

Map Users' Preferences and Performance under Time Pressure

Jan Wilkening¹

¹Geographic Information Visualization & Analysis Group (GIVA), Department of Geography, University of Zurich, Winterthurerstr. 190, 8057 Zurich, Switzerland
Email: jan.wilkening@geo.uzh.ch

1. Introduction

In our everyday lives we regularly have to make map-based decisions under time pressure. For instance, commuters need to choose alternative routes depending on rapidly changing traffic situations, hikers may have to make trail choices under changing weather conditions, or viewers need to extract weather information from complex weather maps shown briefly on TV screens on the evening news. Professionals might also have to regularly engage in time-based decision making, often even in life-threatening situations, such as search and rescue, disaster management and mitigation, as well as in strategic military decision-making operations. In all these cases, the availability of an efficient map is crucial.

Time pressure is one among many independent factors that can determine whether a map is efficient or not, but is often overlooked in empirical map design research. Our study aims at bridging this research gap through a series of controlled user-studies investigating the influence of time pressure on map-based decision-making. In this extended abstract, we report on results of two human subject experiments, investigating the effect of map types on the efficiency of decision-making under various time constraints.

2. Related work

Our research is at the interface of (non-geographic) research on time pressure and decision-making and empirical map studies.

Two concepts from the psychological literature on time pressure and decision-making are relevant for our study: Firstly, the *speed-accuracy trade-off* concept (Wickelgren 1977) suggests that time pressure can reduce the overall quality of a decision, and, secondly, *speed-confidence trade-off* (Smith, Mitchell, and Beach 1982) means that the confidence with which people make decisions might decrease with increasing time pressure.

The geovisualization research community has recognized the need to assess visual displays empirically so as to make them easier to use and more useful in effective and efficient spatio-temporal decision-making (Slocum et al. 2001, Fabrikant et al. 2008). Previous empirical map evaluation studies have employed response time as a dependent efficiency measure to evaluate long-standing cartographic design principles (e.g., Garlandini and Fabrikant 2009). However, our contention is that time pressure as an *independent factor* (i.e., the usage context) might also have an effect on the success of a map design solution. This has been under researched in the geovisualization community so far.

3. Experiment I: Map preferences

Two experiments have been conducted to evaluate the effect of time pressure on map-based decision making. Experiment I assessed users' map type preferences when making map-based decisions under time constraints by means of a route selection task. The rationale for choosing a route selection task was that it is very common and can be performed under conditions with or without time pressure.

Under time pressure (TP), a classic scenario might be to reach a certain place as quickly as possible (a typical emergency situation). In contrast, when planning a holiday trip well in advance, route selections are not driven by time constraints (no time pressure = NTP condition). We exposed participants (N = 104, mostly geography students) to these two different scenarios in order to explore their map use preferences, dependent on whether they had to select routes under time pressure (TP) or under no time pressure (NTP).

Subjects rated six equally sized map types (145x189 pixels) displayed on a 17" desktop computer screen based on their task suitability. The map size was chosen such that participants could see all the maps at once on a single display and compare the designs without having to scroll or click on another page. The selected six map types (Figure 1) represent commonly encountered map types:

Map A: Terrain map with hill shading

Map B: Topographic map including contour lines

Map C: Road map including relief shading and spot heights

Map D: Satellite image with oblique 3D perspective and elevation exaggeration

Map E: Road map including labels with distance information

Map F: Satellite image with top-down perspective including roads and map labels

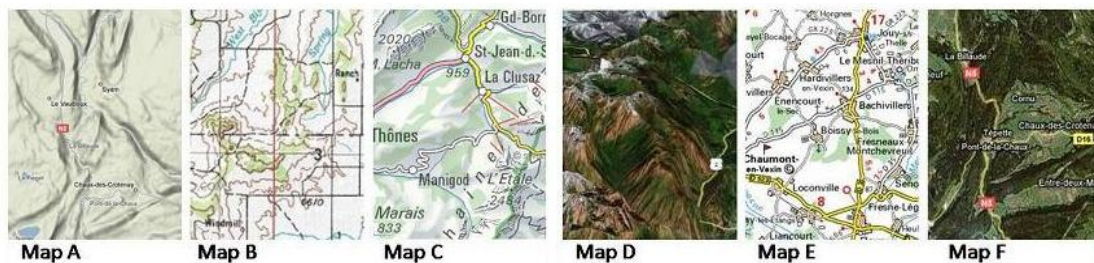


Figure 1. The six displays participants were asked to rate according to task suitability.

