, an emerging potential conflict with the *correspondence* constraint and a solution proposal incorporating a proposition *p* led to fact checking. This information seeking was understood as clarifying the boundary of the correspondence constraint with respect to the solution proposal.

Our ideas link information seeking with design through writing as design. The design orientation focuses on the user's task, and yet it is broadly *cognitive* insofar as the problem space is considered from the users perspective—*i.e.* as the problematic situation. However, it is also *situated,* in as much as it accounts for dynamic responses to opportunities presented by the situation. An analogy that we find useful is to think of information relating to the writing process in the same way that building materials relate to architecture. The discovered properties of building materials and the consequences these have for how materials can be combined into a constraint optimising solution impact on the decisions of the architect. Similarly, the information seeker/writer will be influenced by the properties of the information he or she finds and the consequences that these have for how they can be combined into a coherent argument.

We began this paper by posing two questions: What is the nature of the information seeker's wider task? and how can it best be represented and understood? Taking the task of writing as our scope, and framing this as a design problem, we have used ideas from the psychology of design to develop an account which easily integrates embedded information seeking and related phenomena. The design perspective represents the writer/information seeker's problematic situation as a constraint space which evolves structurally through exploration and experimentation, creative insight, and the making, reviewing and adjusting of commitments. On this view, uncertainty is a natural part of addressing an unstructured problem space. An implication of the design perspective is

that to understand a user's problem, one needs to understand the constraints as construed by them, and understand that these change from moment to moment. To support this fluid process, one needs to enable the user to have a seamless conversation with the materials of the situation, and to enable the continuous interplay between exploration, experimentation, creative insight, commitment and review.

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