Evaluating the InfoCanvas Peripheral Awareness System: A Longitudinal, In Situ Study

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ABSTRACT

A longitudinal, in situ study of the InfoCanvas, a prototype peripheral awareness system, was conducted. The InfoCanvas provides awareness of information through "information art," acting as a kind of electronic painting in which visual elements change appearance to represent changes in the information being monitored. Eight people used the system for a month in their offices. We observed and documented the scenes they designed, how they used the system, and their opinions of the system. Overall, participants felt the system was useful, informative, and fun. With respect to aesthetics, some participants felt that it was appealing but others desired further improvement. Lessons learned from the study may benefit other forms of peripheral displays and ubiquitous computing systems.

Keywords

Peripheral awareness, peripheral display, information art, InfoCanvas, ubiquitous computing, ambient display, evaluation, longitudinal study

1. INTRODUCTION

In the past 5-10 years, growing interest in the use of ubiquitous or pervasive computing has spawned the creation of many different prototype systems in this area. As the technology for designing and deploying ubiquitous computing applications matures and a variety of different systems emerges, a primary challenge then becomes how to evaluate these systems [1,16]. Abowd, Mynatt and Rodden note, "Researchers have only recently begun to address the development of assessment and evaluation techniques that meet ubicomp's demands" and "…there has been surprisingly little research published from an evaluation or end-user perspective in the ubicomp community" [2].

Many different types of ubiquitous computing systems exist and no one specific study could hope to evaluate all these types. Our focus is on peripheral and ambient displays [10,2,18], systems that utilize computer displays or even everyday physical objects to communicate information to people. What is interesting about these systems is that the presentation of information is moved off the main computer display and into the user's environment—on the walls, on shelves, on tables, or even on the ceiling. Such systems allow the user to opportunistically examine the display as part of their work, when taking a momentary break from work, or when coming and going from the environment. Further, by removing the display of information from the traditional computer desktop, more screen space for actual work information is provided.

We feel that it is important to evaluate peripheral awareness systems with potential users of the technology in extended trials in the environments of the users. The novelty and "cool factor" of these systems makes them exciting to researchers, but how will people who are not familiar with these concepts react? Furthermore, lab studies of systems cannot simulate the actual context and conditions of use which are so vital to these systems. Finally, short-term evaluations that do not go beyond a simple introduction may only identify the initial reaction to a new technology. Effective evaluations, ones in which users are observed interacting with a system in routine ways, require realistic deployments into the environment of expected use [1].

We study one particular peripheral display, the InfoCanvas (IC), a kind of electronic painting [14,18]. In the study, we worked with eight people who ran the IC for a period of approximately one month in their office. We used observation, surveys, and semi-structured interviews to gather data. However, our emphasis was to stay relatively detached from day-to-day use in order not to unduly influence the participants.

More specifically, we wanted to learn more about the information that people would monitor and how they would represent that information. We sought to determine people's reactions to the system, its usefulness, flexibility, aesthetics, intrusiveness, and overall appeal. If such a system could be acquired, would people actually want to run it? It was of utmost importance to us that participants "live with" the system for an extended period of time to overcome the novelty factor clearly present with such peripheral awareness applications.

2. RELATED WORK

Relatively little evaluation of deployed peripheral awareness systems has occurred. One reason for this scarcity, we feel, is the difficulty of conducting such evaluations. Furthermore, it is challenging to identify proper evaluation techniques that are appropriate for assessing the objectives of peripheral awareness systems.

That said, some possible evaluation techniques have been suggested. Mankoff et al developed a set of heuristics for evaluating ambient displays as a response to a noted lack of evaluation studies in that research area [12]. Their heuristic evaluation techniques are more appropriate for influencing design in the formative stages of a system rather than as a summative evaluation technique, however. The Experience Sampling evaluation technique has recently been used to help understand ubiquitous computing systems in situ [9,5]. Our study shares some characteristics of Experience Sampling, but not the recurring alerts so strongly identified with it since such interruptions did not appear to be as beneficial in our case where participants spend little time directly engaged with the technology being studied.

Some evaluation of peripheral displays has been conducted. Lab studies of animated ticker systems have examined the information conveyance versus distraction tradeoff in those systems [11,13]. Focus group feedback of initial prototypes has provided developers with feedback for redesign [7].

