

Analysis of the factors affecting information search stopping behavior: A systematic review

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Abstract

This study has been conducted to better and more deeply understand search stopping behavior. The objective of this study was to identify the factors affecting search stopping behavior and notice the knowledge gaps in this field. This study was conducted as a systematic review. By reviewing the databases and studying the retrieved articles with relevant keywords, 1356 articles were identified and after refinement, 34 articles were reviewed without time limit. By studying selected articles in the field of search stopping behavior and using content analysis approach, the most important factors affecting search stopping behavior were analyzed. Factors affecting stopping behavior were classified into two different cognitive and environmental categories. The cognitive factors include information sufficiency and individual characteristics; and the environmental factors include search task, information retrieval system and time as the most important factors affecting search stopping behavior. One of the important research gaps in this field is the lack of a comprehensive model of factors affecting search stopping behavior. This is one of the studies to systematically review and examine the factors affecting information search stopping behavior and provides a model.

Keywords

Cognitive factors, environmental factors, information search, information sufficiency, stopping behavior, stopping rules

Introduction

In the 21st century, collecting the given information at the right time is important in everyone's life. Different individuals have various information needs in their daily life, both for work and non-work purposes (Yap et al., 2020). The web is one of the most important information retrieval systems and a platform full of diversified information to meet the information needs of individuals. For this reason, when searching for information on the web, one should decide when to terminate the search process. Brain activation patterns revealed an extensive distributed network of regions that are involved in the decision to stop searching for information that are not involved in search itself, showing that stopping is a complex and cognitively costly

neural activity. Therefore, since stopping is difficult in information environments (due to over acquisition of information), understanding the factors of stopping is crucial to improve users' task performance (Browne and Walden, 2021).

Research studies in the field of web search include different aspects. Understanding and modeling user behavior is very important in designing search systems (Thomas et al., 2014). In these models, information actions begin

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with recognizing the need for information to investigate a situation or solve a problem and end when user resolve the situation or abandon the pursuit (Prabha et al., 2007). Research studies show that researchers are generally interested in researching user's information seeking behaviors to satisfy their information needs on the web needs (Mansourian and Ford, 2007). As a result, several models have been presented about user's information seeking behavior in scientific or professional contexts (Prabha et al., 2007), but these models have addressed less factors affecting search stopping behavior. So theoretically, investigating the stopping behavior while searching for information enhances our understanding of the individual decision-making process (Browne and Pitts, 2004) and redesigning models of information-seeking behavior. Also, since there are few theoretical principles for the factors affecting search stopping behavior, by conducting further studies in this field, we can generalize the results of previous studies and strengthen the theoretical principles in the field of search stop behavior.

In the process of information search, if one stops too soon, one may lose useful information (Fischhoff, 1977; Fischhoff et al., 1978; Shafir and Tversky, 1992), have an incomplete understanding of the objectives (Pitts and Browne, 2004), and thus make more mistakes in his decision-making (Baron et al., 1988). If he stops too late, he may take a lot of time to review irrelevant documents (Maxwell and Azzopardi, 2018; Maxwell et al., 2015), collecting more information than needed and thus wasting time and resources (cognitive effort) for deriving and analyzing needs (Connolly and Thorn, 1987). Therefore, by identifying the factors affecting information search stopping, a new window can be opened for the design of information retrieval systems and one can be guided to decide to stop at the right time in interaction with information retrieval systems and thus obtain more useful information. So practically, the analysis of factors affecting search stopping behavior has important implications for the design of information retrieval systems.

The reviewed studies showed that, so far, no research has specifically focused on the classification of factors affecting the search stopping behavior. According to the above, there is a need to study the behavioral factors affecting the stopping of information search and scrutiny of these factors. Therefore, identifying the factors affecting search stopping behavior in representing a more realistic model of the search process is important. In this study, after a brief description of the theoretical origin of search stopping behavior, an effort has been made to identify the factors affecting search stopping behavior by reviewing studies conducted in this field.

Background

Stopping behavior is an important part of the information retrieval process and aims to understand the criteria that a

person uses for completing the search (Dostert, 2011). Stopping behavior means terminating a person's search for information. Studies on stopping behavior in the 1970s and 1980s theoretically and experimentally have often been focused on data retrieval from databases and usually reviewed in the context of rational or traditional decision theories (e.g. Kantor, 1987; Kraft and Lee, 1979; Morehead and Rouse, 1982).

Search stopping is typically used to describe a point where one concludes that he has sufficient information to perform their search task. Terms such as stopping behavior, search termination, patience, or persistence are used to describe this phenomenon, but no formal model or definition has been provided in the review (Wu et al., 2014b).

There is a distinction between stopping behaviors that are used at different stages of the decision (Browne and Pitts, 2004). In the field of stopping behavior, some studies consider stopping behavior as the termination of the information collection process and the assessment of information sufficiency (Berryman, 2006; Gerhart and Windsor, 2017; Nickles et al., 1995; Pitts and Browne, 2004). However, some have studied stopping behavior at the post-data collection stage, that is assessment of options and choice (Aschenbrenner et al., 1984; Bockenholt et al., 1991; Busemeyer and Rapoport, 1988; Gigerenzer and Goldstein, 1999; Meyer, 1982; Saad and Russo, 1996; Svenson, 1992). This study analyzes stopping behavior at the stage of collecting and assessing the sufficiency of information and does not include stopping behavior at the selection stage.

