Textual Directions and Cognitive Workload

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Abstract

This project examines and compares the inferred cognitive workload of detailed and non-detailed textual directions in a navigation task. A user study was conducted where participants navigated through two virtual worlds, one urban and one rural, while following detailed and concise sets of textual directions. While navigating, a secondary task measure was used to infer cognitive workload. It was found that although there is no statistical difference between the detailed and non-detailed directions in both environments, there was a difference between the measured cognitive workload and the perceived cognitive workload on the rural map. A trend was also present on one of the maps that showed detailed directions in a simple environment may be redundant. It is important to know how many cognitive resources are allocated when performing a navigation task because it gives insight into how automatically generated directions, in systems such as GPS, should be disseminated to users. It also gives insight into how to communicate spatial information in general.

Keywords: human computer interaction, wayfinding, spatial information theory

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1 Introduction

Wayfinding is a complex task involving orienting oneself in space, identifying decision points, estimating distances, and tracking location (Allen, 1997) where each task requires cognitive resources (resources). Wayfinding as a movement task also makes it necessary for a person to process and take in additional spatial, visual, and textual information (Tversky, 1993). It is important to know how many cognitive resources are allocated when performing a navigation task because it gives insight into how automatically generated directions such as, in systems such as GPS, should be disseminated to users. It also gives insight into how to communicate spatial information in general.

Each person possesses a limited amount of resources which are allocated to a variety of tasks (Kahneman, 1973). For instance, when driving while using a GPS, one will naturally split resources between following the given directions and driving. Resources are allocated to each task depending on how many the task requires and how many are available. Regardless of how many tasks are chosen to allocate resources to, the total amount of available resources will remain approximately the same (Chewar & McCrickard, 2002). This is significant because there are only enough resources available at one time to be able to process so much information at once. Thus it is better to design directions that take a lesser amount of resources away from the navigation portion of a wayfinding task.

It is generally accepted that the more concisely textual directions are written the lesser amount of resources used for the navigation task (Marcus, et al., 1996). The lesser the amount of text to process, the lesser the amount of resources used. This would be a practical summary if wayfinding wasn't the complex task described above. By taking into account Kahneman's model of attention and effort, this project begins to explore the influence of longer directions on both the perceived and implied cognitive workload.

Kahneman's model of attention and effort provides a framework to begin discussing cognitive resources. According to Kahneman's model, the amount of resources available is limited, but how they are allocated is flexible.

The cognitive aspect in the communication of navigational information has been studied from many points of view. From attention allocation while using mobile phones (Patten et. al, 2003) to the best method of map presentation to a user (Rouben & Terveen, 2007), this is a well-studied area of cognitive psychology. Particular to spatial cognition, the way human beings produce and comprehend route directions when speaking to each other has also been studied (Allen, 1997). In the spatial communication community there has also been a focus on defining a data structure for route directions specifically in urban environments. A framework was developed that aimed to use urban knowledge in a way that would be able to be applied by the cognitive system (Klippel et. al., 2009). Lastly, the definition of what "good" directions are has been explored (Lovelace et. al., 1999), but still remains unanswered.

In order to examine the interplay between cognitive workload and the detail level of textual directions, a user study was conducted where participants followed detailed and non-detailed directions in two virtual worlds (maps) while performing a secondary task. Participants were asked to navigate to a goal while counting backwards by two. The counting task served as a secondary task which allowed the researchers to infer a measurement of cognitive workload performance during the navigation task. Participants explored both a city environment and a rural environment. When done, their perceptions of the tasks were measured through a short survey.

This project used a verbal secondary task because it interrupted the navigational experience enough for the participant to consider the task to be difficult, but still allowed them to focus on the navigation itself. The verbal secondary task chosen was to count backwards aloud in sets of twos from 4000 for the first navigation task then from 2000 for the second navigation task. The assumption is that the more resources the participant used while navigating, the fewer resources available to count backwards. Shorter sequences may indicate fewer resources available.

A *t*-test on each map, urban and rural, shows no significant difference between the completion times for each detail level. A *t*-test for the non-detailed and detailed directions for the urban map measures $t(.244)$, p = .810 and for the rural map $t(1.921)$, p = .071. There is also no difference in the number of times a participant was "lost" during the navigation as well as the length of the secondary task sequence for each detail level on both maps.

Although not statistically significant, there is a trend present in the rural map, as shown in the p-values above. The trend shows there might be difference in the completion times between detailed and non-detailed directions. This is likely because in the lesser complex rural environment having detailed directions is redundant. Overall, these results are interesting because they show that it does not take more time for participants to navigate an environment using detailed directions, even though most of the detailed directions were three times longer than their non-detailed counterparts.

The survey administered to participants had two types of questions, two Likert scale questions and four free form questions. The response to the Likert scale questions "How satisfied are you with these directions?" and "How hard were you working following these directions?" ranged from one through five with one being the lowest measurement and five being the highest. On the rural map, regardless of the fact that performance on the secondary task showed no difference, a comparison of the means of the Likert scale questions showed that participants thought the detailed directions made them work harder.

2 Conclusion

First, the results show there is no difference between the inferred cognitive workload on each map or the number of times a participant got "lost." For the completion time of the navigation, there was no difference between the detailed and concise directions on the urban map. For the rural map, there was a trend present that showed there could be a difference, but with a p-value of .07 further testing is needed to determine the significance of this.

Second, the performance of participants did not show a difference between detailed and concise direction sets, but the survey data from the experiment told a different story. On the rural map, regardless of the fact that performance on the secondary task showed no difference, participants answered on the survey that the detailed directions made them work harder. One possible hypothesis for this difference is the fact that the rural and urban maps were different environments. The lack of visual information in the rural environment may have made the extra navigational information in the detailed directions less useful, and therefore unnecessary in the perception of the participants. When navigating in a more complex environment such as the urban map the extra navigational information may have been more useful and therefore not perceived to be unnecessary or an extra cognitive burden.

Third, regardless of the secondary task performance and answers to the previous Likert scale questions when asked to answer the free form questions “Which directions were the hardest for you to follow? Why?”, “Which directions made you work the most?”, and “Which task did you think was the hardest? Why?” 14 out of 19 participants stated that the detailed directions made them work harder than the non-detailed directions. A possible hypothesis for this difference could be a key difference between the inferred cognitive workload of a navigational task versus the perceived cognitive workload.

3 References

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