Search Engine User Behavior – A Research Proposal

Alexandra HUȚANU
Alexandru Ioan Cuza University of Iasi
11 Carol I Blvd., 700506 Iasi, Romania
hutanu.alexandra25@gmail.com

Patricea-Elena BERTEA
Alexandru Ioan Cuza University of Iasi
11 Carol I Blvd., 700506 Iasi, Romania
patricia.bertea@gmail.com

Abstract. *Mobile devices have become an integrated part of our lives in the last few years, being used in any context, sometimes even as a mean to alleviate boredom. More than 5 years ago, mobile traffic surpassed desktop traffic for the first time, the trend only increasing over the years. One main activity performed on mobile devices is web search. Further research has identified that mobile web search is different than desktop web search. On mobile, users have to cope with a smaller screen size, can perform different touch interaction such as swiping and zooming, can search on the go and cannot compare information with ease. Previous research found that mobile web search involves higher cognitive load. Taking this into consideration and the fragmented attention that web search performed on mobile devices receives when searching on the go, there is a need to design search engine results pages that can respond to these requirements. Moreover, when designing SERP for mobile search, page fold plays an important role. Snippet length influences how many results are showed on the page fold and how users behave while examining them. Current paid ads can lead to situations in which only one result occupies the whole first screen. Also, when analyzing web search behavior performed on any device, user biases need to be accounted for. Users do not choose a result only due to its relevance, but because of position bias, attractiveness bias, domain bias and other biases. This article aims to contribute to the body of literature about mobile web search and to develop research questions and a methodology for studying them. We identified the need to study web search for transactional tasks, because most of the literature was developed around informational and navigational tasks. Transactional tasks are more complicated in nature, because they imply other actions on websites, after examining the SERP.*

Keywords: *mobile web search; search behavior; SERP; search engine.*

Introduction

Web search is a major activity performed by users on the internet, on many devices and on every kind of context. Worldwide, the number of daily searches on Google is over 3.5 billion (Mangles, 2018). Just a few years ago they were made on desktop devices, but since 2015, most of them come from mobile devices. The year 2015 was the year when Google first announced that, in 10 countries, the search volume on desktop was surpassed by the one coming from mobile (Word Stream, 2016). Taking this into consideration, it is important to understand how mobile search behavior differs from desktop search behavior. First of all, the size screen on mobile is much smaller. Second of all, the interaction with the search interface is done through different touch actions, such as swiping, zooming, on-screen text input (Mao, Luo, Zhang, & Ma, 2018). Lastly, mobile devices are used in different contexts (while walking, while watching TV, while being with friends) and have a higher need of an immediate satisfaction to the information need, also due to higher cognitive load.

In this article, we will review the body of literature regarding web search behavior, with a focus on mobile search, and analyze the biases in web search. After, we will develop some research questions for further analysis and the methodology.

Taxonomy of web search

The first taxonomy of web search was done in 2002 by Broder. He defined three types of web search queries: *informational* queries – performed when the user wants to find some information; *navigational* queries – performed when the user wants to find a particular website and which have only one "correct" answer; *transactional* queries – that imply other actions on a website in order to finish a task (e.g.: download, online shopping, accessing data base) (Broder, 2002). An extensive research body showed that informational queries require more cognitive effort, implying longer task duration (Buscher, Dumais, & Cutrell, 2010; Cutrell & Guan, 2007; Kim, Thomas, Sankaranarayana, Gedeon, & Yoon, 2017; Sachse, 2019), a higher number of fixations and viewed results (Kim, Thomas, Sankaranarayana, Gedeon, & Yoon, 2017, Sachse, 2019), more scrolling (Kim, Thomas, Sankaranarayana, Gedeon, & Yoon, 2017), higher rates of first scrolls, clicks and jumps, faster reach to lower-ranked results, less lower-ranked results viewed, and longer fixations (Sachse, 2019). Cognitive load means mental effort in the working memory. The working memory has limited capacity, according to Cognitive Load Theory (Paas, Renkl, & Sweller, 2004). Cognitive load is usually higher if the search is performed on mobile devices.

Klöckner et al. (2004) defined two types of search strategies: users who adopt the *depth-first* strategy tend to click immediately when they identify a relevant result. The *breath-first* strategy implies that users first examine all results and after click on one of them (Klöckner, Wirschum, & Jameson, 2004). One year later, Aula et al. (2005) defined examining only the top results *economic* strategy and viewing lower results *exhaustive* strategy (Aula, Majaranta, & Räihä, 2005).