Methodology

This study was conducted as a systematic review in July 2022 through searching citation databases on the subject of analyzing the factors affecting information search stopping behavior. A systematic review was performed using PRISMA guidelines. The keyword used in the search was ("stopping rule" OR "stopping behavior" OR "stop rule" OR "stop behavior") AND ("information seek" OR "information search"). Scopus (in Article title, Abstract, Keywords), WOS (in Topic) and Google Scholar databases were searched without time limit. The records retrieved included 21 records from the Scopus database, 12 records from the WOS database, and 1320 articles from the Google Scholar search engine. Totally, 1356 articles were retrieved from three citation databases and 3 articles were retrieved from other sources. Of the total records, 64 articles were duplicated. 1208 records were removed through a review of Title and Abstract. Out of the remaining 84 records, 50 were removed after a full analysis of their texts. Finally, 34 articles were judged as qualified.

Inclusion criteria of articles were (1) attention to articles on stopping information search behavior, (2) publication of the article in English, (3) availability of keywords

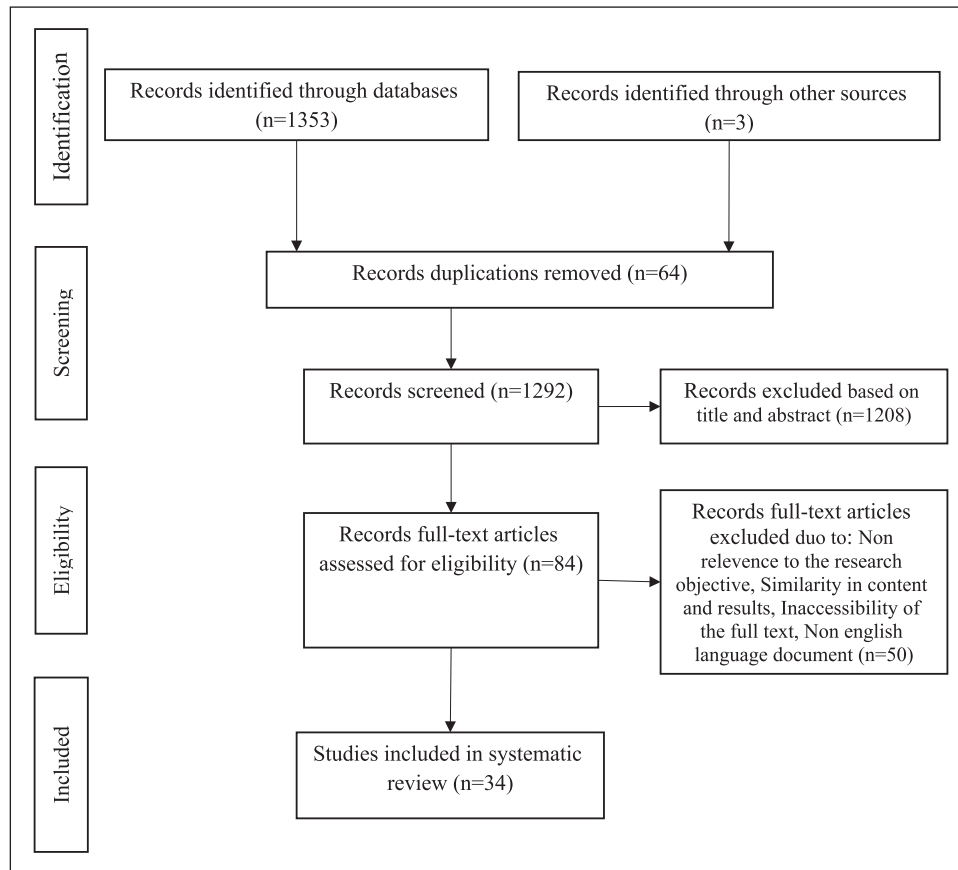


Figure 1. Inclusion process of articles.

or their equivalent in the title, abstract and text of the articles, and (4) availability of the full text of the articles. After applying the inclusion criteria, the full text of the articles was read and among the articles found, 34 articles were included in the study. The inclusion process of articles into this study is shown in Figure 1.

Results

After studying the articles and analyzing their content, the following results were extracted.

Basic research studies in the field of stopping behavior can be attributed to the studies of Cooper (1973), Kraft and Lee (1979), Kantor (1987), and Keen (1992). In these studies, stopping behavior has been formulated quantitatively. Next, Nickles et al. (1995) and then Browne et al. (2005) defined stopping behavior based on Simon's concept of satisficing (Simon, 1955) and proposed a number of cognitive stopping rules. These studies became the theoretical basis of subsequent studies and constituted the majority of studies in this field.

Factors affecting stopping behavior can be classified into two cognitive and environmental categories. Cognitive category is derived from one's inner thinking and is related

to individual characteristics, and environmental category includes factors that are imposed on one from the external environment and affect his stopping behavior. Table 1 shows a list of the most important factors affecting information search stopping behavior and studies emphasizing these factors.

Research methodology in the field of stopping behavior was based on laboratory experimental user study, analysis of users' log files and interviews (semi-structured and group). In the research studies with the approach of laboratory experiment, most of the researchers investigated the search stopping behavior based on the tasks performed by the users and identified the stopping rules used by them. Most of these research studies have focused on the factors of information sufficiency (Altiero and Baudot, 2019; Bouzdine-Chameeva et al., 2006; Browne et al., 2005, 2007; Gerhart, 2020; Gerhart and Windsor, 2017; Liu, 2019; Nickles et al., 1995; Pennington and Kelton, 2016; Pitts and Browne, 2004; White and Harding, 2008) and task (Altiero and Baudot, 2019; Bouzdine-Chameeva et al., 2006; Browne et al., 2005, 2007; Gerhart and Windsor, 2017; Liu, 2019; Nickles et al., 1995; White and Harding, 2008). These studies showed that different professionals used different stopping rules according to the

Table 1. Literature review on the factors affecting stopping behavior of information search.

