Acquisition of Landmark Knowledge from Static and Dynamic Presentation of Route Maps

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Abstract

This contribution reports on ongoing collaborative research at the University of Stanford, Department of Psychology, and the University of Hamburg, Department for Informatics. Extending the research on the effects of static vs. dynamic route presentation on perception and memory (Klippel et al., 2002), we examined different route presentation methods that are commonly used today (e.g. internet maps, GPS maps, etc.) and their effects on the subsequent route memory. Participants learned a route from a map of a fictitious town. The route was presented to them either as a solid line (i.e. static), a moving dot (dynamic), or a dot superimposed on a line (mixed). In a subsequent recall task, participants in all three conditions remembered equivalent number of landmarks, but participants in the dynamic condition recalled less pertinent landmarks than those in the static condition, who in turn recalled less than participants in the mixed condition. The results highlight the importance of landmarks at decision points and hint at differences in mental processing of dynamically and statically presented spatial information.

Introduction

Giving route directions is a complex task that involves several aspects of spatial cognition (cf. Couclelis, 1996) and varies significantly depending on the source of route information. The directions differ for face-to-face interactions, written directions, and sketch maps. They also differ when a route is recalled from memory or when it is described while looking at a map (see e.g., Tappe & Habel 1998; Klippel et al., 2002).

Route maps in particular have gained much interest in recent years as an effective tool to convey route information. Maps convey meaning in graphic form, in a similar manner that descriptions convey meaning by words. However, maps can provide richer and more veridical information of geographic space, employing relation-preserving mappings from the geographic sphere to a two-dimensional, bounded, and external medium.

For example, a route direction "Shell gas station is north of McDonald's" can be expressed succinctly in maps (Figure 1) by placing an icon of a gas station on the north side of an icon of McDonald's. Maps have further advantages since they can embed other information such as the metric distance without additional cost.

Figure 1: Graphical representation of the direction "Shell gas station is north of McDonald's"

Despite the ability to preserve precise relations of geographic space, maps often contain modified features of the physical environment. For example, they may alter the angles of intersections or idealize the positions of landmarks, as these are abstracted to cartographic point-like symbols. Nonetheless, the qualitative locative information of the landmarks is maintained, for example their position at a corner of an intersection.

The benefits of maps are apparent from their ubiquitous existence in our culture. Recently, route maps have become widely available through the Web and on-board navigation systems (e.g. Agrawala & Stolte, 2001). Despite the ubiquitous status of route maps, optimal visual representation methods are still a matter of research.

For example, route maps integrated in on-board navigation systems present routes dynamically with a moving dot that traverses through the map to simulate an imagined navigator. In contrast, internet maps present information statically with lines representing the route. Differences in presentation modes are caused by technical constraints of each medium, rather than by considering cognitive efficacy. When determining which of these two presentation modes—dynamic or static—would provide better instruction for users, dynamic presentation seems to be more attractive and effective at first glance. Animated graphics have shown to be more effective than their static counterparts in some studies (e.g. Kieras, 1992; Nathan et al., 1992).

However, Tversky and colleagues (2001) argue that advantages in animated conditions of these studies are due to other factors, such as interactivity or inclusion of information that are not present in static conditions. Furthermore, other studies fail to demonstrate advantages for animations altogether (e.g. Morrison, 2000; Hegarty et al., 1999).

Why do animations fail to show any benefits over static diagrams? One explanation is that although motion in animations is perceived continuously, people comprehend and remember it in discrete steps (Zacks et al., 2001). The discretizations of events occur systematically and the break points of the events (i.e. points where events are segmented) are better remembered than other points within an event.

Similarly, when people recall route information, they decompose the route into a set of discrete path segments, consisting of only minimal information such as turns and landmarks at the turns, in congruence with effective wayfinding aids (Jackson, 1998). Turning points are better remembered than non-turning points, as most of the landmarks and streets along the route are ignored and omitted (Tversky & Lee, 1998; Denis, 1997), or parts of the route are chunked to more complex route segments (Klippel et al., 2002).

Based on these observations, we predict that dynamically presented route information would hinder effective segmentation since a continuous presentation would bias the user to attend to features along a path equal to those at turns. In the following experiment, we present route information to participants dynamically or statically and examine how the presentation mode affects their memory of landmarks.

Landmarks are important features in organizing the memory for spatial information and they are vital to route directions (e.g. Denis, 1997; Klein, 1982). Landmarks are distinguished features of the environment clearly standing out of a multitude of spatial information perceivable by the senses. They fulfill various functions in organizing route directions, for instance demarcating decision points (e.g. "turn left at the restaurant"), confirming correct progression along the route (e.g. "continue past the school"), or providing a global bearing (e.g. "the sea is on your left and the mountains are on your right").

We predict that a dynamic map with a moving dot would create equal memory trace for landmarks at the turns and landmarks along the route. In contrast, we predict that participants would remember the landmarks at the turns better when they learn from a static map.

By studying how various presentation methods affect the underlying route memory, this study can suggest how applications should be designed to best utilize cognitive structures. Since landmarks at turns are critical components of route information, we will focus on participants' recall of these landmarks.