Only a few field studies of peripheral awareness systems have been performed as well. The CareNet system to assist caregivers aiding elders was deployed in four homes for three weeks and was showed to have a number of benefits [6]. A large-scale field study of the Sideshow peripheral awareness system received usage feedback data and opinions from hundreds of respondents out of thousands of users [4].

Evaluation of Informative Artwork [8], the system most closely related to the IC, has been limited to a trial public deployment of the system on a plasma display at a university, with the system used to communicate bus travel information. Six passing-by people were interviewed about their understanding of and reactions to the system [17].

Our previous evaluations of the IC included a laboratory study that assessed people's ability to interpret and recall a display at a glance. Participants in the study reliably recalled more information from the IC than from a web portal or purely textual display [15]. An earlier pilot study of IC use by four people was more informal than the present study and deployed the system on desktop second monitors [18]. It provided initial design evaluation and feedback, but failed to adequately assess the system with respect to its design principles.

3. THE INFOCANVAS

An IC display is simply a picture that includes a number of different objects. Each object can be logically connected to a piece of information so that the object's appearance (representation, location, size, color) updates to reflect changes in the information. The designer of the picture is able to specify the mapping rules for connecting objects to information.

More specifically, the IC provides a predefined set of *themes*. A theme is a particular type of scene (e.g., aquarium, cityscape, rain forest, beach, etc.) that includes a background view and a set of objects called *visual elements*. For example, a rain forest theme may contain visual elements such as birds, frogs, snakes, flowers, hikers, trees, waterfalls, and so on.

The designer of an IC scene can arbitrarily position visual elements onto the background, though clearly most visual elements have positions that are more appropriate than others. Additionally, the scene designer creates a mapping from some information to the visual element. For instance, the color of a flower can change as a stock market index updates throughout a day, or a parrot can fly higher in the sky to represent a higher current temperature. These changes to visual elements are called *transformations*. The IC provides six primitive types of transformations:

- Slider – An element's position along a straight line encodes a particular data value.
- Swapper – Different visual representations for an element denote different data values.
- Appear – A visual element appears when a certain condition is true and disappears when false.
- Scaler – The size of a visual element encodes a particular data value.
- Population – The number of related visual elements in a set encodes some data value.
- Display – A specific image is acquired from a data source and is displayed.

The fundamental idea underlying the IC is that a person can monitor information of personal interest (weather, financial, traffic, news, prices, etc.) by designing and deploying an appropriate display somewhere in their work or home environment, just as they would place a favorite picture or painting. The person can glance at the display from time to time to maintain awareness of the information, thus freeing screen real estate on their main computer display for other information. Further, this can reduce the need to access and examine web pages containing the same information, thus lessening interruptions and distractions that accompany such accesses [15]. To create the illusion of an electronic painting more fully, we use thin LCD monitors with the plastic bezel around the display removed and replaced by an actual picture frame.

The IC is a java application that reads an XML file specifying the background and visual elements for a scene as well as the transformations from monitored information to element updates. The system polls different information resources at pre-specified intervals of time and then updates the display accordingly. End-users do not interact with the interface per se, except that when a visual element is moused-over, a small tool tip is briefly shown with the exact value of the corresponding information. For more details about the IC system, see [18] or the website `http://www.cc.gatech.edu/gvu/ii/infoart` that includes a downloadable example.

4. STUDY

4.1 Objectives

The IC was developed with a small number of key design principles: personalization, flexibility, consolidation, accuracy, and appeal [18]. We used these design principles, together with some more general, implicit system goals, to develop a set of dimensions along which to evaluate the system. Our objective was to identify specific characteristics of the IC for evaluation, rather than assess the general notion of "Users liked the system/Users disliked the system." We designed the study's evaluation instruments (surveys and interview topics) with these dimensions in mind. These evaluation dimensions also coincide with a number of the areas from Scholtz and Consolvo's evaluation framework for ubiquitous computing systems [16].

Usefulness – Does the IC help people maintain awareness of important information? Does the system save time for people and reduce interruptions? Do users feel that the IC accurately reflects the state of information? Is the consolidation of information onto one display an important and useful characteristic of the system?