Factors affecting search stopping behavior		Studies	
Cognitive factors	Information sufficiency	Agosto (2002), Altiero and Baudot (2019), Berryman (2006), Bouzdine-Chameeva et al. (2006), Browne et al. (2005, 2007), Cooper (1973), Dalton and Charnigo (2004), Dostert and Kelly (2009), Gerhart (2020), Gerhart and Windsor (2017), Kraft and Lee (1979), Liu (2019), Nickles et al. (1995), Paris (1998), Pitts and Browne (2004), Pennington and Kelton (2016), Prabha et al. (2007), Simon (1955), White and Harding (2008), Wu and Kelly (2014), Wu et al. (2014b), Zach (2005)	
	Individual characteristics	Experiences	Pennington and Kelton (2016), Pitts and Browne (2004), White and Harding (2008), Wu and Kelly (2014)
		Skills	Paris (1998) and Wu and Kelly (2014)
Environmental factors	Task	Feelings	Agosto (2002), Kantor (1987), Paris (1998), Wu and Kelly (2014), Altiero and Baudot (2019), Berryman (2006), Bouzdine-Chameeva et al. (2006), Browne et al. (2005, 2007), Gerhart and Windsor (2017), Liu (2019), Nickles et al. (1995), Paris (1998), White and Harding (2008), Wu and Kelly (2014)
		Information retrieval system	Azzopardi et al. (2011, 2013), Card et al. (2001), Keen (1992), Lorigo et al. (2008), Maxwell (2019), Ong et al. (2017), Paris (1998), Wu et al. (2014b)
	Time	Agosto (2002), Berryman (2006), Crescenzi et al. (2021), Dostert and Kelly (2009), Duff and Johnson (2002), Moody and Galletta (2015), Prabha et al. (2007), Zach (2005)	

characteristics of the search task. In the log file studies, the researchers analyzed user search stopping behavior patterns. The main finding of these studies emphasize the factors of information retrieval system (Azzopardi et al., 2011, 2013; Card et al., 2001; Lorigo et al., 2008; Maxwell, 2019; Ong et al., 2017; Wu et al., 2014b) and time (Crescenzi et al., 2021; Moody and Galletta, 2015) in search stopping behavior. Also, in most of the research studies with the interview methodology, researchers have mentioned the information sufficiency (Agosto, 2002; Berryman, 2006; Dalton and Charnigo, 2004; Dostert and Kelly, 2009; Paris, 1998; Prabha et al., 2007; Wu and Kelly, 2014; Zach, 2005), time (Agosto, 2002; Berryman, 2006; Dalton and Charnigo, 2004; Dostert and Kelly, 2009; Paris, 1998; Prabha et al., 2007; Wu and Kelly, 2014; Zach, 2005), and individual characteristics (Agosto, 2002; Paris, 1998; Wu and Kelly, 2014) as factors affecting search stopping behavior. Figure 2 shows the frequency distribution of research methodology based on the factors affecting search stopping behavior.

Factors affecting stopping behavior are reported in detail below.

Cognitive factors affecting search stopping behavior

In this section, according to literature review, the internal or cognitive factors of the individual thinking process that affect search stopping behavior are described.

Information sufficiency. One of the most important cognitive factors is an individual's internal assessment of information sufficiency (Nickles et al., 1995). In most studies

(Dalton and Charnigo, 2004; Dostert and Kelly, 2009; Wu et al., 2014b; Zach, 2005), the reason for the decision to stop the search is explained by the individual's intuition or feeling that what he or she has found is "good enough." For example, in a study by Dalton and Charnigo (2004), historians reported that "when they feel they have sufficient information to write research, they stop (halt to a research study), even if other references promise additional information." This study demonstrates the satisficing of searching for historians' information in the context of research.

Studies conducted on behavioral decision-making called heuristics used by individuals to measure information sufficiency and terminate information search as stopping rules (Nickles et al., 1995). Previous studies have shown that individuals use heuristic methods or stopping rules to terminate information search (Browne and Pitts, 2004; Busemeyer and Rapoport, 1988; Nickles et al., 1995). This section deals with the literature that focuses on the stopping rules used in information sufficiency.

The first stopping rules were proposed by Cooper (1973). He proposed two stopping rules to investigate the list of ranking results: stopping frustration rule, in which one stops after encountering a certain number of irrelevant documents; and stopping satisfaction rule, in which one stops with access to a certain number of relevant documents.

Kraft and Lee (1979) proposed three possible stopping rules used by the user for information sufficiency in terminating information search behavior. These rules are satiation, disgust, and combination rules, all of which focus on the relevance or irrelevance of the retrieved information. Satiation and disgust rules proposed by Kraft and Lee are

Table 2. A brief description of stopping rules.

