Comparing Awareness and Distraction between Desktop and Peripheral-vision Displays

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Abstract
We tested a peripheral-vision display to provide users with awareness of others and their level of interest in interaction in an experiment where participants had to be aware of a simulated workgroup during a visually-demanding primary task. Participants gathered more information from the peripheral-vision display although they attended to it significantly *less often* (less than half the number of glances, and less than a third of the total time spent looking). Our results suggest that the peripheral-vision space around the user is a valuable resource for awareness and communication systems.

Keywords
Awareness, peripheral displays, instant messaging, chat, distributed workgroups

ACM Classification Keywords
H.5.3 Group and organizational interfaces: Computer-supported cooperative work.

General Terms
Design, Human Factors

Introduction and Background

Informal interactions – the spontaneous conversations that occur in collocated groups – have been shown to be a critical component of creative and technical work [1, 16] and maintaining social relationships [12]. Technologies such as instant messaging or chat [13] and media spaces [10] support these informal interactions in geographically distributed groups. One problem with these systems, however, is that they have resulted in an abundance of distractions [7, 11].

Support for less distracting initiation of conversations has proven to be a challenge [14]. Many problems are partly due to an insensitivity to mechanisms of interpersonal attention and awareness, such as physical proximity and gaze cuing, that play a key role in the initiation of many face-to-face interactions [2, 3].

Providing Awareness Information

Early systems that used video images of remote colleagues were criticized because they did not effectively support subtly initiating interaction, in part because they did not always present notification of when others were attending to a user's information in ways that were easy to detect the approach of others. These methods, such as watching a second monitor or remembering the meaning of many audio notifications [8] are distinct from attracting attention in natural contexts, which uses subconscious monitoring for changes in the periphery of the visual field [9].

Such systems need to show approach information so that it is not distracting, but users are aware of when others are approaching or attending to them. Without knowledge of who is watching, people cannot modify their behavior and their privacy is threatened [5].

Toward A Peripheral-Vision Awareness Display

People naturally use peripheral perception to sense and respond to the presence of others, so a peripheral vision display may be a useful approach.

We build on the OpenMessenger (OM) system [4] which allows users to "virtually approach" each other by dragging down on a contact's avatar. As the user drags down further, more information about that contact is revealed and the approached user is notified with increasing salience that the information is being attended to. We explore a new technique for providing this notification information via a peripheral-vision display in the user's real-world peripheral visual field.

We base our exploration on two design principles and goals: First, just as the physical approach of someone draws attention via motion in the visual periphery, the system should make use of the space around the user's workstation. One way to achieve this is via projection of avatars on the wall around the user's primary monitor, which provides a large low-resolution display surrounding the user and workspace. The goal of the projected display is to provide a space for representing people such that presence and virtual approaches can be presented so they are noticeable but not distracting.

Second, presence on the display is conveyed using an avatar image (simple icons in our evaluation system, but any image could be used). Avatars for remote users are arranged in a semicircle around the local user's avatar; the local user's avatar remains at the bottom center of the display, just above and in front of the user in the real world. This allows for representing virtual approaches from remote users by moving their avatars gradually closer to the local user's visual focus.

If desired, a conversation could then be initiated in a variety of ways (e.g., double-clicking with a mouse, or fixating for a particular duration with gaze tracking).

The Present Study

Evaluation Hypotheses

To explore these ideas, we designed a peripheral vision display system and compared it with a basic IM-style system located on the user's monitor. We used an eye tracker to gauge users' visual attention to the displays, and had them simultaneously perform tasks that varied in the required level of visual attention.

In this evaluation, we were first interested in whether the projected peripheral-vision display technique would offer benefits over a display on the primary screen. The peripheral display is much larger, and so we expected that people would be able to gather more information from this version. We therefore hypothesized that:

H1: Participants using the projected display will notice more displayed information, will look at their awareness display both less often and for less overall time, and will perform their task more effectively than those using the on-screen display.

