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Distribution of Cognitive Load in Web Search

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The search task and the system both affect the demand on cognitive resources during information search. In some situations the demands may become too high for a person. This article has a three-fold goal. First, it presents and critiques methods to measure cognitive load. Second, it explores the distribution of load across search task stages. Finally, it seeks to improve our understanding of factors affecting cognitive load levels in information search. To this end, a controlled Web search experiment with 48 participants was conducted. Interaction logs were used to segment search tasks semiautomatically into task stages. Cognitive load was assessed using a new variant of the dual-task method. Average cognitive load was found to vary by search task stages. It was significantly higher during query formulation and user description of a relevant document as compared to examining search results and viewing individual documents. Semantic information shown next to the search results lists in one of the studied interfaces was found to decrease mental demands during query formulation and examination of the search results list. These findings demonstrate that changes in dynamic cognitive load can be detected within search tasks. Dynamic assessment of cognitive load is of core interest to information science because it enriches our understanding of cognitive demands imposed on people engaged in the search process by a task and the interactive information retrieval system employed.

Introduction

Human perception and cognition are engaged at multiple levels during information search. First, the information search process is clearly cognitive in nature (Ingwersen, 1996). Second, interaction with computing devices that mediate the search relies on human perception and cognition (Card, Newell, & Moran, 1983). A Web search is affected by the task, system, and individual searcher characteristics (e.g., Borgman, 1986, 1989; Byström & Jarvelin, 1995; Kim, 2001; Ford, Miller, & Moss, 2001, 2005; Toms, O'Brien, & Mackenzie, 2008; Li & Belkin, 2008). These factors, either alone or in combination, influence the level of difficulty

experienced by a searcher. One kind of difficulty is related to mental, i.e., cognitive, requirements imposed by the search system or the task itself.

Understanding what contributes to a user's cognitive load during search tasks is crucial to understanding the search process and to identifying which search task types and search system features make greater demands of users. We also need to better understand how novel user interfaces and interactive functionality affect user performance and system usability, usefulness, and acceptance. For example, in one system a user relevance feedback feature was avoided by users due to the heightened cognitive load (Back & Oppenheim, 2001). Detecting mental effort levels experienced by a user during a search process is important for understanding cognitive demands imposed by search tasks, user interfaces, and information displays, and for identifying where, and possibly how, to lower the mental effort required for effective interaction. For these reasons the dynamic aspects of cognitive load are of core interest to information science.

The results presented in this article show that cognitive load differs between search task stages and that different components of cognitive load (e.g., intensity, peak load) tend to be related to different aspects of search task performance. A variation of the dual-task methodology is used to show how cognitive load is sensitive to the dynamic changes in task demands such as the changes of load from one task stage to another.

The article is structured as follows. In the next section the concept of cognitive load is presented. Next, cognitive load assessment techniques are described and selected information science research that examined cognitive load is discussed. The emphasis is placed on the manifold nature of cognitive load and its dynamic properties and their implications for assessing cognitive load in information science. Finally, the study, its results, and a discussion of those results are presented.

Background and Related Work

This section discusses the concept of cognitive load and its components. It then presents an overview of measurement techniques and discusses types of cognitive load.