	Stopping rules	Rule definition	Example
Judgment-based rules	Satisfaction (Satiation) rule	One's satisfaction of is defined in the face of the relevance of documents (Cooper, 1973; Kraft and Lee, 1979).	Stop searching after observing eight relevant documents.
	Frustration (Disgust) rule	One's tolerance of is defined in the face of non relevant documents (Cooper, 1973; Kraft and Lee, 1979).	Stop searching after observing four irrelevant documents.
	Combination rule	One should stop reviewing the documents either if he is satisfied with what is relevant or if he is frustrated with what he has identified as irrelevant (multiple criteria). In this case, he stops when one of these two conditions is first met (Kraft and Lee, 1979).	Stop searching after observing eight relevant/ four irrelevant documents.
	Difference threshold rule	One stops searching, believing that he will not learn anything new by reviewing more documents (Nickles et al., 1995).	Search for the causes of drought and stop searching after repeating the information and not learning other new causes.
	Magnitude threshold rule	One stops searching, believing that he has collected sufficient evidence (the person believes that the evidence is sufficient) (Nickles et al., 1995).	Search for physical literacy and stop searching after finding sufficient information about it.
	Single criterion rule	One stops reviewing the evidence after obtaining sufficient information about a particular criterion (usually the most important criterion) (Browne et al., 2005).	Search about hotel reservation in order to participate in the conference and stop searching after collecting information about the distance of hotels to the conference hall.
Reason-based rules	Representational stability rule	When one's mental representation of the problem does not expand and change, he stops information search (Nickles et al., 1995).	Search for a guide to working with a smart refrigerator-freezer and stop searching after understanding and learning how it works.
	Propositional stability rule	When the nature of one's conclusions from the arguments does not change, he stops information search (Nickles et al., 1995).	Search for diagnosing by the treating physician by observing the patient's tests and stopping the search after concluding about the treatment method.
	Mental list rule	One provides a mental list of items and stops obtaining information when all items in the list are verified (Nickles et al., 1995).	Search for buying a mobile phone and stop searching after finding out about internal memory capacity, RAM, screen size, weight, body structure, communication networks, features and capabilities, operating system type, price, etc.

similar to Cooper's satisfaction and frustration rules, respectively.

Some studies have investigated stopping behaviors in relation to the concept of satisficing. Simon (1955) stated that satisficing acts like stopping rules. For satisficing, the search stops when a solution is found that is sufficiently suitable in all dimensions.

Nickles et al. (1995) proposed five cognitive stopping rules to investigate information sufficiency. These rules were the mental list, magnitude threshold, difference threshold, representational stability, and propositional stability rules. Also, another rule called single criterion rule was introduced by Browne et al. (2005) and confirmed in experimental studies.

Stopping rules were first divided into two judgment- and reason-based categories, in a study by Nickles et al. (1995) and later in a study by Maxwell (2019). In judgment-oriented rules, one sets a kind of mental threshold in

the form of a major dimension and has a "running total criterion" or criterion for that dimension. When this criterion exceeds the threshold, he stops accessing additional information and completes the search. In reason-based rules, one collects evidence, makes arguments using the available information, and develops a mental representation of the problem (Nickles et al., 1995). In studies on stopping behavior, one's sense of information sufficiency can be due to the collection of good information, the tolerance of bad information, and/or both (Wu et al., 2014a).

According to the above, researchers have developed a number of stopping rules or heuristics over decades to determine information sufficiency. In order to better understand stopping rules, Table 2 briefly defines stopping rules and provides an example of each.

Many studies have been conducted aimed to identify stopping rules used to measure information sufficiency in stopping behavior of information search. In these studies,

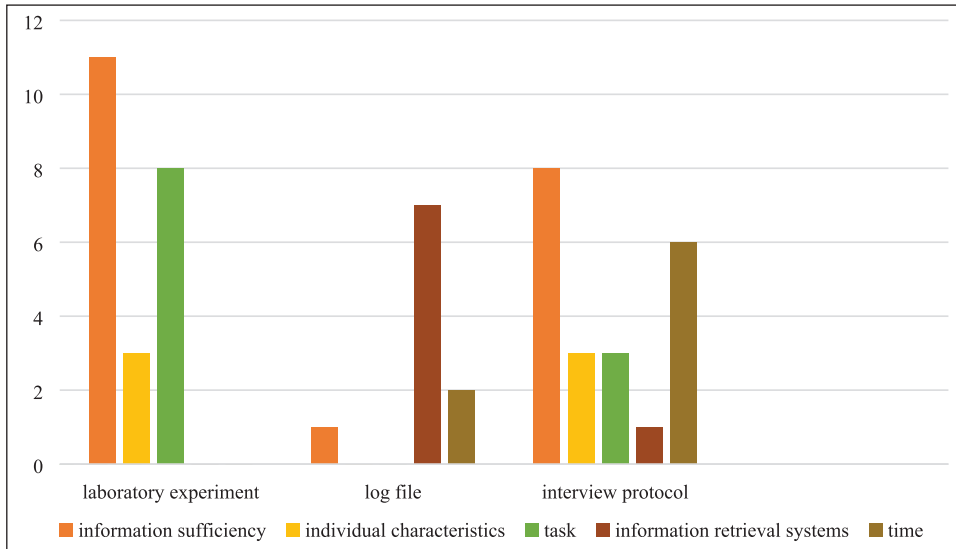


Figure 2. Frequency distribution of research methodology based on the factors affecting stopping behavior.

