Kinesthetic Cues Aid Spatial Memory

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ABSTRACT

We are interested in building and evaluating human computer interfaces that make information more memorable. Psychology research informs us that humans access memories through cues, or "memory hooks," acquired at the time we learn the information. In this paper, we show that kinesthetic cues, or the awareness of parts of our body's position with respect to itself or to the environment, are useful for recalling the positions of objects in space. We report a user study demonstrating a 19% increase in spatial memory for information controlled with a touchscreen, which provides direct kinesthetic cues, as compared to a standard mouse interface. We also report results indicating that females may benefit more than males from using the touchscreen device.

Keywords

Human memory, spatial memory, kinesthesis, touchscreen, gender effects.

INTRODUCTION

We believe systems should be designed not only for usability, but also to make information more memorable. We have shown in previous research that memory for information can be significantly improved by providing the user with distinct visual and audio cues at the time of learning [4]. In this paper, we extend those results by providing the user with kinesthetic cues, or cues derived implicitly from knowing parts of the body's position with respect to itself or to the environment. We conducted a study examining the effects of kinesthetic input on spatial memory, which has been shown to aid performance in desktop computing tasks, such as document management [3]. We present results supporting our hypothesis that kinesthetic cues aid spatial memory. We further demonstrate that input devices providing these cues benefit females more than males and narrow the gender gap in remembering spatial information. This increase in female performance is achieved without a concomitant decrease in male performance.

USER STUDY: METHOD

In this study, we tested users on their memory for the position of objects they had placed on a display screen. We believe the task is representative of direct manipulation tasks in desktop computing environments. We trained users on 30 objects, each of which had to be dragged to a distinct location on the screen. After performing a distraction task for about 10 minutes, users were tested on whether or not they remembered having seen previously placed objects, and if so, how closely they could recall the position where those objects had been placed.

In choosing the objects, we aimed to reduce other memory strategies such as chunking. To this end, we chose 2-dimensional pictures of everyday objects that were semantically unrelated and of roughly equivalent size (less than a cubic foot).

The study had two conditions (mouse and touchscreen), defined by the input device used to perform the tasks. All users viewed the objects on an NEC 1810X LCD monitor, modified with a Keytec MagicTouch touchscreen add-on panel. In the mouse condition, users were provided with a Logitech Cordless Mouse to drag and drop objects. In the touchscreen condition, users used their fingers to interact with the touchscreen device.

We conducted the study in four phases: the practice phase, the learning phase, the distraction phase, and the recall phase. In the practice phase, users were taught how to drag an object to a target location using one of the input devices. They continued to do this until they were able to accurately place four consecutive objects.

In the learning phase, we divided the screen into an 11 by 7 grid. This grid was used to discretize locations, and was not explicitly exposed to the user. Each object was presented one at a time with a square background in the center of the bottom row. To ensure that touchscreen users would not occlude objects with their hands while dragging them, we provided a 'handle' below the objects by which all users had to grab them. Users were told only to place each object on the target presented as a black square on the gray background as accurately as possible, and were given no warning of a later recall test.

In order to prevent users from rehearsing and to allow for memory consolidation, we distracted users by having them play games of Solitaire on the computer for 10 minutes. We then administered the recall test. We added 30 new objects

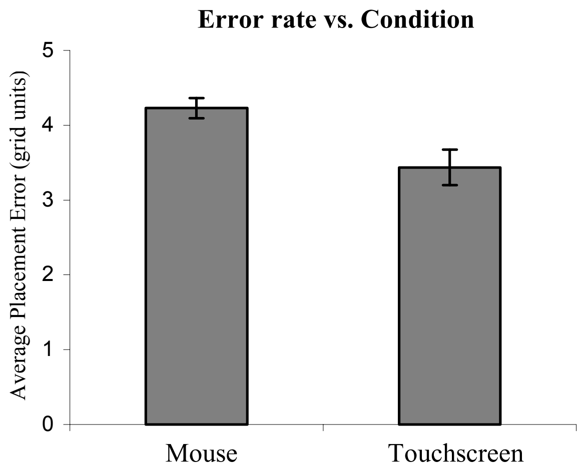

Figure 1: Touchscreen users performed significantly better on the spatial recall test.

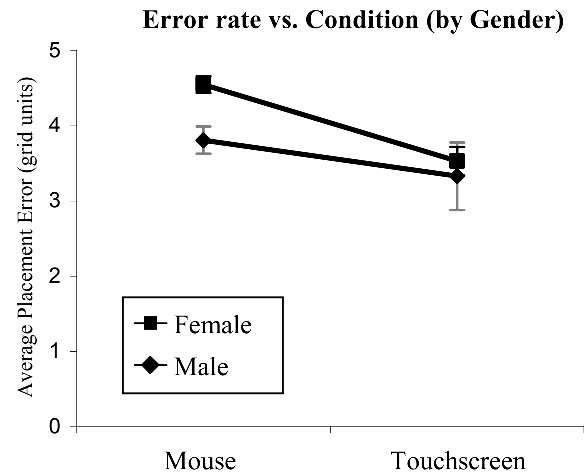

Figure 2: Females benefited more from using the touchscreen than it did males.

to the original 30 and presented users with these objects. Users moved a cursor, which snapped to the invisible grid, either to the location of the object, indicating that they had never seen that object, or to some location on the screen, indicating where they thought they had placed that object earlier. They were given no feedback on whether their responses were correct. We collected the following measures: time spent on learning and recall, percent correctly identified, the actual grid location of objects that had been placed, and the recalled location of these objects.

RESULTS AND DISCUSSION

Twenty-eight (14M, 14F) college students were paid for their participation. An equal number of males and females were assigned to each condition. We found no significant difference between conditions in the times required to perform the learning and recall phases. We also found no significant difference between conditions in the number of correctly identified objects, indicating that the input mechanism did not affect memory for the objects themselves. There was a significant difference between conditions in the distance error of placed cards, $t(26)=2.904$, $p=0.007$. On average, mouse users placed objects 4.22 grid units away as compared to 3.43 grid units for touchscreen users (see Figure 1). This represents a 19% improvement in spatial memory performance.

Motivated by previous literature on gender differences in spatial abilities [1,2], we analyzed gender differences in each of the two conditions. While we expected to find significant differences in both conditions, we found a significant difference only in the mouse condition, $t(12)=-3.039$, $p=0.010$ (see Figure 2). We found no significant difference in the touchscreen condition, $t(12)=-.393$, $p=0.701$. Females appeared to benefit more from the kinesthetic cues provided by the touchscreen and performed nearly as well as males in this condition. As the spatial task is typically an easier cognitive task for males versus females [1,2], we hypothesize that females benefited more from being able to free cognitive resources required to map mouse input to screen movements. We aim to further investigate reasons for this gender difference.

CONCLUSION AND FUTURE WORK

We have presented a study examining memory effects of providing kinesthetic cues to users performing a direct manipulation task. The study task was chosen to mimic desktop computing behavior. We demonstrated a 19% increase in spatial recall for users working on a touchscreen and receiving kinesthetic cues as compared to mouse users. Also, we showed that the use of the touchscreen input device appears to benefit females more than males. We will investigate reasons for this effect in future work. We are currently also planning studies to explore the effects of reinstatement of the cues at time of recall. This might be important in cases where the user is away from the system and needs to remember certain pieces of information.

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