Perceptions of the effect of fragmented attention on mobile web search tasks

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ABSTRACT

Mobile devices are rapidly becoming our main method of accessing the Internet and are frequently used to perform on-the-go search tasks. The use of such devices in situations where attention must be divided, such as when walking, are common and research suggests that this increases cognitive load and, therefore, may have an impact on performance.

In this work we conducted a laboratory experiment with both phone and tablet devices with the aim of evaluating common mobile situations that cause; fragmented attention, impact search performance and impact on user perception. To do this the distraction level was varied by simulating 3 everyday situations: 1) walking quickly (on a treadmill), 2) navigating a pre-defined route and 3) sitting still (which was used as the baseline condition). The results showed that different experimental conditions had a number of different effects on the participants' perceptions of their own search performance, how hurried they felt and how engaged they were in the tasks.

Keywords

mobile search, fragmented attention, search experience, cognition, user study, experimentation

1. INTRODUCTION

Two-thirds of Americans own a smart phone device, 97% of whom use them to access the Internet. These devices "serve as an essential connection to the broader world of online information" [13] and are used by around half of all users for everyday Information Retrieval (IR) tasks such as searching for real estate, jobs and getting information about health problems and government services [13]. People use mobile devices to search the web almost as frequently as desktop and laptop computers and often do this on public transport, while walking from place to place [4, 8, 11] or in social contexts where the presence of others can act as a distraction [2]. Interaction with such devices is commonly achieved via touch screens upon which relatively small "soft buttons" are drawn for users to select items and input text. While these buttons may be easy to accurately press in an *ideal environment*, such as when seated, such small and non-tactile targets may be much more difficult to interact with in other situations [1].

Indeed, distractions during walking, driving, and other real-world interactions can preoccupy users [10], reducing their effectiveness in interacting with the UI [8, 1], resulting in a larger number of misspelled queries and an attempt by users to shorten queries when searching [12, 11]. Walking whilst using a mobile device requires both cognitive and motor abilities and users must divide their attention between the two tasks [6]. This means either an increase in cognitive load, a decrease in pace, a decrease in task performance or a combination of these [7].

A large body of work has investigated how fragmented attention affects user input on mobile devices. Early work investigated how attention is diverted from the interface when following a pre-defined, but otherwise uncontrolled, route through a city and found significant impairment when compared with a "non-social laboratory condition" [10]. In a more controlled set of experiments, Lin et al. [8] demonstrated that error rates of stylus input significantly increased as the amount of distraction, and thus degree of attention fragmentation, increased. Similar effects were demonstrated for touch-based input, with error rates increasing with walking speed [9]. Delays and time pressures, which may be induced by increased levels of distraction and input error rate, have a significant impact on search behaviour and objective performance [3]. Large-scale analysis of mobile search logs [5] has shown that the significant increase in time cost for mobile searches deters some types of search behaviour, such as exploratory search, and causes search sessions to be considerably shorter than in desktop search.

In contrast to previous work, we intend to focus on how different levels of fragmented attention impact on user performance on specific search tasks and on the participants' perceptions of this impact. Does the change in context have an effect on user *behaviour* and is this something that users themselves are aware of? To ensure repeatability, our study is conducted in a lab with simulated contexts, including on a treadmill and navigating an obstacle course. As people frequently also use tablets to access the web on the go, we conduct experiments with both tablet and phone devices.

Our main research questions are:

- Do common mobile situations that cause fragmented attention have an impact on search performance and

Conference'10, Month1-2, 2010, City, State, Country.

DOI: http://dx.doi.org/10.1145/2766462.2767731.

how do users perceive this?

- Do these perceptions differ as the task becomes more difficult/attention becomes more fragmented?
- What effect, if any, do the different environments have on user search behaviour?

2. METHOD

We conducted a laboratory experiment with 19 participants drawn from a large European University (a mixture of academic staff, support staff and post-graduate students), of whom 10 were male and who had a modal age range between 25 and 30. There were two independent variables: the type of *device* (tablet or phone) and the level of *distraction*. The distraction level was varied by simulating 2 everyday situations experienced by mobile device users: walking quickly on a treadmill and navigating an environment with obstacles (a pre-defined obstacle course), as well as a baseline condition in which the participant was seated. Distraction level was a between-subjects variable, while device type was within-subjects.