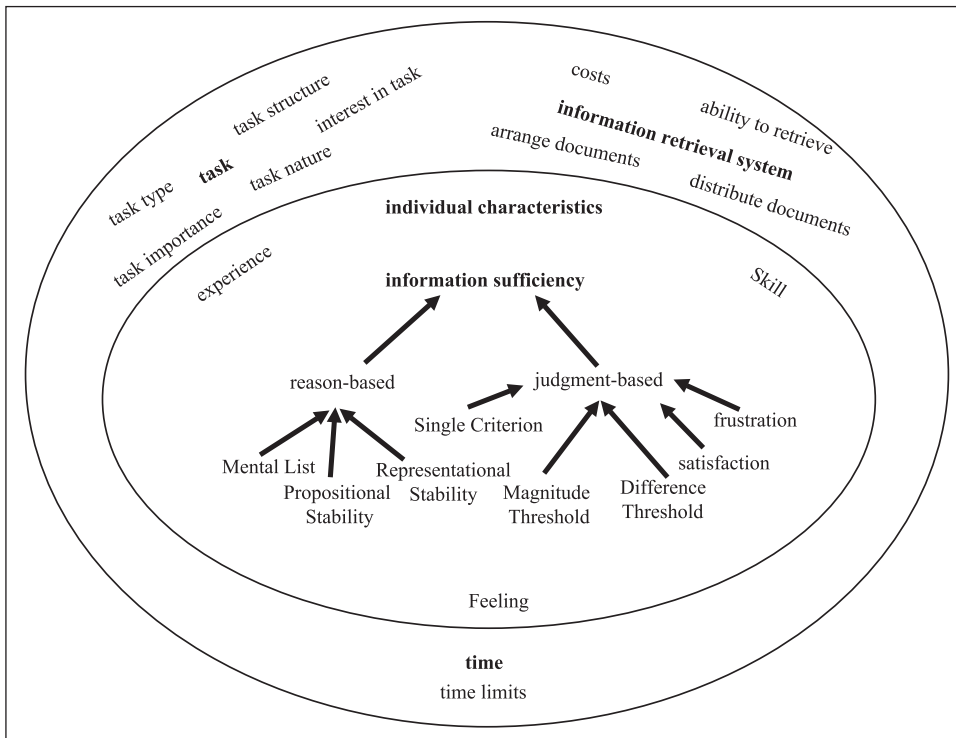


Figure 3. Layered model of factors affecting information search stopping behavior.

stopping rules have been analyzed in various professions, including students (Bouzdine-Chameeva et al., 2006; Browne et al., 2005, 2007; Gerhart, 2020; Gerhart and Windsor, 2017; Liu, 2019; Nickles et al., 1995), public sector policymakers (Berryman, 2006), system analysts (Pitts and Browne, 2004), auditors (Altiero and Baudot, 2019; White and Harding, 2008), and investors (Pennington and Kelton, 2016). All of these studies have confirmed

stopping rules defined by Nickles et al. (1995) and Browne et al. (2005).

Some studies have not explicitly mentioned information sufficiency, but by analyzing traces of satisficing behavior can be seen. A study by Prabha et al. (2007) showed an example of satisficing information needs in relation to academic tasks. In part of this study, 31 faculty members, and 47 undergraduate and graduate students were asked to

discuss the criteria for stopping research reports, preparing and delivering lectures for classrooms as examples of academic tasks. Many quantitative and qualitative criteria were described for students and faculty members to stop searching information. According to the study results, it can be inferred that quantitative criteria such as collecting the required number of citations and access to the required number of pages emphasize the concepts of satisfaction rule. Qualitative criteria such as information redundancy in several references is similar to the difference threshold rule; find a comprehensive set of information references is similar to magnitude threshold rule; search for all synonyms and any possible combinations is similar to mental list rule; find current or cutting-edge research is similar to single criterion rule; and understand the concept in doing academic tasks is similar to representational stability rule.

In a study by Agosto (2002), 9th- and 10th-grade students considered information redundancy as one of the most influential reasons for deciding to stop searching. This study showed the use of the difference threshold rule for terminating information search. In a study by Dostert and Kelly (2009), subjects including 23 graduate students reported that intuition was the main factor in their decision to stop. In addition to these factors such as of document redundancy (difference threshold rule), reduction in relevant documents (representational stability rule), increase in irrelevant documents (representational stability rule), lack of new documents (difference threshold rule), etc. were other reasons for individuals to stop. Similarly, in a study, Wu and Kelly (2014) investigated stopping behaviors of online information search by 48 employees from different departments of the university. The results of qualitative study showed that individuals used different search stopping rules (stopping point of the current search and/or starting a new one) and stopping the task (stopping point of the search). From the participants' point of view, the number of documents collected could be a criterion for determining search stopping point, which was a justification for using satisfaction and frustration rules. In addition, they used the rules of Nickles et al. (1995) and Browne et al. (2005) to terminate task. In a qualitative study on 115 health science professionals (including 71 women and 44 men), Paris (1998) provided insights into the factors affecting the user stopping. Factors such as find the information searched (similar to satisfaction rule), find no information searched (similar to frustration rule), using all possible search terms (mental list rule), and terminating the search (magnitude threshold rule) have been reported as reasons to stop search from the perspective of health science professionals.

The reviewed studies on stopping behavior showed traces of information sufficiency and the use of stopping rules for terminating information search.

Individual characteristics. Studies have shown that some individual factors such as experience, skills, and feelings

Experiences. Analysis of one's search stopping behavior in some studies showed that search experience had an effect on stopping behavior. Pitts and Browne (2004) analyzed information sufficiency collected by 54 practicing system analysts from various industries to determine a set of requirements for designing an online food purchasing system. The results showed that the analyst's experience affected search stopping behavior. In particular, experienced analysts tended to use magnitude threshold and mental list rules, while less experienced analysts tended to use difference threshold and representational stability rules. In addition, applying difference threshold rule to the task was useful for inexperienced analysts. In a study by White and Harding (2008), collected information from interviews with experienced auditors using the think aloud verbal protocol showed a relationship between task experience, the use of the mental list stopping rule, and performance in identifying risks.

