

Exploring the Design Space of Awareness Displays for Mobile Devices

ABSTRACT

Awareness display system research has moved beyond traditional workplace media spaces and has expanded to include systems installed in domestic environments and public cityscapes. Another research direction is towards developing awareness displays for mobile devices. Within this specific area, there has been little work in developing a design space for these displays, making it difficult to categorize, compare, or evaluate such systems. By surveying literature in HCI, cognitive science, psychology, and graphic design, we describe a design space of mobile awareness display systems and examine existing systems along these dimensions. This analysis shows a lack of variety in the types of context sensed and the types of layouts used to present information, as well as an absence of interaction between icons in the display. Motivated by this analysis, we suggest ways that designers of mobile awareness display systems can develop novel designs.

Categories and Subject Descriptors

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Design, Human Factors

Keywords

Awareness, CSCW, information visualization, mobile computing

1. INTRODUCTION

Early work in awareness display research focused on ways of supporting remote presence or activity in the workplace. Examples of this work include Media Spaces [3] and Portholes [8]. Studies of awareness display use in the workplace suggests

that background awareness for both co-located and distributed groups can increase work productivity and efficiency [9]. More recently, research in awareness has expanded beyond the workplace. For example, systems have been built to support awareness in domestic environments [5, 11].

Another new research direction is the emergence of awareness displays in “placeless” locales such as mobile devices [10, 12, 15, 16]. Investigating awareness displays on mobile devices presents several unique design considerations. First, with the rapid proliferation of mobile communication devices such as cell phones, these awareness displays have no specific target user; they are young and old, tech-savvy and not, professionals and students. This stresses the need to design systems that can accommodate the needs of all these populations. Second, mobile devices afford interaction while on-the-go and a user may have only a few seconds to consult the awareness display. Thus, designing a display to be glanceable is crucial to user adoption. Finally, the display size of mobile devices forces a designer to view screen real estate as a prime commodity and one not to be wasted. As a result, it is essential to provide as much data as is appropriate, while still imposing a minimum cognitive load upon the user.

Despite the growing body of work in this area, there has been little effort in organizing the literature and developing frameworks for categorizing this work. This makes it difficult to compare the design of one mobile awareness display to another. It also becomes difficult to critique one design without knowing the design dimensions in this domain and where this design fits in a design space. In this paper, we propose a general design space for these systems, drawing from the literature in HCI, cognitive science, psychology, and graphic design. Finally we discuss the “holes” in this design space and suggest ways to explore the under-examined areas.

2. DESIGN VARIABLES FOR MOBILE AWARENESS DISPLAYS

We begin the discussion of the design variables for mobile awareness displays by discussing the most common scenarios of use. These scenarios highlight two design goals for this application domain—*glanceability* and *ease of interpretation*.

Table 1. Description of mobile awareness display design variables

Variable	Description
Display Components	
color	Components are shown in different colors
levels of abstraction	Ability to show raw data (e.g., from sensors) as well as provide an abstraction of the data from the raw stream
2d/3d	Ability to show information in two or three dimensions
amount	Amount of information on the display can change
hierarchy	Ability to have multiple “views” based on the level of detail desired
occlusion	Display components can overlap over one another
size	Display components have different sizes
shape	Display components have different shapes
orientation	Orientation of the component affects how it is interpreted
Temporal Variables	
pacing	User can control how fast the display is updated with new information
duration	Icons appear for varying durations of time
simultaneity	Icons appearing simultaneously has a meaning different than appearing in succession
movement	Icons can move in various directions with varying speeds
frequency	The number of times an icon is displayed has meaning
interaction	Icons interact with one another (e.g., collision, attraction/repulsion)

2.1 Scenarios of Use

The most common application for mobile awareness displays in existing work has been the coordination of communication. Suppose Alice wants to call Bob to tell him about a change in meeting location. However, she may be missing several pieces of context which could help her decide whether or not to call him. Bob could be in an important meeting, he could be driving a car and approaching a busy intersection, or he may be asleep. A mobile awareness display would be able to provide this information to Alice, allowing her to decide whether the importance of her call is appropriate enough for her to interrupt Bob given his current context.