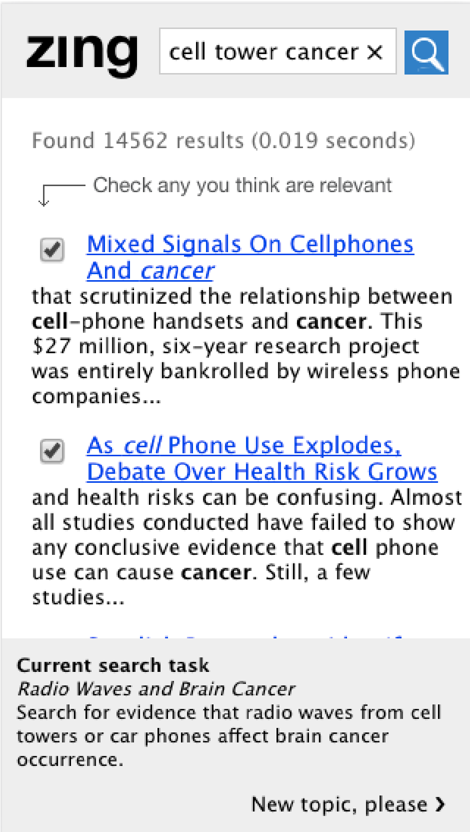

Figure 1: zing search interface on an Apple iPhone 5. Checkboxes used to indicate relevance.

We developed a simple mobile search interface named *zing*, shown in Figure 1, which mimics a standard SE interface by showing 10 links in descending order of relevance together with snippets for each. The interface allowed participants to enter search terms and indicate (via checkboxes) which documents they thought were relevant. It showed the current task (TREC topic) at the bottom of the screen and allowed participants to progress to the next topic at any time. The interface also prompted users to fill in pre- and post-topic questionnaires to survey their perceptions about the task and their self-assessed post-task performance, satisfaction, perceived time pressure and focus/involvement on the task. Half of the participants completed their first 2 topics on a phone, moving on to the tablet for their final 2 topics, while the other half began with the tablet.

We used a standard test collection: AQUAINT[1] together with the 50 TREC 2005 Robust track topics, of which 4[2] were randomly chosen from a subset of those which are neither too difficult nor too easy. Indexing and searching was provided by Apache SOLR[3]. Each participant was given the same 4 topics (tasks) in a random order with a per-task time limit of 15 minutes and alternated between the two *device* conditions. Participants were asked to imagine they wanted to learn more about the subject of each topic for a short report and were requested to select 3-5 documents they thought were relevant. Participant actions and behaviour was recorded by means of a GoPro camera worn on the head, a wide-angle view of the obstacle course and by recording all interactions with the touchscreen and interface (Figure 2).

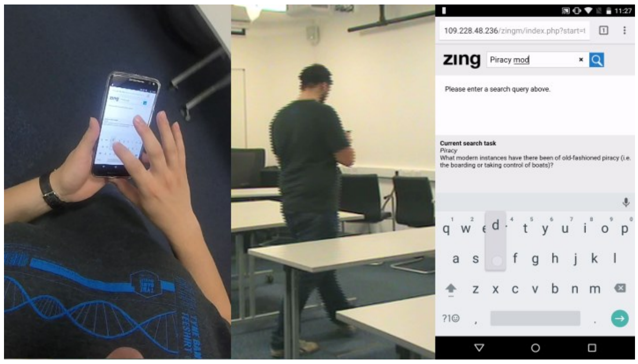

Figure 2: Example of data recorded via the cameras and screen recording software. Note that information from all 3 sources is temporally synced.

3. RESULTS

3.1 Pre-study questionnaire

Before being told anything about the experiment, participants were asked to fill in a short pre-study questionnaire asking them about their use of mobile devices and search engines as well as how difficult they would expect it to be to search on a phone or a tablet in various contexts.