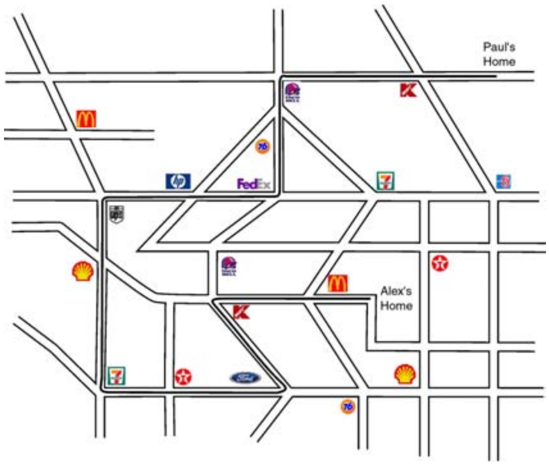

Figure 2: Static presentation of the route

Dynamic vs. Static Presentation of Maps

Participants

Sixty-four undergraduates, 36 male and 28 female, from Stanford University participated individually in partial fulfillment of a course requirement. The minimum criterion of 20% recall rate eliminated the data of two men and four women. The data of the remaining fifty-eight participants were analyzed.

Material and Procedure

We employed a map of a fictitious town consisting of a street network and various landmarks, such as McDonald's and gas stations. We restricted the design to the following functions and appearances of landmarks:

- We pre-tested and chose only well known landmarks, such as McDonalds and Seven Eleven, which were instantly recognizable to everyone.
- The landmarks were placed only at street intersections, thus landmarks along the route and at turns are equally viable decision points.
- There were an equal number of landmarks at turning and non-turning intersections.
- We restricted ourselves to point-like landmarks and avoided street names.

The route in the map was presented statically, dynamically, or both. The static condition presented the complete route between a start and a destination point as a solid line (Figure 2). In contrast, the dynamic condition conveyed the route with a moving dot, which represented an imagined navigator traversing through the route. A mixed condition combined the static and dynamic components of the route presentation by superimposing a moving dot on a solid line.

The participants were assigned randomly to one of the three presentation conditions. They were asked to remember the route as they viewed the map. They were also asked to verbalize the route during the viewing session. They viewed it three times, for 1.5 minutes each. After they finished verbalizing the route, they were given a map with only the street network and were asked to draw the landmarks they remember.

Recall Memory of Landmarks

	Turns	Non-turns	Total
Dynamic	**52.0**	**50.9**	51.5
Static	**55.3**	**44.7**	50.0
Mixed	**59.0**	**43.3**	51.2
All	55.5	46.3	

Table 1: Proportion of recalled landmarks (in %)

Table 1 illustrates the percentages of recalled landmarks when the route was shown dynamically, statically, and both. The landmarks at the turning intersections were recalled better (55.5%) than the landmarks at the non-turning intersections (46.3%). $F(1,55) = 5.25$, $p < 0.026$. Furthermore, planned contrasts showed that the landmarks at turning and non-turning intersections were recalled equally well (52.0% vs. 50.9%) for the dynamic condition ($t(55) = 0.153$, $p > 0.4$), but the landmarks at the turning intersections were remembered slightly better (55.3%) than the non-turning intersections (44.7%) for the static condition ($t(55) = 1.47$, $p < 0.074$). These results suggest that the presentation mode affects the route memory. In the dynamic condition, participants seemed to follow the movement of the dot along the route and attend equally to all landmarks. In static condition, participants seemed to attend to all landmarks during verbalization, but their subsequent recall showed better memory for landmarks at the turns, i.e. landmarks that are more pertinent to the route.

Surprisingly, when a moving dot was superimposed on top of a static route, participants recalled even more landmarks at turns (59.0%) than non-turns (43.3%). $t(55) = 2.18$, $p < 0.017$. We expected that this condition would yield results that are somewhere between those of dynamic and static condition, since the availability of both the complete route and the moving dot would give participants a choice to segment either by following the moving dot or by using the static route.

However, the results suggest that a combination of dynamic and static route presentation focuses the participants' attention further on the pertinent landmarks, namely on landmarks at turns, than either presentation mode alone. This is noteworthy because the mixed condition did not provide any additional information to help recall landmarks than a static route presentation. Instead, the benefit seems to come from directing attention to the appropriate landmarks on the path segments.

Prior to the experiment, we also had concerns that the dynamic condition was significantly harder than the static condition because participants had to reconstruct the route from a moving dot in dynamic condition. However, the total number of recalled landmarks did not differ significantly between conditions (51.5%, 50.0%, 51.2% for dynamic, static, and mixed conditions, respectively; $F(2,55) = 0.04$, $p>0.9$), suggesting that the recall task was equally difficult for all conditions.

Conclusion

We varied the presentation mode of routes in maps (i.e. dynamic, static, and mixed) to examine how it affects the memory for landmarks at intersections. We predicted and found that after static presentation memory for landmarks at turning intersections is fostered and that, on the contrary, dynamic presentation of routes constrains users to remember all landmarks equally. Since landmarks at turns are more critical to route directions, we conclude that static display of route information should be preferred over dynamic display.

However, a combination of both—static and dynamic route presentation—resulted in even better recollection of landmarks at turning points than by static presentation, suggesting that mixed presentation can provide a more effective tool to direct users' attention to important cues. The mixed condition combines benefits of both modes: The static condition allows users to organize the spatial information at hand more freely, applying principles he acquired in interaction with the environment, and it encourages a planning component. On the other hand, dynamically displayed information guides users along their way, reducing the stress to self–organize the amount of time available. The combination of different presentation modes and the resulting memory improvement for vital information add to findings regarding the benefits of redundant information display (Hirtle, 1999).

An interesting fact is that even though every information is stressed in the same way in mixed condition the results indicate the importance of certain features of the route, i.e. the participants focused on critical components of route directions. The outcome encourages further research on the interaction of various information sources, especially their display by different modalities.

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