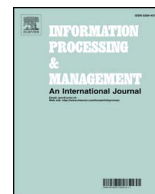


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Examining the impact of domain and cognitive complexity on query formulation and reformulation



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A B S T R A C T

The purpose of this analysis was to evaluate an existing set of search tasks in terms of their effectiveness as part of a “shared infrastructure” for conducting interactive IR research. Twenty search tasks that varied in their cognitive complexity and domain were assigned to 47 study participants; the 3,101 moves used to complete those tasks were then analyzed in terms of frequency of each type of move and the sequential patterns they formed. The cognitive complexity of the tasks influenced the number of moves used to complete the tasks, with the most complex (i.e., Create) tasks requiring more moves than tasks at other levels of complexity. Across the four domains, the Commerce tasks elicited more search moves per search. When sequences of moves were analyzed, seven patterns were identified; some of these patterns were associated with particular task characteristics. The findings suggest that search tasks can be designed to elicit particular types of search behaviors and, thus, allow researchers to focus attention on particular aspects of IR interactions.

1. Introduction

Some interactive IR research questions are most appropriately studied in naturalistic settings (i.e., in the wild), but many questions are best investigated through experimental or quasi-experimental studies (Kelly, 2009). In such studies, the researcher will typically assign specific search tasks to be completed by all or a subset of study participants (Kelly & Sugimoto, 2013). Such an approach allows the researcher to control task characteristics across study participants, focusing attention on the independent variables being manipulated.

To be effective in achieving the goals of an experiment, assigned tasks must be designed in a way that is consistent with those goals. For studies that stress ecological validity, simulated work task situations are typically used as the assigned search tasks. “A simulated work task situation is a short textual description that presents a realistic information requiring situation that motivates the test participant to search the IR system” (Borlund, 2016, p.395). By incorporating information about the source of an information need, the environment in which it arose, the problem to be solved, and the objectives of the search, the simulated work task situation can provide study participants with a standardized stimulus for their search and it can thus be assumed that all study participants are

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responding to the same stimulus. In addition, it can be assumed that the stimulus represents a realistic (even if fictional) work task.

Depending on the researcher's goals, assigned tasks may be designed to elicit particular types of search behaviors (including but not limited to "typical" behaviors). For this reason, tasks may vary by such attributes as type (e.g., Li, 2009; Pharo & Krahn, 2011), complexity (e.g., Albertson & Meadows, 2011; Jansen, Booth, & Smith, 2009), or domain (e.g., Toms, Freund, Kopak, & Bartlett, 2003). In each case, it is assumed that differences in the level or category of each task attribute will have an impact on the search behaviors elicited from the study participants. There is significant evidence to indicate that this assumption is often correct. For example, Jansen et al. (2009) found an impact of the cognitive complexity of the assigned task on the number of queries per session, average query length, unique terms used in the query, as well as other search behaviors. Similarly, evidence for the impact of domain on search behaviors is reported, by Toms et al., (2003). When they compared searches conducted in four domains (consumer health, general research, shopping, and travel), they found effects on the time taken at various search states, the number of instances of each search state, and the search strategies used.

For the study reported here, the cognitive complexity and the domain of the simulated work tasks assigned to the study participants were manipulated. An initial analysis indicated that the task's level of cognitive complexity did have an impact on such searcher behaviors as number of queries generated and their length, number of unique query terms used, number of clicks on the search engine results page (SERP), and number of URLs visited (Kelly, Arguello, Edwards, & Wu, 2015). The additional analyses reported here focus on the effects of the cognitive complexity and domain of the task on the specific search moves made during search strategy formulation and reformulation. This detailed examination of people's search behaviors can potentially reveal how people respond to tasks in particular domains at particular levels of cognitive complexity, and as a consequence may help us understand variations in search behaviors, as well as reveal ways in which assigned search tasks can be designed to elicit particular search behaviors.

2. Background

Three areas of prior research provide a foundation for the current paper. The first focuses on studies of search strategy formulation and reformulation. Past studies have used a number of different approaches to define and analyze search tactics and moves. Here, we will review these approaches, with special attention to their use for examining the sequences of specific moves that constitute a search strategy. Second, we will examine the literature on task complexity. The ways in which complexity has been defined within the context of interactive IR research have recently been reviewed (Wildemuth, Freund, & Toms, 2014), so we will focus attention on studies that have investigated tasks' cognitive complexity. Third, we will review the ways in which the domain of the assigned task may influence search behaviors, particularly when domain knowledge is not expected to vary across study participants.

2.1. Search strategy formulation and reformulation

Wacholder's (2011) review of research on query formulation and reformulation begins by noting the difficulty of studying query formulation processes, since they are cognitive processes and not directly observable. This challenge means that studies of search strategy formulation and reformulation must rely on either the product of the formulation process (i.e., the query that is submitted to the IR system) or the searcher's self-reports of their own cognition. The studies reviewed here, like the current study, based their analyses on the queries directed to the IR system.

To examine the processes of search strategy formulation and reformulation, the researcher must categorize the transitions made from one query to another and/or the multiple search moves represented within each query. Early work taking this approach differentiated search strategies and search tactics, defining a strategy as "a plan for the whole search" and a tactic as "a move made to further the search" (Bates, 1979, p.207). In the following decades, as transaction logs from online search systems became available for analysis, more fine-grained views of searches were possible and researchers began to look at the specific moves made within each query. In her seminal study, Fidel (1985) defined a search move as any "change in a query formulation" made during the course of a search (p. 61). She examined the searches conducted by seven professional searchers and identified eight operational and twelve conceptual moves that they made. Wildemuth & Moore (1995) built on this early work, examining the searches conducted by medical students as they participated in patient care teams.

Others have taken slightly different approaches to defining search moves. Based on a study of searches conducted by veterinary medicine researchers, Shiri & Revie (2003) defined seven cognitive moves and ten physical moves. While this distinction seems parallel to that used by Fidel, Shiri and Revie's cognitive moves are not nearly as fine-grained. A few years later, Rieh & Xie (2006) looked at searchers' reformulations as recorded in Web transaction logs, and categorized them as specification, generalization, replacement with synonyms, or parallel movement (similar to the categories defined by Lau & Horvitz, 1999). After identifying each of the moves made in a search, they focused their analysis on sequential patterns of moves, describing them as search tactics.

Some researchers have augmented their analysis of search moves by including data on the searcher's intentions for a search. Thatcher (2006) collected retrospective think-aloud protocols to more fully understand the Web queries (moves and tactics) generated in response to four assigned search tasks. In a similar vein, (Xie & Joo's 2010; 2012) lab-based study analyzed both the individual moves recorded in the transaction logs and a variety of other interaction-related behaviors (e.g., evaluating retrieved items or monitoring the search process). In both these studies, the use of think-aloud protocols allowed the researchers to infer the searcher's intentions and include those intentions in the definition of particular search moves. This approach, then, will not generalize to studies in which think-aloud protocols are not collected.

Shute & Smith (1993) initiated another stream of research by conceptualizing a search tactic as a "frame-based semantic

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