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# The impact of task complexity on people's mental models of MedlinePlus

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ABSTRACT

This study explored the impact of task complexity on people's mental models of MedlinePlus, an information-rich web space providing consumer health information to the general public. Thirty-eight subjects were randomly assigned to two groups, performing either simple or complex search tasks. After the search session, subjects' perceptions of MedlinePlus were elicited using a concept listing protocol where subjects listed concepts concerning MedlinePlus in the order each concept occurred to them. The analysis of the concepts suggested that task complexity impacted subjects' mental models by influencing the objects in the system that they perceived and represented, the specificity of the representations, their evaluations of and emotions about the objects, and the heuristics that they developed for what works and what does not in the system. The pragmatic aspect of mental models was represented by subjects' descriptions of the steps that they would follow to tackle a hypothetical task. The analysis showed that task complexity affected the strategies that subjects perceived themselves using to solve new tasks using the system.

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## 1. Introduction

Mental models are internal knowledge structures that serve as proxies for people to interact with the external world (Craik, 1943; Gentner & Stevens, 1983; Johnson-Laird, 1983). In the fields of human computer interaction (HCI) and information retrieval (IR), researchers generally postulate that people employ mental models to interact with various systems (e.g., Norman, 1983; Young, 1983); specifically, mental models describe "how a system works, its component parts, the processes, their interactions, and how one component influences another" (Fein, Olson, & Olson, 1993, p. 157). Therefore, knowledge about mental models can, when appropriately transformed, effectively inform system design and user instruction (Carroll & Olson, 1987; Young, 2008). Thus, there is a continuous effort in HCI and IR to better understand mental models (e.g., Brandt & Uden, 2003; Cool, Park, Belkin, Koenemann, & Ng, 1996; Doyle & Ford, 1998; Hendry & Efthimiadis, 2008; Papastergiou, 2005; Rieh, Yang, Yakel, & Markey, 2010).

In the past several decades, research on mental models, particularly in Information Science (IS), mainly focused on examining: (1) features, attributes, or characteristics of mental models (e.g., incomplete, not scientific, and parsimonious) (e.g., Papastergiou, 2005); (2) elements or content of people's mental models of IR systems (e.g., Makri et al., 2007; Westbrook, 2006); and (3) the impact of mental models on people's information searching behavior and performance (e.g., Borgman, 1986; Dimitroff, 1992).

In these studies, researchers gradually found that the features, composition, or quality of people's mental models of an IR system could be affected by various factors, including users' individual differences, such as computer experience (e.g., Thatcher & Greyling, 1998), educational status and academic background (e.g., Zhang, 1997), gender (e.g., Zhang, 2008b),

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and level of familiarity with a hypertext system (e.g., Otter & Johnson, 2000), system images, particularly system feedback (e.g., Muramatsu & Pratt, 2001), and environmental or contextual factors, mainly training conditions (e.g., Borgman, 1986; Savage-Knepshield, 2001).

Understanding how mental models are affected by various factors has both theoretical and practical implications. Theoretically, it could enhance our knowledge of the nature of mental models and their roles in people's interaction with IR systems. Practically, it can inform the design of systems that are able to facilitate users in building better understanding of the systems. Thus, it is worthwhile to initiate a series of studies to investigate the relationship between mental models and factors involved in interactive information searching. This study is an attempt to explore the impact of search tasks, an important contextual factor, on people's mental models of a consumer health information system, MedlinePlus.

Search tasks are consistently reported to have significant effects on information searching behavior and performance (e.g., Byström & Järvelin, 1995; Ingwersen, 1996; Ingwersen & Järvelin, 2005; Toms et al., 2007; Vakkari, 1999; Wildemuth & Hughes, 2005). People's mental models of IR systems are constructed, developed, validated, and modified when they complete tasks (Katzeff, 1990). Thus, tasks can affect the development of mental models by constraining the range of interactions that a user has with the system. However, little is currently known about how tasks affect mental models.

MedlinePlus (http://www.medlineplus.gov) was selected as the platform for this study. The website is a typical consumer health information portal. The site's content is updated often, and it has a large user base. A recent Pew study reported that eighty percent of adult Internet users in the US have searched for health information on the web (Fox & Jones, 2009). Many more web-based consumer health information systems are appearing (Kim & Chang, 2007). We expect that this study could also inform the development of such systems.

## 2. Related literature

The existing research on relationships between tasks and mental models has primarily focused on the impact of mental models on people's performance on search tasks. Studies showed mixed results. Some found that better mental models led to faster completion of tasks, fewer errors, and more results (e.g., Dimitroff, 1992; Kerr, 1990). Some reported that mental models did not have a significant impact on recall, precision, number of documents that subjects saved (Savage-Knepshield, 2001), subjects' behavior of initiating interactions with a system, navigation, query construction, and search patterns (Zhang, 2008b). Others found that the effect of mental models on people's information searching behavior and performance was contingent on the complexity of tasks. Better mental models led to better performance on complex tasks but not on simple tasks (e.g., Borgman, 1986; Halasz & Moran, 1983).

Another camp of research has focused less on the impact of mental models on task performance, and instead has attempted to understand the nature of mental models in relation to tasks. For example, based on the research on people's use of pocket calculators, Young (1983) suggested that one type of the subjects' mental models of calculators was based on task-action mapping. A task/action model encompasses a core set of corresponding relationships between tasks and actions. In such mental models, new tasks are expressed as variants of the core tasks. Subsequently, sequences of actions corresponding to the new tasks are derived from the core actions that correspond to the core tasks. diSessa (1986) distinguished two types of mental models, structural and functional models, in terms of contextual specificity. Structural models contain information about the internal structure of the system and are independent of specific tasks; while functional models are task related and contain information about how to use a selected set of functions to perform a specific task.

In the existing body of literature, search tasks were considered to be an important contextual factor and were consistently reported to have a significant impact on people's information searching behavior and experience (Li, 2009). For example, Liu, Gwizdka, Liu, and Belkin (2010) found that subjects who performed difficult tasks spent significantly more time, issued more queries, and examined more unique content pages to complete the tasks than those who performed easy tasks. In using an experimental IR system, White, Ruthven, and Jose (2005) found that subjects preferred explicit relevance feedback for less complex tasks and implicit relevance feedback for more complex tasks. Capra, Marchionini, Oh, Stutzman, and Zhang (2007) found that subjects who performed lookup tasks were more satisfied with the trial IR system than who performed exploratory tasks.

Although some researchers have proposed that tasks might influence people's mental models of an information system (e.g., van der Velden & Arnold, 1992), little empirical research has been done to investigate that speculation. In the single study found (Savage-Knepshield, 2001), the author investigated the impact of tasks on the quality of mental models, specifically, whether combinations of two types of tasks, a standard task and an aspectual task, affected the quality of subjects' mental models of an experimental IR system. She found that subjects who performed identical tasks over two different trials (1 week apart) did not improve their mental models' accuracy and completeness, whereas subjects who performed different tasks in the two trials showed increased congruency in their mental models.

In order to improve our understanding of the formation and construction of mental models, it is not sufficient to learn the fact that different types of tasks have impact on mental models. Rather, we need to learn how tasks, specifically their various facets or characteristics, might affect, shape, or constrain people's mental models of a system.

To illustrate how tasks would impact mental models, the first challenge is measuring the mental models. The main methods used to elicit or represent people's mental models in the existing literature are: (1) eliciting verbal accounts using interviews or think-aloud protocols (e.g., Katzeff, 1990; Slone, 2002); (2) asking people to draw their mental images of a system

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