Participants rated their map display preferences on a rating scale ranging from “1 – the map is not suitable” to “5 – the map is very suitable” for each map for both the TP and NTP scenario. As shown in Figure 2, the two road maps (C and E in Figure 1) were most preferred in both the TP and the NTP condition. Both satellite images (D and F) earned the second highest ratings, while the topographic map (B) and the terrain map (A) were least preferred for both tasks. Moreover, ratings for both satellite images were significantly lower under the TP condition.

In summary, we found that test participants significantly preferred abstract road maps over satellite maps over the other tested types for route selection tasks, especially when having to make decisions under time pressure.

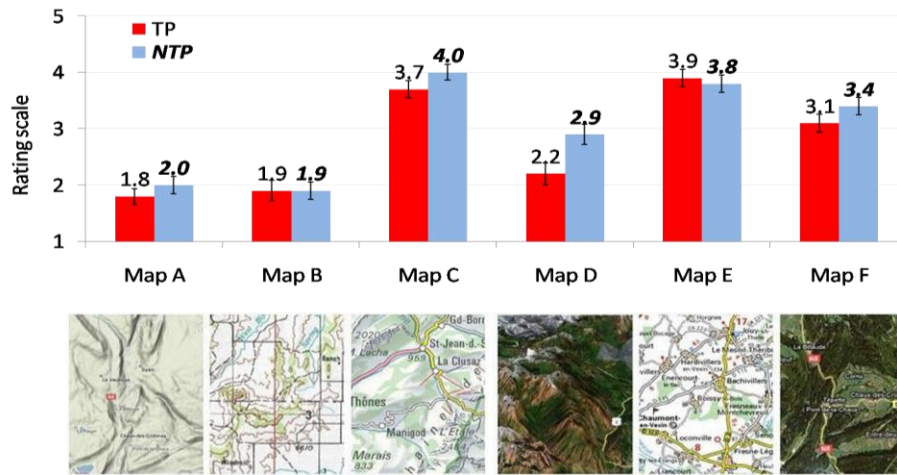


Figure 2. Mean rating results for different map display types (error bars = ± 2 SE).

4. Experiment II: Performance with different maps

The aim of Experiment II was to investigate whether time pressure and map types not only influence human preference judgments, but also affect usage performance for a road selection task (with and without time pressure). We focused on orthorectified satellite images and abstract road maps in order to further investigate the higher preferences for road maps shown in Experiment I.

We varied the time pressure factor by including response time limits that were identified in a pilot experiment. Participants ($N = 76$, mostly geography students) were given 10, 20 or 30 seconds to select a route based on a randomized series of 24 map stimuli, which consisted of twelve road maps and twelve equally sized satellite images (400x400 pixels, see Figure 3) shown on a 17" desktop computer monitor. The stimuli represented twelve different flat urban environments from all over the world, in which the shortest or fastest route selection from A to B was not obvious. Figure 3 shows two map stimuli examples used in the experiment.

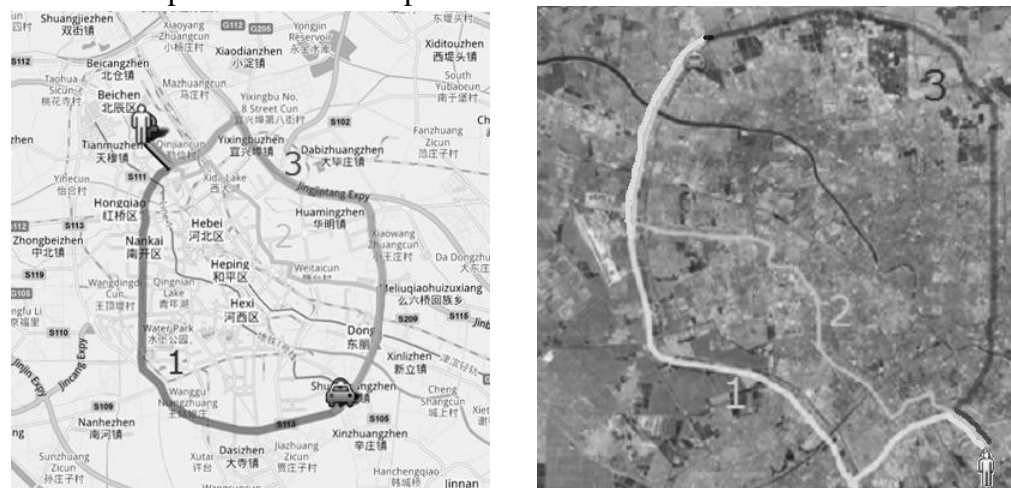


Figure 3. Test stimuli: abstract road map (left) and rotated satellite images of the same area (right).

