On Interfaces Projected onto Real-World Objects

Mark Podlaseck, Claudio Pinhanez, Nancy Alvarado, Margaret Chan, Elisa Dejesus

IBM T.J. Watson Research Center
19 Skyline Drive
Hawthorne, NY 10532 USA
{podlasec, pinhanez, alvarado, margchan, ebdejesu}@us.ibm.com

ABSTRACT

This paper describes preliminary results of research on the perception and usability of interfaces projected onto real-world objects. Using a projector setup that enables us to compare users' color preferences, we show that the objects onto which colors are projected influence a user's choices. We also observe that many users are unable to recall and/or were unaware of the objects onto which the color interface was projected. These results suggest that there may be complex interactions affecting the use of interfaces that integrate the virtual and the real world.

Keywords

Augmented reality, projected interfaces, tangible interfaces, functional fixedness.

INTRODUCTION

Whereas most projected imagery has heretofore occupied the framed white space of a screen, in recent years artists and researchers have been projecting interfaces on walls, tables, floors, coffee cups, and even people. However, no study has so far looked into whether and how the interface is affected by the characteristics of the projected surface or by the projected object itself. In particular, we are interested whether interfaces are affected by "functional fixedness," the psychological phenomenon by which most people perceive the functionality of any given object as fixed (see [1] for definition and details).

The Untouchables

Our interest in this issue started after a demonstration of the Everywhere Display system performed at SIGGRAPH 2000 [2]. In this hands-on demo experienced by more than 600 people, users first touched a "button" projected on a wall. Later, they chose a color by touching one of many projected "buttons" on a table. When required to touch a similar button projected on the side of a paint can, many users who had successfully touched two buttons just moments ago were not able to accomplish this last task until explicitly guided by the demonstrator.

Why was this a difficult interaction to elicit? We conjectured that the users' difficulty may have been attributable to functional fixedness: users had trouble integrating a new kind of interaction with a paint can into their preexisting functional models of paint cans.

LEAVE BLANK THE LAST 2.5 cm (1") OF THE LEFT COLUMN ON THE FIRST PAGE FOR THE COPYRIGHT NOTICE.

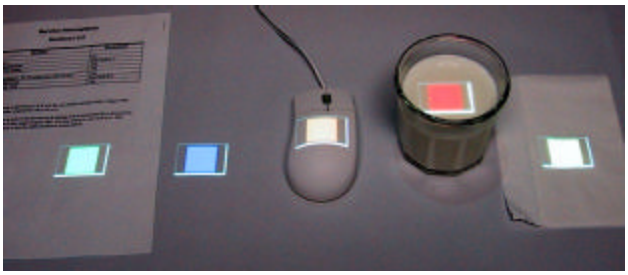

Figure 1. Setup of the first study: colors projected on a piece of paper, a countertop surface, a computer mouse, a glass of milk, and a paper napkin.

FIRST STUDY

A study was designed to assess whether the functionality of different everyday objects affects a user's ability to interact with these objects. Figure 1 shows the five different objects/surfaces used: an 8 ½ x 11 sheet of paper with text regarding maintenance requests; the white counter of the supporting table; a computer mouse; a glass of milk; and a paper napkin. The study asked users to indicate their favorite color out of five colors displayed on a monitor and/or projected onto the objects. We hypothesized that users would be positively/negatively affected in their choices by the surface/object onto which the color was projected.

Three groups of about 20 users each participated in the study. All subjects worked in the T.J. Watson Research Laboratory as researchers, interns, or facility staff. The first group of subjects (the control group) saw a sequence of ten clusters, each composed of five colors, displayed on a conventional computer monitor. Then the same sequence of ten clusters was repeated with the colors in different positions on the screen. For each cluster, users were instructed to "click on the color that appeals to you most."

Half of the second group saw the first sequence of color clusters on the monitor, then saw the second sequence projected on the objects. The other half of the second group chose colors from the objects first, then from the monitor. The third group saw both sequences of color clusters projected on different objects. Instructions for the selection of color on objects were to "touch the color that appeals to you most." Subjects were debriefed after going through the study.

Findings of the First Study

Although subjects were asked to "touch the color", only 32% of the subjects actually did so. 35% of the subjects touched the object and 29% merely pointed at the colors. A small fraction (3%) spoke the name of the object.

