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Searching for information on the web: Impact of cognitive aging, prior domain knowledge and complexity of the search problems

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ABSTRACT

This study focuses on the impact of age, prior domain knowledge and cognitive abilities on performance, query production and navigation strategies during information searching. Twenty older adults and nineteen young adults had to answer 12 information search problems of varying nature within two domain knowledge: health and manga. In each domain, participants had to perform two simple fact-finding problems (keywords provided and answer directly accessible on the search engine results page), two difficult fact-finding problems (keywords had to be inferred) and two open-ended information search problems (multiple answers possible and navigation necessary). Results showed that prior domain knowledge helped older adults improve navigation (i.e. reduced the number of webpages visited and thus decreased the feeling of disorientation), query production and reformulation (i.e. they formulated semantically more specific queries, and they inferred a greater number of new keywords).

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1. Introduction

With the wide development of the Web and the aging of population, a greater number of older adults use the Internet for their daily activities to search for information (Dommes, Chevalier, & Lia, 2011; Slegers, Van Boxtel, & Jolles, 2012). Even though search engines (such as Google, Yahoo!) try to provide information searching tools to help users (e.g. query suggestions), these tools do not cope with older adults' needs and difficulties. Previous studies showed that older adults experienced difficulties when reformulating queries, when navigating the web (Aula, 2005; Chevalier, Dommes, & Marquié, 2015) and when browsing websites (Aula, 2005; Chevalier et al., 2015). Among the factors impacting information searching performance, many studies have reported the role of cognitive flexibility (Czaja, Sharit, Ownby, Roth, & Nair, 2001; Dommes et al., 2011; Sharit, Hernández, Czaja, & Pirolli, 2008; Wagner, Hassanein, & Head, 2014), prior domain knowledge (Hölscher & Strube, 2000; Wildemuth, 2004; Willoughby, Anderson, Wood, Mueller, & Ross, 2009) and problem complexity (Barsky & Bar-Ilan, 2012; Dommes et al., 2011). These studies showed that cognitive flexibility, which corresponds to the ability to switch from one way of processing information to another (Chevalier & Chevalier, 2009), explained most of older adults' difficulties when switching from one web page to another (i.e. when navigating), or when reformulating query

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(Dommes et al., 2011). Prior domain knowledge (i.e. knowledge on the topic of the search) was reported to enhance search performance and to improve the relevance of the queries produced (Hölscher & Strube, 2000; Lei, Lin, & Sun, 2013). Problem complexity can impact both the actions to perform and how users have to implement these actions to complete the problem (Barsky & Bar-Ilan, 2012; Dommes et al., 2011), which can eventually decrease search performance. However, effects of prior domain knowledge only appeared when the information searching problem required users to use their prior knowledge (Monchaux, Amadieu, Chevalier, & Mariné, 2015; Salmerón, Cañas, & Fajardo, 2005). Hence, studying the role of domain knowledge on information searching also requires studying the level of complexity of the search problem itself. Indeed, information searching involves a great variety of information-solving problems: from the most specific fact-finding problems, to the most ill-defined and open-ended ones. This variety requires users to adapt to different constraints and requirements, which can be complicated for older adults as they tend to be less flexible (Czaja et al., 2001; Dommes et al., 2011).

Very few studies have analyzed both the role of prior domain knowledge and search complexity on the age-related differences on information searching. We argue that examining the effects of domain knowledge on the impact of age on information searching with search engines would improve our understanding of the cognitive difficulties encountered by older adults. The present study aimed at analyzing how age impacts reformulation and navigation when searching for information, and how prior domain knowledge could cope with the age-related difficulties. The level of search problem complexity was taken into account because it required different levels of prior knowledge activation. In the following two sections, we will present related works on the impact of cognitive aging (Section 2.1), domain knowledge (Section 2.2) and problem complexity (Section 2.3). Then we will point out the objectives and hypotheses (Section 3), the method (Section 4), and the results we obtained (Section 5). This article will be concluded with the discussion (Section 6) as well as the limitations and further works (Section 7).

2. Related work

2.1. Impact of cognitive aging on information searching

Most cognitive models highlighted that information searching first requires users to elaborate a mental representation of their information needs (e.g., their goals), and to keep it active in working memory (see CoLiDes model developed by Kitajima, Blackmon, & Polson, 2000; EST model developed by Rouet & Tricot, 1998, for an overview see Dinet, Chevalier, & Tricot, 2012). Then, users have to produce a query, to process the results retrieved by the search engine and to evaluate them. If no results are satisfactory enough, users can modify their initial query, keeping the goal the same or modifying it. Sharit et al. (2008) developed a model that is particularly interesting for our objectives, as it includes a wide range of cognitive abilities and query production. This model, which considers information searching as a problem-solving and decision-making activity, divides information searching into three stages, which may be iterative.

- The first stage deals with query planning and formulation. Users elaborate a mental representation of the problem to be solved, internalize the search problem statement and extract or infer useful keywords to formulate a query (and then type their query into the search engine text box).
- The second stage involves planning operations to complete the search goal. Users have to analyze and evaluate the search results by comparing them with the goal they elaborated (based on keywords analysis for example). If no results match the users' information need, users may decide to reformulate the query they produced and go back to stage 1 to produce a new query. Back to stage one, users may modify their mental representation of the search goal, or some keywords contained in their query, or their entire query.
- The last stage involves the selection of a relevant link, the deeper processing of the information contained in websites and the carrying out of the planned operations made in stage 2. This final stage involves the processing of the webpage selected by the user, but may also involves navigation if the user browses several webpages within the website he selected. If the webpages selected are not satisfying enough to carry out his/her goal, the user may go back to stage 2 by switching from the website opened to the search engine pages to analyze new search engine results, select new results to open up, or reformulate.

The present study focused on the age-related differences found in query formulation and reformulation on stage 1 and on navigation strategies developed during stage 2 (i.e. during the planning of operations defined by Sharit et al., 2008). Regarding query production and reformulation at stages 1 and 2, prior works reported that because of the age-related declines of cognitive flexibility and other fluid abilities such as inhibition processes, older adults use more keywords extracted from the search statement problems (Dommes et al., 2011), stick to the keywords they initially select, reformulate less (i.e. produce fewer queries), and produce fewer new keywords than young ones (Dommes et al., 2011). Fluid abilities (or fluid intelligence), which refer to the ability to think, reason abstractly and solve problems, independently of learning, experience and education (Cattell, 1971), are reported to impact web navigation and the ability of users to adapt to environment changes (Pak & Price, 2008). Prior works also showed that when planning their search at stage 2, older adults use different information searching strategies (van Deursen & Van Dijk, 2009) and also have difficulties interacting with search engines and websites. Older adults are slower, they spend longer time analyzing the search engine results (Chevalier et al., 2015; Matsuda, Uwano, Ohira, & Matsumoto, 2009), and they take longer to decide which website they want to visit (Sharit, Taha, Berkowsky, Profita, & Czaja, 2015). These results might be accounted for by older adults' difficulties to elaborate a

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