Participants were first asked to *either* select the fastest route (driving time) *or* the shortest route (in distance) from three depicted routes on the map. Following that, participants rated their response confidence on a scale ranging from 1 “not confident at all” to 4 “absolutely confident”. Hence, for each participant we obtained two map

success measures: response accuracy (percentage of correct answers) and (self-reported) confidence.

4.1 Results

The results shown in Figure 4 suggest that there was a slight increase in participants' response *accuracy* with increasing decision time available, but this increase was not statistically significant. However, we found a significant difference in participants' *confidence* ratings due to time pressure ($p < 0.01$ for the 10/20 seconds limit). While the hypothesized speed-accuracy trade-off did not seem to emerge clearly in our results, we found a speed-confidence trade-off pattern as expected (see Figure 4b).

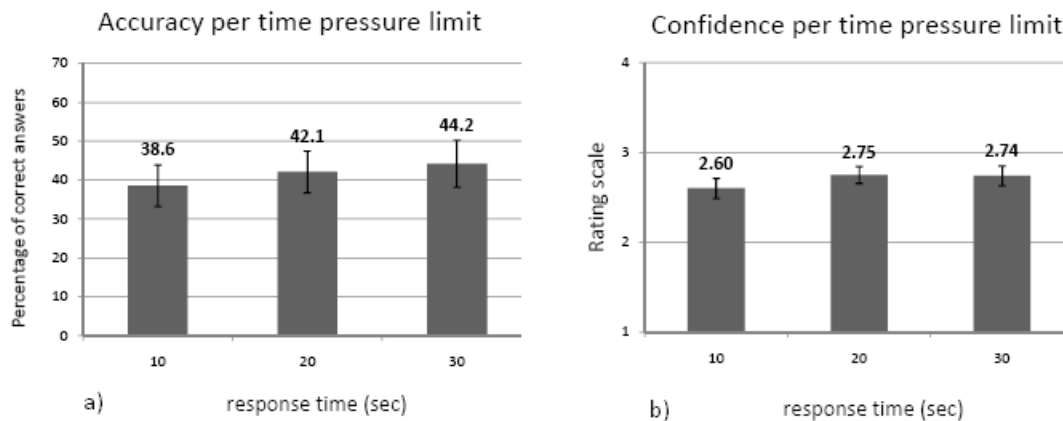


Figure 4. (a) Average accuracy (percentage of correct answers) and (b) confidence of subjects under different time limits (error bars = ± 2 SE).

Figure 5 depicts participants' response accuracy dependent on task and map type. Overall, participants' accuracy did not depend on the map type. However, when differentiating by map task we found that response accuracy was higher for the *shortest route* task with a satellite map ($p = 0.05$), while for the *fastest route* task accuracy was significantly higher with the abstract road map ($p < 0.01$), which is in concert with the preference for road maps we found in Experiment I. In other words, the effectiveness of a map type depended on the map use task.

Participants' confidence values showed a different picture, as can be seen in Figure 6: Participants were more confident in the satellite images independent of the task. Overall, we found a significantly higher confidence for satellite images compared to road maps in this experiment ($p < 0.05$), which is somewhat contradictory to the higher preference ratings for road maps from Experiment I.

We could not detect any learning effect with participants, that is, there were neither higher confidence nor higher accuracy values with answers towards the end of the experiment.