Personalization and flexibility – Is the IC flexible enough to meet the information awareness needs of individuals with very different interests and habits? How important is the ability to build a customized IC unique to an individual, both in terms of information monitored and visual representation?

Aesthetics – Is the IC an appealing addition to an office? Do people find the different pictures (themes) attractive? Which pictures do they prefer? Would people hang such a system on a wall in their office or home?

Distraction – Is the IC a distraction? Is the system's presence an intrusion, or alternatively, does it promote calmness by removing distractions and interruptions?

Novelty and fun – Does the IC make staying aware of information more enjoyable? Is the system engaging? How do other people, such as office visitors, react to the system?

Summary impressions – All factors considered, how do users view the system? Would they continue to use it if given the opportunity? Do any user characteristics or demographics appear to influence perceptions of the system?

One particular aspect of the IC not being evaluated in this study is the ability of people to build and modify their own IC view from scratch. Because scene specification is performed by writing an XML file detailing information sources, visual element characteristics, and the mapping between the two, we did not feel that potential participants would be able to implement one without significant training, and even then, the process still may be too complex for people lacking a technical background.

4.2 Methodology

Each participant in the study designed their own personal IC and ran the system in their office at work for a period of approximately one month. The examiners' interactions with participants occurred at four key points.

An initial session with each participant lasted approximately 90 minutes. An extensive interview uncovering the participant's particular information of interest and existing information awareness habits was conducted. Participants also completed a survey about their current information awareness characteristics. Next, each participant viewed 16 different IC themes including color prints of the theme's background image, the set of associated visual elements, and example populated views. The participant selected one theme for use and designed their IC scene by 1) associating a particular visual element with each data source to be monitored and 2) positioning the visual element on the background image. Finally, the participant selected an office location to deploy the IC.

After this initial inquiry and design session, we implemented and tested a corresponding IC view. This development process typically took one or two days. Upon completion, we returned to the participant's office and deployed the system, making sure that it was functioning correctly. The IC display utilized a 15" LCD monitor with the bezel replaced by a picture frame. It was positioned away from each participant's primary monitor or monitors (views of each deployment will be shown later). For half the participants, a spare computer was available and drove the system. For the other half, we purchased a spare video card and installed the system as a second monitor, the picture frame display connected by a long VGA cable, on their primary computer. Deploying the system in a person's office took roughly 15-30 minutes.

We returned for the third interaction session after participants had run the system for approximately two weeks. In this session, participants completed the same initial survey about their information awareness characteristics and a survey about their perceptions of the IC. We also conducted a semi-structured interview with the participant, and the participant was given an opportunity to modify their IC. The session lasted approximately 45 minutes.

After another two weeks had elapsed, we returned for a wrap-up session including participant surveys and semi-structured interviews much like the midpoint session. We also gathered the IC and affiliated hardware. The final session lasted approximately 45 minutes.

The same 10-question survey about a person's information awareness habits and perceptions was completed by participants in the initial design, midpoint, and final sessions. The purpose of this questionnaire was to help learn about the personal information access and use characteristics of each individual in the study and to see if those characteristics or the person's perceptions of information awareness changed over time with use of the system.

At the midpoint and final sessions, participants completed the same 25-question survey about specific characteristics of the IC. These questions were designed to elicit participants' opinions along the six evaluation dimensions listed earlier in the article. The final questionnaire also included four more questions about overall, concluding perceptions of the system.

Both the midpoint and final sessions were videotaped and reviewed for further analysis. Multiple examiners were present at the sessions so that one could serve as interviewer and one or two others could take notes.

We would have liked to have acquired data about how often and when participants looked at their IC displays. We felt, however, that having participants log glances or asking participants to use some system interface to record actions would be unnecessarily intrusive and be more harmful to the study than helpful. Further, because the system was deployed in participants' own offices, any kind of video logging was impractical. It was of utmost importance to us to be as detached as possible and that participants experience the technology on their own terms.