H2: Participants completing the high visual intensity task will look at their awareness display both less often and for less overall time than those completing the low visual intensity task.

In addition, we hypothesized that participants' perceptions of their experience would align with the eye tracking and task performance data. We expected that they would find the projected display less distracting and preferable overall to the on-screen display.

Methods

A within-participants 2 x 2 design was used. Independent factors were the notification system used and the visual intensity of the task. There were 14 participants (6 males and 8 females) who all were undergraduates at a large US university and received either $10 cash or course credit for their participation.

Participants completed online puzzles at two levels of visual intensity. In the low intensity condition, they were shown two similar images and told to find as many differences between them as possible. In the high intensity condition, they watched a movie trailer video into which numbers and letters had been spliced. They had to watch for these numbers and letters, and type them into a web form when they appeared.

Participants were also told that they were borrowing the desk of an employee and that people may try to contact him via the company's messaging system. They were told how the system worked and to keep a list of people who tried to message him and at what time. Participants did not interact with the collaborators.

Experimental conditions

Two messaging systems were used in the study. In the peripheral-vision display condition, the awareness display by was projected onto the wall in front of participants. Avatars for "remote colleagues" would appear and disappear on the peripheral display and move toward the participant when a "colleague" wished to interact. As there was no actual interaction with the fictional remote users, we used a Flash movie for the display so that it was identical for all participants. In the on-screen condition, participants used an IM system that we created. Contacts were shown on a

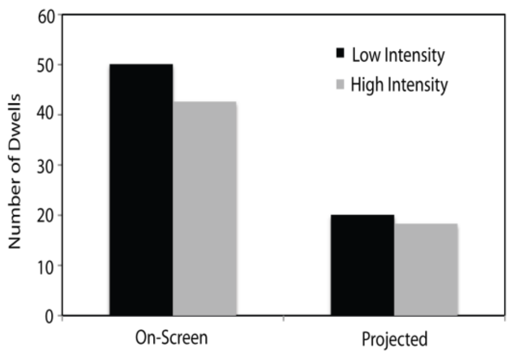

figure 1. Number of dwells at the two levels of task intensity, in the two display conditions

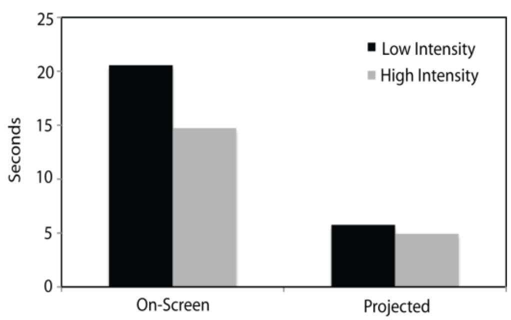

figure 2. Total dwell time at the two levels of task intensity, in the two display conditions

display in a browser window. In this condition, when a contact wanted to talk, a message would appear. As in the peripheral display condition, we used a Flash movie to display the contact panel notifications.

Procedure

Participants wore an ASL H6 head-mounted eye tracker, which was first calibrated for accuracy. conditions, including one practice at each intensity level followed by 3 repetitions of tasks at both intensity levels in each display condition. After, they completed a questionnaire that asked a series of Likert scale items about their experience, and were briefly interviewed.

Data Collection and Analysis

Eye tracker data were analyzed using the Eye-Nal software package which provides the number and duration of dwells within each region of interest. Dwells are defined as one or more consecutive eye fixations within a designated area of interest. A fixation was defined as when the eye was relatively still for 100 milliseconds or longer.

Results

H1 predicted that people would notice more displayed information, would look at their awareness display both less often and for less overall time, and would perform their task more effectively when using the projected display than when using the on-screen display.

We compared the number of names (out of 12 total) recorded in the different conditions. Two participants had to be removed because their lists were invalid. There was a significant main effect for display condition, with slightly more names written down in the projected condition (M = 11.58, SD= 1.17) than in the on screen condition (M = 10.75, SD = 1.14), $F(1, 11) = 6.06$, $p < .05$. That is, participants got more information from the projected display.