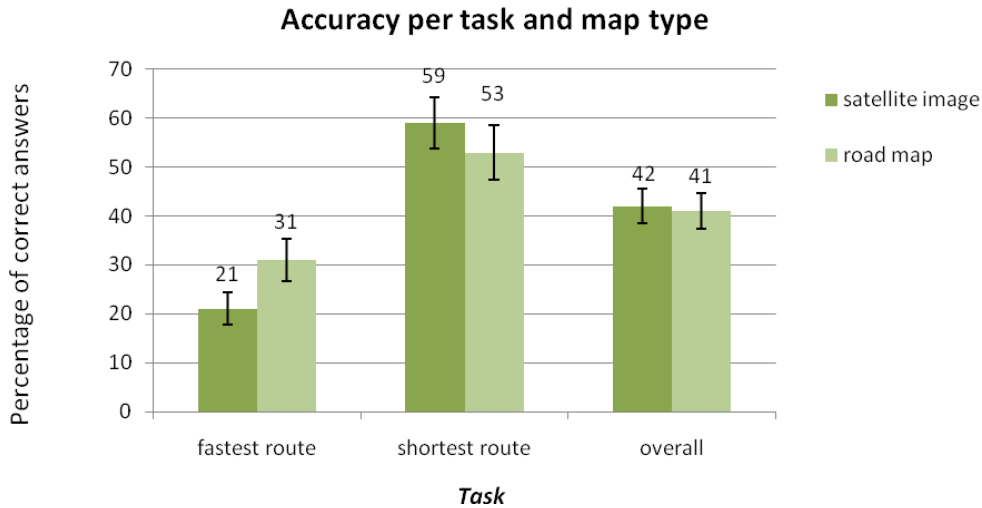


Figure 5. Mean accuracy (percentage of correct answers) with maps and satellite images (error bars = ± 2 SE).

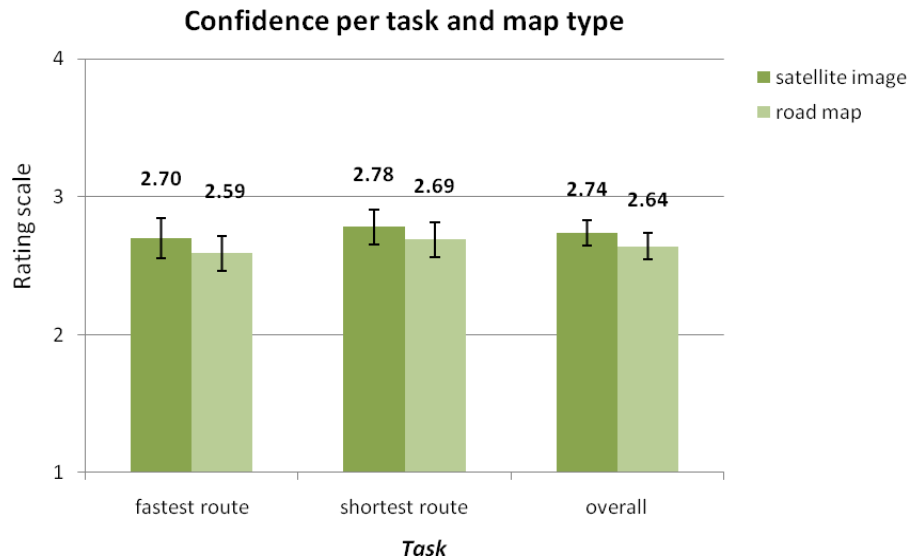


Figure 6. Mean self-reported confidence in maps and satellite images (error bars = ± 2 SE).

5. Conclusion and further work

These two empirical evaluations have generated first insights into the role time pressure plays in human decision-making with maps. The results of Experiment I, in which map preferences were assessed, suggest that people using maps for decision-making indeed prefer different types of map display according to whether they are under time pressure or not. Generally, preferences seem to be higher for road maps than for satellite images for solving road selection tasks. This preference for road maps is even more prominent under time pressure. Possible explanations for these differences are that the satellite maps contain more irrelevant details that distract users from the task at hand, especially under time pressure.

In Experiment II, human performance was compared with the results from the preference study. We did not detect any overall *accuracy* differences between the

tested road maps and satellite images for the route selection task. However, participants' decision-making *confidence* was significantly higher when using satellite maps for this task compared to road maps. One interpretation could be that participants tend to overestimate their performance with satellite images (or underestimate their performance with abstract road maps) as Hegarty et al. (2009) have found. This might be yet another indication of the naive realism phenomenon (Smallman and St. John 2005), i.e. novice users' misplaced faith in the utility of realism. Hegarty, Smallman, and Stull (2008) found that novice users tend to favour realistic displays more than experienced users.

Regarding time pressure as an independent factor influencing subjects' performance, participants' performance (response accuracy) for a road selection task does not seem to be significantly affected by different time pressure scenarios (10, 20, 30 second limit). This might be due to the fact that this task was not particularly complex. However, the identical time limits have an effect on confidence in map-based decisions, which is significantly higher when having more than 10 seconds to solve the route selection task. Hence, the speed-confidence trade-off seems to be more evident in map-based decisions than the speed-accuracy trade-off. This, in turn, could imply that the accuracy of subjects' map-based decisions is actually less dependent on time pressure than they believe.

In order to further assess the effect of time pressure on map-based decision making, follow-up experiments are currently underway. In these experiments, the third dimension is integrated to add more complexity to the decision-making process. We have also conducted interviews with experts in map-based decision making under time pressure (including search and rescue-vehicle dispatchers, ambulance drivers, helicopter pilots) to inform these follow-up experiments.

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