All but 1 participant uses a mobile device several times a day, 14 use it at least once per day whilst walking and all but 3 use it to search the web on a daily basis. Participants generally expected that using both devices whilst walking on a treadmill would be more difficult than sitting still and navigating an obstacle course even more so (median responses: “very easy,” “difficult” and “difficult” respectively) . As participant age increased, the expected difficulty

[1]We removed duplicate documents in a pre-processing step, to provide a better and more familiar user experience.
[2]Topics 362, 367, 404 and 638.
[3]http://lucene.apache.org/solr/

of using a tablet on a treadmill (R-squared: 0.2359, p-value: 0.02) and when navigating an obstacle course (R-squared: 0.124, p-value: 0.077) increased, however this was not the case for phones or for use when sitting still. The more confident people were at using search engines in general, the easier they expected the task to be on the treadmill (p-value: 0.018) and obstacle course (p-value: 0.017), however this did not seem to be the case for sitting still.

3.2 Pre-task perception

Before each task (topic), participants filled in a questionnaire about their prior knowledge of the topic, their interest in it and how difficult they expected the task to be (overall difficulty, difficulty in finding relevant documents, and difficulty in knowing when to finish). There was little variation in the responses between the topics with most people stating that they had fairly little prior knowledge and were moderately interested in the topics. There was only a single instance where a participant was unsure of how to complete the task and in only 14% of cases was a topic deemed to be either very difficult or very easy. As expected, responses to all 3 questions on perceived task difficulty were all significantly correlated with each other (pairwise correlations: Q4-Q5=0.63, Q4-Q6=0.33, Q5-Q6=0.3).

Condition	Sitting	Obstacles	Treadmill
Overall difficulty	2.3	3.0	3.6
Finding rel. docs.	2.5	2.5	3.0
When to finish	2.9	3.2	3.9

Table 1: Mean responses about task difficulty from pre-task questionnaires by condition.

It seems that participants took experimental condition into account when estimating the difficulty of tasks as there were differences in the perceived difficulty of tasks, as shown in Table 1. Those who knew they would be sitting still expected the tasks to be significantly easier than those who were navigating the obstacle course and both thought it would be significantly easier than those on the treadmill. Those who were sitting still and those on the obstacle course thought finding relevant documents would be equally easy, however those on the treadmill expected this to be significantly more difficult. There were no significant differences in perceived task clarity between any of the groups, although those in the baseline group did claim to know more about the topic a priori than those in the other groups.

3.3 Post-task perception

#	Question
Q1	I felt hurried or rushed when completing this task
Q2	It was important to complete this task quickly
Q3	Overall, I thought this was a difficult task
Q4	I am satisfied with steps I took to find information
Q5	I forgot my immediate surroundings during the task
Q6	I was so involved that I ignored everything around me
Q7	I was so involved that I lost track of time
Q8	I was was absorbed in my search task

Table 2: Selected post-task questions.

Immediately after each task participants filled in a post-task questionnaire (see Table 2 for questions). There were significant differences in terms of perceived difficulty between the 4 topics with 2 topics scoring a median Q3 agreement of 2, one at 3 and the most difficult scoring 4. There were, however, no significant differences between the 4 topics for the other questions. Women reported feeling significantly more hurried or rushed (Q2), less absorbed in the task (Q8) and felt less like they lost track of time (Q7).

Condition	Sitting	Obstacles	Treadmill
Q1	2.28 †	2.54 †	3.29
Q2	2.6 ∗†	3.21	3.32
Q3	2.52 †	3.0	3.32
Q4	3.8 †	3.33	2.93
Q5	3.44 ∗	2.58 †	3.43 ∗
Q6	3.2	2.54 †	3.43 ∗
Q7	2.9	3.2	3.9
Q8	3.8	3.17	3.79

Table 3: Mean responses from post-task questionnaires by condition. ∗ = sig. diff. with Obstacles; † = sig. diff. with Treadmil

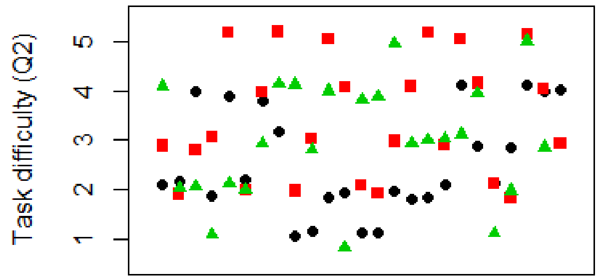

Figure 3: Perceived post-task difficulty by condition. • = sitting; ▲ = obstacle course; ■ = treadmill

