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## Exploring search task difficulty reasons in different task types and user knowledge groups

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### ARTICLE INFO

#### Article history:

Received 20 May 2014

Received in revised form 20 August 2014

Accepted 5 October 2014

Available online 30 October 2014

#### Keywords:

Task difficulty reason

Task type

Topic knowledge

### ABSTRACT

Search task difficulty has been attracting much research attention in recent years, mostly regarding its relationship with searchers' behaviors and the prediction of task difficulty from search behaviors. However, it remains unknown what makes searchers feel the difficulty. A study consisting of 48 undergraduate students was conducted to explore this question. Each participant was given 4 search tasks that were carefully designed following a task classification scheme. Questionnaires were used to elicit participants' ratings on task difficulty and why they gave those ratings. Based on the collected difficulty reasons, a coding scheme was developed, which covered various aspects of task, user, and user–task interaction. Difficulty reasons were then categorized following this scheme. Results showed that searchers reported some common reasons leading to task difficulty in different tasks, but most of the difficulty reasons varied across tasks. In addition, task difficulty had some common reasons between searchers with low and high levels of topic knowledge, although there were also differences in top task difficulty reasons between high and low knowledge users. These findings further our understanding of search task difficulty, the relationship between task difficulty and task type, and that between task difficulty and knowledge level. The findings can also be helpful with designing tasks for information search experiments, and have implications on search system design both in general and for personalization based on task type and searchers' knowledge.

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## 1. Introduction

Online information searching has become an everyday activity in the lives of people around the world. With today's search systems, people can often easily find the information they need. However, at times, people may have a hard time searching for information to fulfill a particular information need, for example, planning for a trip, buying a car, or researching the literature on a topic. These *difficult* tasks can lead to users not finding desired information and accordingly cause frustration and/or system switch behaviors. Search systems aimed at helping people locate information effectively, efficiently, and enjoyably should make it an important goal to reduce task difficulty, assist users with difficult tasks, and increase users' satisfaction.

Task difficulty has been attracting more and more research attention in the field of information retrieval (IR). Some researchers studied query performance and query difficulty from the language model perspective (e.g., Carmel, Yom-Tov,

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Darlow, & Pelleg, 2006; Cronen-Townsend, Zhou, & Croft, 2002). Others studied task difficulty from the search task level. Kim (2006) suggests that difficulty is the task doer's perception of task complexity. Li and Belkin (2008) define task difficulty as a subjective perception assessed by task doers. Studies along this line have examined users' search behaviors in difficult vs. easy tasks (e.g., Aula, Khan, & Guan, 2010; Gwizdka, 2008), users' perception of task difficulty before and after working on the tasks (Liu, Liu, Yuan, & Belkin, 2011), and the prediction of task difficulty from search behaviors and/or other factors such as user characteristics (e.g., Arguello, 2014; Gwizdka, 2008; Liu, Belkin, & Cole, 2012).

Despite the above research directions of task difficulty, little has been known about why users feel certain tasks are difficult and what makes them feel this difficulty. Even though a system can predict, from monitoring the users' behaviors, that they are having difficulty in their search, the system cannot help users overcome the difficulty without a further understanding of what caused the difficulty. This calls for an exploration of search task difficulty reasons, and Liu and Kim (2013) started to address this issue and developed a task difficulty reason scheme based on a lab experiment with 32 participants searching for 4 tasks. It would be helpful to test this scheme with more participants. In addition, it would be interesting to explore if the difficulty reasons vary across task types and across users with different backgrounds. In order to better understand the nature of search task difficulty and eventually benefit search system design, the current research attempts to explore the following research questions:

1. What are the reasons users perceive a search task is difficult?
2. Do the task difficulty reasons vary across different tasks and task types?
3. Do the task difficulty reasons vary between searchers with different levels of task topic knowledge?

## 2. Literature review

### 2.1. Search task difficulty and user behaviors

Search task difficulty has attracted quite some research attention in IR, especially in recent years. There is not a consensus on a definition of task difficulty. Some researchers suggest that task difficulty is subjective. Kim (2006) defined that difficulty is the task doer's perception of task complexity. Li and Belkin (2008) noted in their comprehensive task classification scheme that task difficulty can only be subjective, as assessed by task doers. Some other researchers define task difficulty based on certain objective criteria and/or measurements. For example, Aula et al. (2010) employed a user's task answer being correct or not as the criterion of the task being easy or difficult. Liu, Liu, Cole, Belkin, and Zhang (2012) designed tasks with different difficulty levels based on the retrieved results' precision@10 using the topic terms as search keywords.

One line of studies explored the relationship between task difficulty and searchers' behaviors. Kim (2006) examined the effects of task difficulty on user behaviors in three types of tasks: factual, interpretive, and exploratory. Task difficulty was elicited through users' ratings on a Likert scale based on their subjective judgments. It was found that in factual tasks, post-task difficulty was significantly associated with task completion time, and the numbers of queries and documents viewed; in exploratory tasks, user behaviors were significantly correlated with pre-task difficulty; but in interpretive tasks, most correlations between behaviors and task difficulty were not significant. Liu, Gwizdka, Liu, and Belkin (2010) also used users' subjective perceptions on task difficulty as elicited by their ratings on task difficulty questions. They examined through a lab experiment how user behaviors vary in tasks with different difficulty levels, as well as different types. They found that in difficult tasks, users had longer task completion time, issued more queries, viewed more content pages, and had longer dwell time on content pages.

Aula et al.'s (2010) took a more objective way to define task difficulty. It was determined by user success or failure in finding the answers to their task questions, which were closed information tasks that had a single, unambiguous answer. The authors conducted two studies to research task difficulty, one being a lab experiment and the other a large-scale study. Results showed that in difficult tasks, users formulated more diverse queries, used advanced operators more, and spent longer time on the search result pages.

Another line of studies has been attempting to predict search task difficulty from searchers' behaviors. Gwizdka and Spence (2006) examined how searchers' behaviors could indicate the difficulty of a factual information-seeking task. Task difficulty was self-assessed by users after each task. Their results indicated that higher search effort, lower navigational speed, and lower search efficiency were good predictors of task difficulty tested by regression models. In Liu, Gwizdka, et al. (2010) study, tasks were categorized as easy and difficult based on searchers' post-task judgment on tasks' difficulty levels. Searchers' behaviors were grouped at two levels depending on the time point when the behavioral factor value can be captured: the whole-task-session level factors whose values can only be obtained after a search session is done, and the within-task-session level factors whose values can be obtained while a search session is ongoing. They found that both whole-session level and within-session level user behaviors could serve as task difficulty predictors in logistic regression models. Whole-session level variables showed higher prediction accuracy, but do not enable real-time prediction. On the other hand, while within-session level factors can ensure real-time prediction, the prediction accuracy in general was mediocre, especially in certain types of tasks, possibly because of the limited number of within-session factors that were considered and used in their model.

Liu, Liu, et al. (2012) investigated users' behavioral differences between difficult and easy search tasks and built prediction models based on users' behavioral factors. The behaviors they used were at three levels, distinguished by the time point

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