Another common usage scenario is to use the display to stimulate the overall affect of the user by increasing awareness of a remotely located family member, friend, or co-worker. For example, Alice has been working at her desk for hours and wonders what her children are doing at home. On the mobile awareness display mapped to her children, she sees a flurry of activity and—given other cues—interprets it as “playing”. She then puts away her display and returns to work.

In both scenarios, the mobile awareness display exhibits two qualities which we use to motivate some of the design dimensions. First, the display is glanceable. Alice is able to quickly access the display, obtain the needed information, and return to her primary task. Second, the display is used primarily as a tool to obtain information—in this case, awareness information. As a result, when Alice consults the display, she sees an abstract representation of the raw data and must interpret this representation to glean the desired information. In the next

sections, we use these design properties—*glanceability* and *ease of interpretation*--to motivate the taxonomy of design variables we use to describe the design space.

2.2 Designing for Glanceability

When using the display to obtain awareness information, the user engages in a visual search task. Since the user may already be engaged in another task or may only have a few seconds to consult the display, the user may not want to devote significant time to this task, making glanceability a desirable characteristic for these displays. It is suggested that designing for glanceability includes designing visuals to enable top-down and bottom-up search processes without being distracting [14]. *Top-down* mechanisms are goal-driven mechanisms that invoke cognitive processes [4]. Visuals that support top-down search will be easy to cognitively interpret. *Bottom-up* search mechanisms operate on raw sensory input, rapidly and involuntarily shifting the viewer’s attention to salient visual features of potential importance. Visuals that support bottom-up search tend to facilitate a greater occurrence of *pop-out* effects, where an object in the visual field becomes distinctive along some visual dimension (e.g., color, size) [1]. Prior work suggests several features which can induce pop-out effects, including color, brightness, movement, direction of illumination, distinct curvature (shape), and tilt [13, 17] .

2.3 Designing for Ease of Interpretation

Mobile awareness displays may need to present to the user several different types of contextual information on a limited amount of screen space. Thus, design guidelines for creating effective visual representations allowing for ease of interpretation are relevant to

designing a mobile awareness display. Work by Bertin [2] and Dondis [7] identified several basic graphic design variables to consider when designing visual representations including color value, hue, texture, shape, position, orientation, size, and texture. These design primitives are important dimensions to be considered when developing a design space for mobile awareness displays.

2.4 Taxonomy of Design Variables

Based on a literature survey of existing mobile awareness displays and a survey of relevant work in cognitive science, psychology, and graphic design, we present a list of design variables to consider as primitives when discussing the design space of mobile awareness displays. We divide the variables into two groups. First, we consider the visual properties of the display components (e.g., text, icons). Then we consider the design or behavior of animations within the display (e.g., speed of animation). The variables serving as dimensions of the design space are described in Table 1.

3. ANALYSIS OF EXISTING MOBILE AWARENESS DISPLAY SYSTEMS

Figure 2 shows the analysis of four existing mobile awareness displays (Awarenex [16], Hubbub [12], Live AddressBook [15], and MyVine [10]) in the context of the proposed design space. First, we compare the types of context sensed or displayed. Then, each variable described in Table 1 is treated as a binary variable by which to describe the design of the awareness display. For example, in the row labeled “size” we check to see if individual components of each display are presented in different sizes, with a different meaning attached to each size. “0” and red shading indicate that the display does not support that row’s particular design feature. “1” and green shading indicate this design feature is incorporated into the display.