As shown in Table 3, the different experimental conditions had a number of different effects on the participants' perceptions. Those on the treadmill felt significantly more rushed than in the other two conditions (Q1) and those sitting still felt significantly less pressure to complete the tasks quickly than the other 2 groups (Q2). It appears that those sitting still generally found the tasks easiest (Q3) - significantly more so than those in the treadmill group - and were more satisfied with the steps they took to find relevant information (Q4). Those sitting and on the treadmill were significantly more likely to forget their immediate surroundings than those on the obstacle course (Q5) and felt more involved in the task (Q6). Although differences were not significant, there was a trend that those on the treadmill felt more involved in the task to the point where they lost track of time (Q7) and those on the obstacle course felt less absorbed in the search tasks (Q8).

4. DISCUSSION AND CONCLUSIONS

In this work we conducted a laboratory experiment with both phone and tablet devices with the aim of evaluating common mobile situations that cause; fragmented attention, impact search performance and impact on user perception. To do this the distraction level was varied by simulating 3 everyday situations: walking quickly (on a treadmill), navigating a pre-defined route and a sitting still (which was used as the baseline condition).

Our pre-study questionnaire showed that participants expected using both devices whilst walking on a treadmill would be more difficult than sitting still and navigating an obstacle course. The older a participant was, the greater the expected difficulty of using a tablet on a treadmill but this was not the case for phones or when sitting. Perhaps this is because younger people are more familiar with such devices and may have more experience using them in mobile situations.

Participants seemed to take the experimental conditions into account when estimating task difficulty with significant differences in perceived task difficulty. Those who knew they would be sitting still expected the tasks to be easier than the other conditions. Those who were sitting still and those on the obstacle course thought finding relevant documents would be equally easy. It is interesting that people expected the treadmill to be most difficult, despite the fact that it should require more cognitive effort to avoid the obstacles. This may be because these participants have control over the pace at which they are walking, while those on the treadmill are kept at a constant speed by the mechanism. Those on the obstacle course have the possibility to slow down while conducting demanding tasks, such as assessing document relevance, thereby reducing their overall cognitive load [6].

Post-task perception showed that different experimental conditions had a number of different effects on the participants' perceptions. Those on the treadmill felt significantly more rushed than in the other two conditions. Oulasvita et al. [10] pointed to the effect of a situation on the duration of continuous attention, finding that participants in their laboratory experiments were more focused on the tasks compared with participants on a busy street. In this study, those sitting and on the treadmill were significantly more likely to forget their immediate surroundings than those on the obstacle course and more involved in the task. This may be because there is an increased need to attend to the surrounding environment when walking, but with the treadmill this is not the case as the situation does not change [8].

Participants on the obstacle course felt less absorbed in the search tasks. This could be due to the fact that walking while using a cell phone requires "both cognitive and motor abilities and appropriate division of attention to each" [6]. The level of absorption in the search tasks is less due to the participant needing to be aware of their surroundings. The participants are walking and using the device, in doing so they take longer to complete a set route and, therefore, walk more slowly. There are two repercussions to this, they will slow down on the obstacle route (because they have control) and experience increased cognitive load on the treadmill (not being able to adjust their speed) [7].

4.1 Future work

As future research in this area we plan to expand on this work by collecting data from more participants and looking at more objective measures of performance (e.g. total time, number of relevant documents, etc.) to investigate how this varies by condition, by age and by prior experience. We have also been recording GoPro footage of each participant as well as screen recordings of their interactions which we plan to evaluate to identify patterns and behaviours unique to each experimental condition. Using the data from the GoPro we will be able to evaluate the participants' spatial awareness (especially on the predefined route) and their "attention-switches" away from the device in different situations. Using the 3 everyday situations we will be able to assess the levels of immersion with each task and compare the GoPro data to the pre-task perceptions - does their initial thinking match reality?

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