The study results of Pennington and Kelton (2016) analyzing stopping behavior of 91 nonprofessional investors showed a relationship between the investor's experience and stopping rules used by him. Investors with the most investing experience used the absolute standard rule (stop after obtaining a certain amount of information or fulfilling a predetermined list of information) to stop searching. Inexperienced and/or less experienced investors used single criterion rule. In addition, investors using the absolute standard stopping rule collected more and more accurate information items than investors using difference threshold stopping rule.

How one interprets the cues or snippets of information presented on a search engine result page, understands the subject of the search, etc. are other factors that cause stopping the search (Wu and Kelly, 2014).

Skills. One's skill and ability search is one of the individual factors affecting the search termination. These are internal factors, they are formed over time and based on a person's experience and knowledge from the environment. In a study by Wu and Kelly (2014), many individuals attributed the reason for search stopping to the nature of the phrases. They changed phrases because they were unsure of the search. Some individuals also considered the reason for delaying the search stop as a useful strategy for finding suitable terms for replacement. Also in a study by Paris (1998), some individuals investigated more evidence because of a lack of confidence in their search skills. Others stopped searching because of their inability to express their information needs to the information retrieval system. Therefore, the skill of expressing the need for information, formulating the phrase and in general the skill of information search are other important factors for stopping the search.

Feelings. Kantor (1987) believed that one's strong belief

more consecutive irrelevant documents and therefore stops later. Thus, one's feelings affect his decision to stop. Frustration at finding useful information is another reason for stop search (Wu and Kelly, 2014).

In a study by Paris (1998), users believed that when they felt tired or a lot of time pressure (e.g. rushing to another appointment), they would retrieve less evidence and stop sooner. Factors such as fatigue, drowsiness, back pain, headache, and eye pain are other reasons to stop searching (Agosto, 2002).

Environmental factors affecting search stopping behavior

In this section, according to literature review, environmental factors affecting search stopping behavior are described.

Search task. Vakkari (2005) considered task as an activity that one performs in order to achieve a specific objective and motivates the search for information. The results of studies showed that task affects one's decision to stop the search. Nickles et al. (1995) were the first researchers to study the effect of task type on stopping behavior. They identified the rules that 90 students (senior management, MBA, and other graduate students) used to terminate information search in tasks of home sales and bank interest rate prediction. These tasks were tested under different experimental conditions. These experiments were: (1) familiar information versus new information, (2) alternating conclusions from information versus unanimous conclusions, and (3) contradictory information versus confirmatory information. The results showed that in Experiment 1, magnitude threshold and mental list rules; in Experiment 2, difference threshold and mental list rules; and in Experiment 3, magnitude threshold, representational stability, difference threshold, propositional stability, and mental list rules were used. Therefore, the type of task affects the search stopping behavior.

Paris (1998) addressed the effect of task on stopping the search. In this research, sense of a "futility point" referred to the number of documents retrieved that the inquirer would like to review before giving up due to frustration with his search. From the point of view of some health science professionals, futility point varied according to the subject of the search. In broader subjects, futility point increased and in rare and vague subjects, futility point reduced due to the small number of articles. In addition, the objective of the search task, the type of search task, and interest in the search task influenced futility point.

One of the important components of problem solving and decision making is task structure (Davies, 2003; Morera and Budescu, 1998; Simon, 1973). Task structure refers to one's level of recognition of inputs, operations relevant to inputs, and outputs (Browne et al., 2007; Byström and Järvelin, 1995; Simon, 1973; Vakkari, 1999).

Literature review showed that differences in the structure of tasks lead to the use of different search stopping behaviors by him. In tasks with different structures, one applies different stopping rules. In a study by Browne et al. (2005), for example, 90 undergraduate and graduate students in the M.B.A. were asked to complete a 5-megapixel camera purchase online task and then answer a questionnaire about why they stopped searching. The results showed that the participants used stopping rules of mental list and single criterion more than the other three rules. In a study, Bouzdine-Chameeva et al. (2006) investigated stopping behavior of 44 undergraduate and graduate students for deciding to wine purchase online tasks. The results showed that in the context of online purchase, most individuals used the rules of mental list and magnitude threshold. In another similar study, Browne et al. (2007) investigated the effect of the role of task on stopping behavior. In this study, 115 undergraduate and graduate students in business management completed three online search tasks, including (1) purchasing a 32-inch TV from BestBuy.com (structured and decomposed), (2) job search on Amazon.com (structured and decomposed), and (3) mapping the Battlefield of the Fallen Timbers (unstructured and holistic). The results showed that in structured and decomposed tasks, individuals used mental list and single criterion rules more than other rules. Also, in unstructured and holistic tasks, magnitude threshold and representational stability rules were used more than other rules. In a study, Gerhart and Windsor (2017) replicated the study by Browne et al. (2007) in a new information setting with new search methodologies and technologies. The results showed that in the structured tasks, the same stopping rules were used as in the main study. In unstructured tasks, individuals used magnitude threshold and difference threshold rules. This study showed that stopping rules used for unstructured tasks have changed over time. Therefore, task structure has an important effect on search stopping behavior.