4. DISCUSSION

When examining the types of context sensed or displayed by this sample of awareness display systems, all four displays showed “general activity” and “location”. While these are important pieces of context, we feel they were included because they were the easiest to sense. In the four systems examined, the types of context fed to the display were decided by the technology available, rather than what a user of such a system may deem to be important. In a recent study of mobile phone usage, De Guzman *et al.* [6] posit several guidelines regarding what types of context would be most useful to a caller deciding whether or not to make a phone call.

With the exception of MyVine, most mobile awareness displays have similar visual designs. The information is presented to the user in the form of a vertical list. Font styles (e.g., bold, italic) are used to make one line of text stand out from the others. Finally, icons that populate the display are static and uniform in size. We hypothesize that these design limitations are partially due to the limitations in technology (e.g., lack of availability of color PDAs for prototyping, primitive APIs for programming on mobile devices). Another possible reason for the lack of variety in design is the adoption of the IM “buddy list” metaphor. While the use of metaphors may aid users in developing the correct conceptual model for using these systems, we hypothesize that this metaphor stifles creativity.

Table 2. Analysis of four mobile awareness display systems along binary design dimensions

	Awarenex	Hubbub	Live Address Book	MyVine
Context Sensed/Displayed				
calendar entries	0	0	0	1
general activity	1	1	1	1
current comm. device	0	1	0	0
location	1	1	1	1
background audio	0	0	0	1
Design Variables				
Display Components				
color hue	0	0	0	1
levels of abstraction	1	1	1	1
2d/3d	0	0	0	0
amount	1	1	1	1
hierarchy	1	0	0	1
occlusion	0	0	0	0
size	0	0	0	1
shape	1	1	1	1
orientation	0	0	0	0
Temporal Variables				
pace	0	0	0	0
duration	1	1	1	1
simultaneity	0	0	0	0
movement	0	0	0	0
frequency	1	1	1	1
interaction	0	0	0	0

All of the sample awareness displays failed to demonstrate a variety of design features (if any) in the “Temporal Variables” section. As hypothesized with the visual layout of these displays, this may be due to technological limitations. APIs for programming on PDAs may not have supported dynamic text or advanced graphics on mobile displays. Furthermore, limitations in server bandwidth or PDA processing power may have made it impossible to have true “streaming” data being collected by sensors and displayed in real-time on a mobile device’s screen. We feel that most technological infrastructures today are sufficient to support experimenting with novel display layouts and exploring the design features in the “Temporal Variables” section.

5. IMPLICATIONS FOR DESIGN

Motivated by our analysis of a representative sample of previous work in mobile awareness display systems, we present the following suggestions for designers wishing to explore the “holes” in the design space:

Experiment with various display layouts. If the display is mapped to several contacts at once, consider layouts other than vertical lists. For example, contacts can be arranged based on the physical proximity to the user, the contact’s social relationship to the user, or in an order reflective of frequency of communication. When displaying various types of context through icons, consider layouts other than horizontal lists (i.e., in a “buddy icons” style). Icons can be positioned relative to each other or the contact name to indicate importance or recency of information.

Design for meaningful interaction between icons. Given the relaxed limitations of server bandwidth and processing power of mobile devices, an awareness display should be capable of receiving an increased number of data streams. Furthermore, it should be capable of updating itself with this data at a rate close to “real-time”. Designing for collision, attraction, repulsion, and vibration between icons allows a display to be more expressive without occupying additional screen real estate.

Consider collecting/displaying other types of context. In the spirit of user-centered design, mobile awareness displays should support types of context that are considered important to the users of these systems—not necessarily what can be easily sensed by existing technology. De Guzman *et al.* [6] present results of a recent study of mobile phone usage and distill these results into a set of guidelines for awareness display systems. Among these guidelines are descriptions of novel types of context such as the distance from the contact to his/her phone, the history of past interactions and the social relationship (e.g., friend, co-worker, boss) between the caller and the receiver, and access to the caller’s own context.