As expected, subjects were more consistent in selecting the same colors as appealing when the colors were presented on the monitor. The monitor/monitor group matched a mean of 5.82 colors out of a possible 10. The monitor/object group had a mean of 4.45 matches and the object/object group had 4.33. This difference is statistically significant, confirming our hypothesis.

However, the glass of milk accounts for much of the difference. Given the same clusters projected on the monitor and on the objects, subjects choose a color on the fourth position 29% of the time, while the same color projected on the milk resulted in 18% of all choices. Also, 8 of the 41 subjects who interacted with the objects (about 20%) never chose a color that appeared on the milk.

The Disappearing Milk

When we asked the subjects who never chose colors projected on the milk why they did not so, 4 of these subjects (10% of the user group) could not remember seeing a glass of milk at all during the experiment.

Given that these "milk-blind" subjects did not choose any color on the milk, this does not seem to be a case of short-memory failure to recall. We believe that these subjects did not see a color projected on the milk at all, and subtracted the glass of milk —including the projected color— completely from the task they had. This led us to conjecture that some people cannot cognitively perceive objects with extreme high functional fixedness (such as the glass of milk) as information interfaces. Similar selective blinding has been reported [3] in a different context.

SECOND STUDY

After the first study and the surprising result described above, the authors decided to rerun part of the study and measure the subjects' recall of the objects after completion of the color selection task.

Only the object/object study was rerun with the following changes. The setting of the study was changed to a rural physicians' office, and subjects were health care professionals, office staff, and patients (n = 20). The color of the laminate-surfaced countertop used was red, instead of white. Although it interfered somewhat with the perception of colors projected onto it, the authors felt that it provided a stronger background against which to perceive the objects. Subjects were given the instruction to "point to the color that appeals to you most" (as opposed to "touch the color") in order to minimize the effect of the interaction mode on selections (in particular with the milk).

After completion of the selection task, subjects were first asked to *list* the objects and surfaces onto which colors had been projected. Following, they were asked to *circle* the objects and surfaces from a list of twenty objects/surfaces.

A control group was added to the study with 10 subjects asked to look at the objects (now enclosed by a rectangle of duct tape and with no projection) for one minute and to report any changes. At the end of the minute, the subjects were asked to answer the same two questions as above.

Findings of the Second Study

Color matches and position selections were consistent with the findings for the object/object group in the first study. 18 of the 20 subjects pointed, as directed, to the projected colors. The other 2 touched the projected colors.

Between 65 and 75% of subjects recalled seeing projections on a sheet of paper, the countertop, a mouse, and a glass, but only 25% remembered seeing a napkin. In the control group, 100% of the subjects recalled the objects, except the napkin, which only 40% remembered. Although we cannot explain why the low recall for the napkin, the results show that performing the task affected the recall of objects and, possibly, the subjects' awareness of them.

All subjects chose at least one color on every surface, so we did not see new cases where both interaction and recall were affected by objects with high functional fixedness.

CONCLUSION

The results described in this paper, although preliminary, suggest a possible challenge for the integration of information with real-world objects and environments, as envisioned by augmented reality (AR) and tangible interfaces research. Since users may be "blind" to interfaces projected on some objects, interfaces designed for these scenarios have to employ mechanisms to increase their saliency. Also, since sometimes users seem to interact with interfaces projected on objects without being aware of them, applications that augment real-world objects may have to be designed to highlight their connection with them.

We have not yet performed experiments to determine whether similar results occur in typical AR (with goggles) or tangible interface applications. However, the results of the experiments described in this paper seem to warn that there may be unexpected cognitive issues on the road to augmented reality and ubiquitous computing.

REFERENCES

1. Duncker, K. On Problem Solving. *Psychological Monographs 270*, 1945.
2. Kjeldsen, R., Pinhanez, C., Pingali, G., Hartman, J., Levas, T. and Podlaseck, M. Interacting with Steerable Projected Displays. Proceedings of the Conference on Automatic Face and Gesture Recognition. May, 2002.
3. Rensink, R.E. When Good Observers Go Bad: Change Blindness, Inattentional Blindness, and Visual Experience. *Psyche 6 (09)*, August 2000.