Mobile web search

Compared with desktop devices, mobile devices have reduced screen size. During web search on mobile, it is more difficult for users to extract information and to compare it. Also, users show less eye movements and take longer time to complete a task. As mentioned, in mobile search, interacting with the search interface involves some touch actions, such as swiping, zooming, on-screen text input (Mao, Luo, Zhang, & Ma, 2018). Vertical scrolling has been compared with horizontal scrolling (pagination) by Kim et al. (2016). Using eye tracking on mobile devices, they found that vertical scrolling leads to more time spent on the SER and more time for identifying the correct result. This additional time is needed to manage the interface and not to read, thus being considered "not productive" time. Compared to horizontal search, vertical search involves five times more finger actions, leading to a lower search speed. Although the standard mobile search is vertical, it was demonstrated that pagination leads to better search accuracy and more results read on the back page for lower-ranked results, without affecting higher-ranked ones (Kim, Thomas, Sankaranarayana, Gedeon, & Yoon, 2016). One clarification needs to be mentioned regarding this study: we consider that horizontal search (swipe right and swipe left) is different from pagination. In pagination, to reach a further page, one needs to press a button, marked usually with [1], [2] etc., located at the end of the page, after scrolling down. Horizontal search would mean changing the result pages by only swiping left or right. In the above mentioned study, there is no such difference between pagination and horizontal search. We considered that further research should be done in this matter, especially due to the popularity of Tinder, the dating mobile application that uses a binary system of swiping left or right. The worldwide adoption of this app could have led to changes in mobile user behavior.

Taking into consideration that mobile search involves touch interactions and that many web search models consider only the clicks, Williams et al. (2016) developed a click-less model that accounts for touch, swipe and reading actions. They studied good abandonment, which appears when a user is directly satisfied by the result (the snippet) and abandons the SERP without any further actions. Good abandonment appears more on mobile than desktop and is the opposite of bad abandonment, which means the abandonment of the SERP because of being dissatisfied with the results (snippets) (Song, Shi, White, & Hassan, 2014). William et al. found that swiping and interacting with organic results indicate bad abandonment, while extensive reading interactions suggest good abandonment. Also, the more time users spend touching the SERP interface, the less likely it is that they are satisfied with the results (Williams, Kiseleva, Crook, Zitouni, Awadallah, & Khabsa, 2016).

Another differentiation between desktop and mobile search is the fragmented attention paid on mobile (Harvey & Pointon, 2017). People use mobile phones in different contexts: while they are moving, in social contexts, as a remedy against boredom or just as a mean to occupy free time. Therefore, most of the times,

the attention paid while searching on mobile is shared between walking, talking or other activities. The distractions can decrease effectiveness in interacting with the UI (Bragdon, Nelson, Li, & Hinckley, 2011) and even in the way they perceive the difficulty of tasks (Crescenzi, Kelly, & Azzopardi, 2015). This leads to misspelled search queries and leads to the tendency to shorten search queries (Schaller, Harvey, & Elsweiler, 2012). With increased cognitive load, people searching on mobile devices even experience subconscious changes on how they walk – they lower the pace, tend to decrease the cognitive load or try a combination of these two (Licence, Smith, McGuigan, & Earnest, 2015). The error rate increases as walking speed does (Nicolau & Jorge, 2012). Mizobuchi et al. (2005) even showed that text entry is the primary source of cognitive load in mobile search and the second is walking speed (Mizobuchi, Chignell, & Newton, 2005). However, this study was conducted in 2005, when the mobile devices were not integrated in users' lifestyles as they are now.

Harvey and Pointon (2017) conducted a lab experiment with 24 participants, trying to understand how distractions affect web search. They asked the participants to search either on a mobile phone or on a larger tablet while walking on a treadmill, navigating through an environment with obstacles or just by seating, without any distractions. They found that the subjects felt significantly more rushed when searching on the phone, and that they perceived the tasks to be more difficult, even though the performance recorded on both devices was similar. Regarding the level of satisfaction, the participants who searched on mobile felt significantly less satisfied about the information they found than those who used the tablet. Also, participants who were assigned on the obstacle course felt less absorbed in the task, having to divide their attention on both cognitive and motor abilities (Harvey & Pointon, 2017). These findings are important when designing mobile search interfaces. Researchers should take into consideration the issue of fragmented attention and try to design interfaces that reduce cognitive load, especially when a walking-like motion is detected.

Wang et al. (2018) analyzed real search log from mobile devices and discovered that users have the tendency to examine the first results more in the initial viewport. Viewport is the visible portion of a web page (Wang, Su, He, Liu, & Ma, 2018). When users do not end the search immediately after examining the top results, they have a higher probability of examining the following results. However, revisiting results is not usual on mobile search. Regarding the bottom results of the SERP, they discovered that users are not sensitive to their position. Also, they suggest that 5 seconds are enough for a user to examine a result. These findings contribute to web search methodology, because a result can be considered examined if viewed for 5 seconds. Also, this 5 seconds threshold can suggest that a user can have a higher probability to click on a result. However, on the contrary, it can suggest the abandonment of the SERP without clicking, because the snippet can provide enough information to satisfy the information need, leading to good abandonment. Also, clicked results get longer examination duration. Therefore, by analyzing the examination duration of a result, it could be predicted if a user will click on it. Wang et al. also confirmed the position bias (Wang, Su, He, Liu, & Ma, 2018).