6. CONCLUSION

Technology intended to provide users with awareness information has been studied extensively within the CHI and CSCW communities. In this paper, we closely study a subset of this work—research in mobile awareness displays—and propose a design space with variables motivated by relevant literature in cognitive science, psychology, and graphic design. We then analyze four mobile awareness displays along the dimensions of this design space and describe the “holes” uncovered by this analysis. Based on our findings, we propose a set of guidelines for designers wishing to further explore this design space. By considering different types of context, experimenting with different visual layouts, and allowing for interaction among display elements, designers can generate displays that are novel in design and represent under-examined areas of the design space.

7. REFERENCES

- [1] Baldassi, S. and Burr, D.C. 'Pop-out' of targets modulated in luminance or colour: the effect of intrinsic and extrinsic uncertainty. *Vision Research*, 44 (12). 1227-1233.
- [2] Bertin, J. *Semiology of graphics: diagrams, networks, maps.* University of Wisconsin Press, 1983.
- [3] Bly, S.A., Harrison, S.R. and Irwin, S. Media spaces: bringing people together in a video, audio, and computing environment. *Communications of ACM*, 36 (1). 28-46.
- [4] Conner, C.E., Egeth, H.E. and Yantis, S. Visual attention: Bottom-up versus top-down. *Current Biology*, 14. R850-R852.
- [5] Consolvo, S., Roessler, P. and Shelton, B.E., The CareNet Display: Lessons Learned from an In Home Evaluation of an Ambient Display. in *Proceedings of the 6th International Conference on Ubiquitous Computing*, (2004), 1-17.
- [6] De Guzman, E.S., Sharmin, M. and Bailey, B.P., Should I Call Now? Understanding What Context is Considered When Deciding Whether to Initiate Remote Communication via Mobile Devices. in *Proceedings of Graphics Interface*, (2007).
- [7] Dondis, D.A. *A Primer of Visual Literacy.* MIT Press, 1973.
- [8] Dourish, P. and Bly, S., Portholes: Supporting Awareness in a Distributed Work Group. in *Proceedings of the ACM Conference on Human Factors in Computing Systems*, (1992), 541-547.
- [9] Fish, R., Kraut, R.E., Root, R. and Rice, R., Evaluating Video as a Technology for Informal Communication. in *Proceedings of the ACM Conference on Human Factors in Computing Systems*, (1992), 37-48.
- [10] Fogarty, J., Lai, J. and Christensen, J. Presence versus Availability: The Design and Evaluation of a Context-Aware Communication Client. *International Journal of Human-Computer Studies*, 61 (3). 299-317.
- [11] Hindus, D., Mainwaring, S.D., Leduc, N., Hagstrom, A.E. and Bayley, O., Casablanca: designing social communication devices for the home. in *Proceedings of the ACM Conference on Human Factors in Computing Systems*, (2001), 325-332.
- [12] Isaacs, E., Walendowski, A. and Ranganathan, D., Hubbub: a sound-enhanced mobile instant messenger that supports awareness and opportunistic interactions. in *Proceedings of the ACM Conference on Human Factors in Computing Systems*, (2002), 179-186.
- [13] Julesz, B. A brief outline of the text on theory of human vision. *Trends in Neuroscience*, 7 (2). 41-45.
- [14] Matthews, T., Forlizzi, J. and Rohrbach, S. *Designing glanceable peripheral displays* Technical Report No. EECS-2006-173, University of California, Berkeley, 2006.
- [15] Milewski, A.E. and Smith, T.M., Providing presence cues to telephone users. in *Proceedings of the ACM Conference on Computer Supported Cooperative Work*, (Philadelphia, Pennsylvania, United States, 2000), ACM Press, 89-96.
- [16] Tang, J.C., Yankelovich, N., Begole, J., Kleek, M.V., Li, F. and Bhalodia, J., ConNexus to awarenex: extending awareness to mobile users. in *Proceedings of the ACM Conference on Human Factors in Computing Systems*, (2001), ACM Press, 221-228.
- [17] Treisman, A. The perception of features and objects. *Visual Attention*. 26-54.