When exploring how many times participants looked at each display, there is a main effect for display condition, $F(1,5) = 37.49$, $p < .01$. Participants looked at the on-screen display an average of 94.29 (SD = 37.72) times -- over twice as many times as they did the projected display (M= 38.57, SD= 16.13).

For the total time participants spent looking at each display, we found a significant main effect for display condition, $F(1,5) = 17.36$, $p < .01$, Participants spent three times more total time looking at the on-screen OM display (M= 34.55 seconds, SD=21.39) than at the projected display (M=10.97 seconds, SD = 5.71). Average dwell time for the on-screen display condition was .35 seconds (SD= .12) and for the projected display was .28 seconds (SD = .08). There was no significant main effect for condition, $F(1, 5) = 2.02$, $p > .1$; or task intensity, $F(1,5) = 1.34$, $p > .1$.

Task Performance

Task performance was measured via the percentage of differences identified between images (low intensity) and characters identified (high intensity).

There was no significant main effect of display type on task performance, $F(1,6) = 1.32$, $p > .1$. In the on-screen condition, participants spotted an average of 60% of the 30 possible differences (SD=11.90%) between images and 83.9% of the 45 characters displayed (SD=11.67%). In the projected condition, participants spotted an average of 66.2% of the differences (SD=6.8%) between images and 85.5% of characters (SD=10.8%) were spotted. There was a significant interaction between condition and the order in which the conditions were experienced, $F(1,6) = 7.64$, $p < .05$. This suggests that participants tended to perform better in the second condition they experienced. Some learning likely took place in task performance, but does not negate our findings.

Overall, these performance results suggest that participants noticed information on both displays, but that the projected display enabled them to identify more information with less direct attention to the display. Neither display was distracting from the task.

Our second hypothesis was that during the high visual intensity task, participants will look at their awareness display both less often and for less overall time than during the low visual intensity task. For the number of times participants looked at each display, there was no significant effect for task intensity, $F(1,5) = 4.08$, $p = .1$. For the total amount of time participants spent looking at each display, we found no significant main effect for task intensity, $F(1,5) = 1.76$, $p > .1$.

Participant Perceptions and Assessment

Our questionnaire asked participants about the display interfaces, the tasks, and their experience. Items used 7-point Likert scales anchored by "Strongly Disagree" (1) and "Strongly Agree" (7). For most items, there were no significant differences between the displays.

Interview Data

Finally, we interviewed participants. Seven preferred the projected system, four preferred the on-screen system, one liked both equally, and two liked neither. Those that preferred the projected system liked the icon movement and color notification. The off-screen position of the display was also seen as less invasive.

The off-screen location was not favored by all users, however. The on-screen position was the top reason for those that preferred the on-screen system. It was perceived as easier to monitor while doing the tasks, despite the performance results suggesting otherwise. Additionally, one user preferred the on-screen notification over the animation of the projected system.

Discussion

The key contribution of this study is a display technique that helped people notice more information with less conscious looking, as measured by the number and duration of fixations on the display, which suggests that the peripheral perception of motion or activity can be used to attract attention. Additional work with dyadic interaction is required in order to determine the precise role of these attentional processes in interpersonal awareness, but this work provides a theoretical and practical foundation for additional dyadic studies.

There are three main implications of our study for the design of awareness and communication systems. First, our results suggest that designers consider displaying information about approaching interactions in the user's peripheral visual field. Second, this technique also provides a foundation for exploring the combination of gaze tracking [15] with gaze cuing of interpersonal attention [6]. Finally, this suggests more generally that human perceptual properties could be better exploited in notification displays.

We are currently working to move beyond evaluation of the display technique and to integrate peripheral display into an operational system that facilitates both the provision of awareness information and increasing notification as this information is attended to by others.

Given the promising results from this early test of a peripheral vision display, we will continue by implementing gaze tracking as a mode of interaction in both experimental and field settings. Through these additional evaluations we will refine our designs that draw on the techniques described here.

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