Because mobile devices have limited size to display the search results, the snippet length should be optimal in space. But here, a dilemma arises – should the snippet length be longer, to contain more information but occupy more space, meaning less results seen above the fold and more scrolling, or should it be shorter, to optimize space, but offer less information? Sachse (2019) conducted an eye tracking study on mobile devices and with 31 participants, in order to understand which length provides the best user experience. Using only organic results, she varied in the experiment three snippet lengths – short, with one line, medium, with three lines, and long, with five lines, and two types of tasks – navigational and informational. For navigational tasks, she found that long snippets improve user experience and decrease task duration. For informational tasks, long snippets lead to more fixations, more jumps and more results viewed. However, medium snippets are preferred in this case, the search being more efficient. In both types of tasks, short snippets received more fixations, suggesting higher cognitive load, and encourage users to use the exhaustive strategy (Aula, Majaranta, & Räihä, 2005), viewing lower-ranked results earlier and being less likely to jump backward and forward among the first search results before considering the lower ones. Also, when asked, the participants said that the short snippets provide too little information (Sachse, 2019).

This study is insightful in how users generally search on mobile devices. In more than half of searches (54.8%), scrolling is the first user action and not a click. This research supports the findings of Djamasbi et al. (2013), who found trough an eye tracking analysis that scrolling is the first preferred action for most users and that one third of them chose click as a first action (Djamasbi, Hall-Phillips, & Yang, 2013). Additionally, in Sachse's study, there was a slight difference in task type – for informational tasks, 60.7%

preferred scrolling as a first action, while for navigational tasks, users preferred to click first. If for navigation tasks, 60.93% of users clicked on the first four results, for informational tasks, the percentage was only 39.07%, suggesting that users prefer to examine more results in informational tasks and confirming that these type of tasks require more mental effort. Also, it was demonstrated that most of the users ended their search after they clicked on one result (69.31%). When users find a result to be relevant, they stop examining the other results and tend to click on that one considered relevant. If, however, they do not click on the result, they continue to analyze another one or two lower results before returning to the relevant one. Also, this study confirmed that users scan the SERP from top to bottom, in linear order and use the economic strategy (Aula, Majaranta, & Räihä, 2005). Moreover, the number of fixations decreases as rank result increases. The lowest rank viewed is the second result (25.85%), followed by the first one (18.37%), the third one (13.61%) and the forth one (10.88%). But the last rank viewed is influenced by snippet length. In the case of short snippets, the first and third results are equally often the lowest rank viewed. In the case of medium and long snippets, the second result, then the first result is the lowest rank viewed. In the case of long snippets, the second result is the lowest rank viewed more often than with medium snippets.

The study illustrates also the importance of page fold on attention distribution. The snippet length greatly influences the number of results showed on the first screen. Users examine all visible results on the first screen and tend to scroll in order to read the result that is partially visible, the preferred position on mobile screens being around the middle (Lagun, Hsieh, Webster, & Navalpakkam, 2014). This is why, for shorter snippets, the third result is more valuable and leads users to read also the forth result. Furthermore, the first and the second result for short snippets receive lower fixations than for medium and long snippets. As snippet length increases, the number of results viewed decreases. However, Lagun et al. (2014) found in an eye tracking and viewport study that the second link receives more attention on mobile and that the reading pattern is different from desktop, where results are analyzed in a top-to-bottom pattern (Lagun, Hsieh, Webster, & Navalpakkam, 2014). Regarding the study conducted by Sachse, only organic results were analyzed. Further research should be conducted to account for paid ads, especially for the situation in which, because of their extensions, the ads occupy the whole page fold, as in the image below.

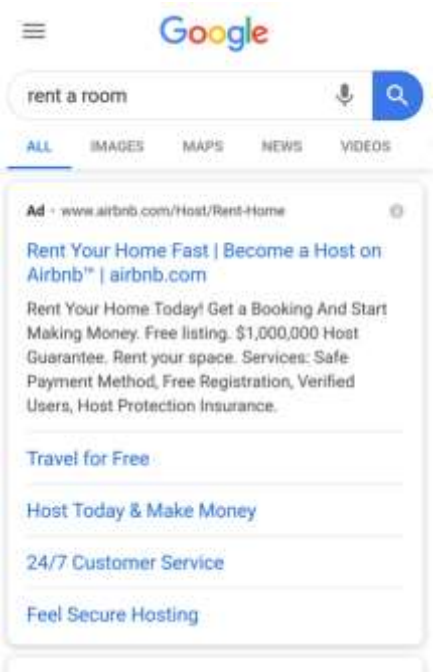

Figure 1. *Example of paid result that occupies the whole page fold*

Regarding search strategies used on mobile, depth-first strategy is applied more often on mobile devices than on desktop (Kim, Thomas, Sankaranarayana, Gedeon, & Yoon, 2015, Klöckner, Wirschum, & Jameson, 2004). Most probably, this strategy is used because of the number of results showed on the screen (Sachse, 2019).