In a study by Berryman (2006), 21 policy workers of Australian public sector reported that they had difficulty determining information sufficiency to perform tasks when they started. But as the task structure was formed, their stopping point became clearer. The study results were a justification for the application of stopping rules of representation stability and mental list. The study results of White and Harding (2008) showed that auditors (10 managers and 10 seniors) used a subjective model-based approach to collect evidence, understand the customer, and make decisions in situations of uncertainty. Similarly, Altiero and Baudot (2019) in a study investigated stopping behavior of auditors for evidence sufficiency through semi-structured interviews. The auditors (five directors, five senior managers, and five in-charge auditors) recalled an easy audit task and a difficult task, and were then interviewed about audit evidence sufficiency. The analysis of the interviews showed that the auditors used mental list

and magnitude threshold rules for easier judgments, and representational stability and difference threshold rules for more difficult judgments. Therefore, the degree of difficulty or ease of the task was effective on using stopping rules and terminating the search.

Studies have shown that task affects the effort made by individuals to search and the amount of information required to achieve information sufficiency. In a study by Wu and Kelly (2014), for example, participants explained that the importance of the task determined the number of documents retrieved. In unimportant tasks, one or two documents are enough to solve the problem, but in very important tasks of society, a deeper search should be made. In addition, the nature of the task affected the decisions to terminate the task. Participants in tasks that required a fair assessment of the problem sought to make an impartial decision and stopped when they felt they had a variety of information. Similarly, a study by Liu (2019) showed that more complex task structure required more time and cognitive effort to perform the task, and affected search stopping behavior. In this experimental study, four undergraduate students performed two different structured and unstructured search tasks. Participants applied different stopping rules to the three stopping behaviors mentioned. The unstructured task stopped later than the structured task. Therefore, it can be concluded that a more complex structure of the task requires more time and cognitive effort to perform the task and affects search stopping behavior.

Studies have shown that task is an important factor of search stopping behavior. Factors such as the type, the objective, the structure, the importance, the nature of the task, etc. affect the decision to stop.

Information retrieval system. Some studies have emphasized the role of satisfaction and frustration rules in search stopping and showed that the system's ability to retrieve the number of relevant documents can affect the user's persistence. These studies showed that characteristics of information retrieval systems can affect search stopping behavior. Keen (1992) believed that the likelihood of extracting relevant documents would have a greater effect on user persistence, and suggested that relevant search results could encourage the user to continue searching. In a study by Paris (1998), some users explained that their stopping behavior was influenced by the presence of relevant and up to date retrieved documents in the system. Card et al. (2001), investigated users' search stopping behavior by accurately recording their actions when searching in the browser. Research data were collected from 14 Stanford University students with a mean age of 23 years. In this study, users performed six web-based search tasks and the think-aloud protocol was used when searching. The study results showed that when the user faced a page with a lot of information scent (relevant

documents) on the site, he was more inclined to visit other pages of the site. As the scent of information on the pages of the website reduced, there was a tendency to leave the website or return to the previous pages, that is as long as the relevance of information on the website is higher than the threshold, the user continues to search the website and vice versa. In a study, Lorigo et al. (2008) investigated the search by individuals when performing tasks. Visual tracking data of 23 undergraduate students (14 men and 9 women) at Cornell University in the age group of 18–23 years were analyzed. Each participant performed 10 search tasks with different degrees of difficulty and types of tasks (informational and navigational tasks). The results of data analysis from 437 searches indicated that the individual, based on the relevance of the first results, decided to stop the search and/or start a new one.

The way documents are displayed in the information retrieval system had an effect on stopping the search. In a laboratory study by Wu et al. (2014b), 48 participants were asked to perform six search tasks. Participants were exposed to different search engine result pages (SERP) with different distributions and numbers of relevant results. The results showed that search stopping depended on the first search engine result page. When the first search engine result page contained more relevant results, participants searched for more documents and, in the search results list, searched more deeply and stopped search later. In addition, when there were fewer relevant results or relevant results were displayed in lower rankings, participants were more likely to stop the search. Therefore, the perceived quality of search results had a significant effect on search stop. Ong et al. (2017) repeated the experiment by Wu et al. (2014b) with two groups of 36 participants in desktop and mobile settings. Similar results were obtained from this study.

The costs of using the information retrieval system affect one's decision to stop the search. For example, a study by Azzopardi et al. (2011, 2013) showed that by increasing the search cost in the user interface compared to the standard user interface, individuals had fewer searches to the user interface and reviewed more documents per search. Therefore, the depth of the review of the documents and stopping of the search was affected by its cost. According to the study results, when the retrieval system fails to retrieve relevant items in the top 10 results, individuals review less documents and stop.

In part of a study, Maxwell (2019) investigated search stopping behavior in different search contexts. By studying behaviors of 48 users, he analyzed the effect of summary of results and type of information retrieval systems on stopping behaviors. The results showed that as the summary of results increased, users became more confident in their decision about linking documents, but their accuracy in identifying content relevant to longer summaries did not improve. They also investigated less results per search,

which may be due to the increased time spent reviewing the summary by the user. In addition, users had more searches when using a diversified information retrieval system than a non-diversified information retrieval system, and investigated less results in each search and stopped.

Therefore, it can be said that the characteristics of the information retrieval system such as the system's ability to retrieve relevant information, how to arrange and distribute retrieved documents, costs of the retrieval system, the thematic coverage of the retrieval system, etc. affected search stopping behavior (search redesign, pagination, and depth).

Time. Another environmental factor affecting search stopping behavior is time. In a study by Zach (2005), senior art executives believed that time limits, especially for issues that have a significant potential effect on the organization, played an important role in stopping behavior. A study with a similar approach to that of Zach (2005) was conducted by Berryman (2006). In this study, time limits in decision-making imposed a lot of stress on policy workers. A study by Duff and Johnson (2002) on historians' information search behaviors showed that for the historian, time was an important limit of information collection and thus search stopping.

Analyzing adolescents' decision-making abilities for web-based search, Agosto (2002) reported that self-imposed time limits were one of the reasons adolescents terminated their search. In a study by Prabha et al. (2007), from the perspective of university members, the time limit for preparing assignments, lectures, presentations, designing and holding workshops, and meeting scientific and research needs was influential in the decision to stop the search. The important result of this study was that the quantitative criterion of time limit reduced the number of documents studied by academic users and thus stopped information search. In another study by Dostert and Kelly (2009), stopping behavior of 23 graduate students under time limits was examined. The subjects reported that they felt sufficient about the number of documents collected due to their understanding of the elapsed time. Therefore, individuals' perception of search time may affect stopping.

In part of a study by Moody and Galletta (2015), the effect of time limits on search performance (number of tasks performed successfully) was investigated. In this study, 119 subjects from basic psychology and information systems courses were selected and performed a total of 10 search tasks in two online stores (five search tasks in each store). The results showed that time limits limited one's cognitive capacity as well as the scope of exploration and led to non-optimal performance of information retrieval. In a study by Crescenzi et al. (2021), the effect of time limits on information search behavior was investigated. In

this study, 48 participants, including staff, faculty members, and university students, performed six decision-making tasks. The results showed that participants decided faster in the absence of such time limits in the presence of such time limits. The number of searches was higher in terms of time limits, and individuals observed fewer documents.

The results of these studies indicate that individuals adapt their search process to time limits and time is one of the factors affecting search stopping behavior of individuals.

Discussion

Studies on stopping behavior pointed to the factors affecting search stop. Studies have shown that analysis of search stopping behavior is complex (Browne and Walden, 2021) and depends on several factors. In general, these factors can be classified into two cognitive and environmental categories. Cognitive factors include one's internal causes derived from inner thinking. Information sufficiency and individual factors are cognitive factors affecting search stopping behavior. Environmental factors include external causes that can be imposed on a person and affect his stopping behavior. Search task, information retrieval system characteristics, and time are environmental factors affecting search stopping behavior.

In most studies on stopping behavior, there is a trace of information sufficiency while searching for information. It stops when one feels satisfied with what one has found in the process of information search (Nickles et al., 1995). He uses various heuristics or stopping rules to terminate information search. The emphasis of research on factor of information sufficiency indicates that the most important cognitive factor of stopping the search is information sufficiency. If we plot the factors affecting stopping behavior as model, information sufficiency can be thought of as the fundamental factor of stopping the search. The next cognitive factor affecting search stopping behavior is individual factors. Individual factors are personal abilities and feelings affecting one's decision to stop. For example, one's experiences (Pennington and Kelton, 2016), skills (Paris, 1998), knowledge, understanding of information search task (Wu and Kelly, 2014), and different feelings such as fatigue, back pain, etc. (Agosto, 2002). are individual factors affecting information search stopping behavior and affect information sufficiency. Another category of factors that can affect search stopping behavior are environmental factors. Environmental factors are the conditions under which one should act. One of the most important environmental factors is the task. Task is the scenario in which one collects information and stops. Literature review showed that the search task with different characteristics (type, objective, structure, degree of importance, and nature) leads to the use of different stopping rules and plays an

important role in stopping the search (Browne et al., 2007). Another environmental factor is the information retrieval system. Information retrieval system characteristics such as how to arrange and distribute documents are in this category (Wu et al., 2014b). Time is another environmental component that affects stopping behavior (Zach, 2005). Figure 3 shows the model of the cognitive and environmental factors affecting search stopping behavior. In this model, a transition from cognitive factors to environmental factors is observed. In the inner part of the model, one's cognitive thinking dominates and in the outer part of the model, environmental factors that are imposed on the person and affect his stopping behavior become apparent.

Conclusion

Many studies have been conducted to understand information search stopping behavior. A small number of these studies have considered search stopping behavior and the factors affecting it. This study has systematically reviewed studies conducted in this field, identified the most important factors affecting search stopping behavior, classified them from the perspective of cognitive and environmental factors and presented a model of factors affecting search stopping behavior. This research has depicted a more comprehensive representation of the stopping behavior by factors analysis of affecting the search stopping behavior.

Various cognitive and environmental factors influence the search stopping behavior. Studies have only briefly mentioned the factors affecting stopping behavior and there is no comprehensive and complete classification of these factors. For example, research studies have not paid attention to the effect of demographic characteristics (gender, education level, language, age), cognitive styles, information processing styles, decision making styles, thinking styles, mental models, etc. Therefore, more studies are needed in order to identify other factors affecting on the search stopping behavior. Identifying these factors can be used in redesigning information seeking behavior models (theoretically) and information retrieval systems (practically).

In the field of stopping behavior, many studies have been conducted on information sufficiency and the application of stopping rules in different contexts. But it is not yet possible to say exactly how much each of the cognitive and environmental factors affect search stopping behavior and motivate which the stopping rule. In addition, cognitive and environmental factors affecting search stopping behavior interact and affect each other. Different environments may have different factors affecting one's search stopping behavior, and, in the same environment, different individuals may have different search stopping behaviors. Therefore, it is important to conduct empirical studies that test the effect of these factors. In addition, the analysis of these factors can explain the variety of stopping rules used by a person.

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