Biases in web search

In the domain of information retrieval, biases happen *where searchers seek or are presented with information that significantly deviates from true likelihoods* (White, 2013). Therefore, biases strongly influence the way users analyze search results and click on them for reasons beyond relevance. The most famous and studied bias is the *position* or *trust* bias, which determines users to click more on higher-ranked results. Because the users trust the search engine and the retrieval function, they believe that higher-ranked results are more relevant (Joachims, Granka, Pan, Hembrooke, & Gay, 2005). Users have this bias on both mobile and desktop devices (Kim, Thomas, Sankaranarayana, Gedeon, & Yoon, 2015).

The *attractiveness* or *presentation* bias says that users click on results that seem to be relevant. For example, bolded words can make a result seem attractive (Yue, Patel, & Roehrig, 2010). Attractiveness is not equal with relevance. Attractiveness represents perceived relevance.

Another type of bias is *reputation* bias. The reputation bias implies that well-known sites are considered favorably by the users. Ieong et al. (2012) later introduced a very similar bias – *domain* bias, which makes users believe that a certain page is more relevant because it belongs to a particular web domain they trust or one that is reputable (Ieong, Mishra, Sadikov, & Zhang, 2012).

The *click necessity* bias says that some search results have low click necessity, because they can directly satisfy the need of information of the user without requiring any click (Mao, Luo, Zhang, & Ma, 2018). Here is the case for instant-answer results, such as rich results, answer boxes and knowledge graph. The *examination satisfaction* bias appears when a user leaves the SERP feeling satisfied, after examining a result that is attractive and has low click necessity (Mao, Luo, Zhang, & Ma, 2018).

White (2013) demonstrated that people tend to select positive results in favor of negative ones and that they seek to confirm their beliefs when searching (White, 2013). *Bias against ads* says that people tend to ignore paid results (Buscher, Dumais, & Cutrell, 2010).

Research questions and proposed methodology

Taking into consideration the importance of mobile web search, we aim to conduct a study for answering the following research questions:

- What factors determine mobile web search behavior to be different than desktop search behavior?
- Do users hold biases when examining search results on mobile? If so, what are the biases?
- Is the behavior towards organic results and paid results different on mobile?
- Is scrolling beneficial on mobile web search?
- How do users evaluate results in transactional tasks on mobile?

The methodology proposed to answer these research questions is an eye tracking experiment conducted in a lab, followed by retrospective think aloud method (RTA). This method is a verbal reporting technique, an alternative to think aloud method (TA). The disadvantage of TA is that it can lead to increased cognitive load, because the subjects are asked to verbally report their intentions and thoughts while completing the task (Brand-Gruwel, Kammerer, van Meeuwen, & van Gog, 2017). RTA is a better alternative which aims to decrease cognitive load by asking the participants to report their behavior after completing the task.

Because we want to focus on web search in e-commerce, we will give each participant one transactional task and we will record the eye movements during solving the task with a Tobii Pro X2-30 device. For the RTA method, we aim to show each participant, immediately after completing the task, the recording of their eye movements and ask them to verbally explain their actions.

Conclusions

This study aims to contribute to the body of literature regarding mobile web search behavior. Previous researches show that mobile web search is different than desktop web search. Good abandonment is more likely to appear while searching from mobile devices. On mobile, the viewport (the information displayed

on the first screen) can influence user behavior. There are cases when the viewport displays only one ad, if the ad contains many extensions. At the same time, the viewport is affected by the snippet length. Also, on mobile, touch interactions are different. There is more scrolling on mobile, and there are more situations in which the first user interaction is scrolling and not clicking.

With the continuous integration of mobile devices in everyday life and in any context, there is a need to further understand this behavior. Until now, most of the studies are developed around informational and navigational tasks. Transactional tasks, being so complex in nature, are not completely understood and studied. Analyzing user behavior in transactional tasks across devices would help specialists in understanding a complete user flow and designing efficient web search interfaces on both types of devices, interfaces that offer a continuous, uninterrupted experience to users. Also, marketers and business owners could better develop online strategies and decide whether to invest in paid ads or in SEO.

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