Note that in the IC used in this experiment, a particular limited set of information items could be monitored. In concept, the IC can display a representation for any data value that can be acquired through some means, but this study was limited to the sources that could be specified in the XML specification file being used at the time. The information items available for monitoring were

- Weather information (current temperature and conditions, today's and tomorrow's forecasted conditions and high and low temperatures, all for any zip code in the USA)
- Traffic conditions (average current traffic speed for different highway regions in the local metropolitan area)
- Current time of day
- Stock prices (the current value, per cent change, or dollar value change in an individual stock or market index)
- Airfare price (the current lowest price of a roundtrip flight between any two cities for chosen dates)
- Web image (an image being shown on a particular web page)

4.3 Participants

Eight people participated in the study. Because of a limited number of LCD monitors, the study consisted of two phases with four people each participating concurrently. Participants were sought via fliers and email advertisements, thus some self-selection because of interest in the

topic did occur. Nonetheless, strong variability in the amount and manner of information awareness was evident across the eight individuals.

The participants ranged in age from 34 to 51 years and consisted of two women and six men. A wide variety of professions were represented but all the participants' work was in some way connected to technology and all used computers regularly. Only one participant, number 4, had any knowledge or familiarity with the IC before the study.

Below, we briefly describe each participant and their information awareness characteristics learned from the surveys and interviews. At the end of each description appears a list the participant's responses to the questions below from the initial survey with a scale of 1-*strongly disagree* to 7-*strongly agree* on the first three questions and 1-*definitely not enough* to *5-far too much* on the last question. The participant numbers listed here will be used consistently throughout subsequent discussions to identify the individual.

Q1. I find myself checking information pretty much throughout the day.

Q2. I feel like I effectively keep track of this information.

Q3. Keeping up with the information is a source of anxiety.

Q4. How much time do you spend checking information relative to what you should?

1. A 35-year old technical support staff specialist focusing on usability and HCI. She often evaluates computer user interfaces at work. Routinely, she monitors relatively less information than most of the other participants. (5,4,3,3)

2. A 34-year old business consultant. He interacts with many people and must know about many different local companies. He had the largest and most diverse set of monitored information of any participant. (7,6,4,4)

3. A 43-year old vice-president of development for a start-up software company. He noted that he does not typically monitor information such as that involved in the IC. (1,4,1,3)

4. A 35-year old assistant professor of computer science. He is awash in information, in particular e-mail, and has even written some of his own information handling applications. (7,3,6,3)

5. A 42-year old manager of a biology laboratory. He must maintain awareness of much information about the laboratories he manages, but he monitors study-related information at a relatively low level compared to other participants. (4,3,4,3)

6. A 41-year old investment specialist with a venture capital organization. He must maintain awareness of various news and business information for his job. He is familiar with technology innovation. (5,5,3,3)

7. A 51-year old Chief Executive Officer of a technology company. He closely monitors information details (news, stock performance) of competing companies. Precise values and news matter to him. (7,3,4,4)

8. A 45-year old administrative assistant. She routinely manages and coordinates much information for the people she supports and she maintains awareness of personal information too. She had the least experience with technology of any participant. (6,5,3,3)

5. RESULTS

5.1 InfoCanvas Designs and Use

For all eight of the participants, the IC display was positioned off the person's main desk and away from their primary monitor or monitors. For five of the participants, the IC was hung on a wall like a picture. For the three others, it stood on a table or shelf using a small picture stand or a ledge in one case. Figure 1 shows the positions of all eight IC displays in the study.

Shortly after initial deployment, Participant 3 (P3) moved the IC from the wall above his desk to a wall near the door of the large outer room that holds his cubicle space. Thus, that particular IC display received more use by co-workers and became a kind of group display. All of the other participants had the display in their private office except for P7 who, like P3, has a partitioned personal work area in a larger enclosed and shared office.

Of the 16 different themes available for use, the eight participants selected 6 with 2 themes selected by two different participants. Figure 2 shows example views of the themes used by each person. Four participants chose themes with a more photo-realistic look (the view was taken from an image); three selected themes that were collections of clip art objects; and one selected a theme with objects that were hand-drawn and digitized.

The number of information items monitored and thus corresponding dynamic visual elements present in the IC displays ranged from a low of 6 (P4) elements to a high of 17 (P7) elements with an average of 10.1. P4 had one piece of information represented by three different visual elements as well. As an example, P2's scene is shown in more detail in Figure 3. The visual elements, transformation types, and associated information sources used in it are also listed there.

Figure 1. Views of the eight InfoCanvas deployments in the study, in participant order.

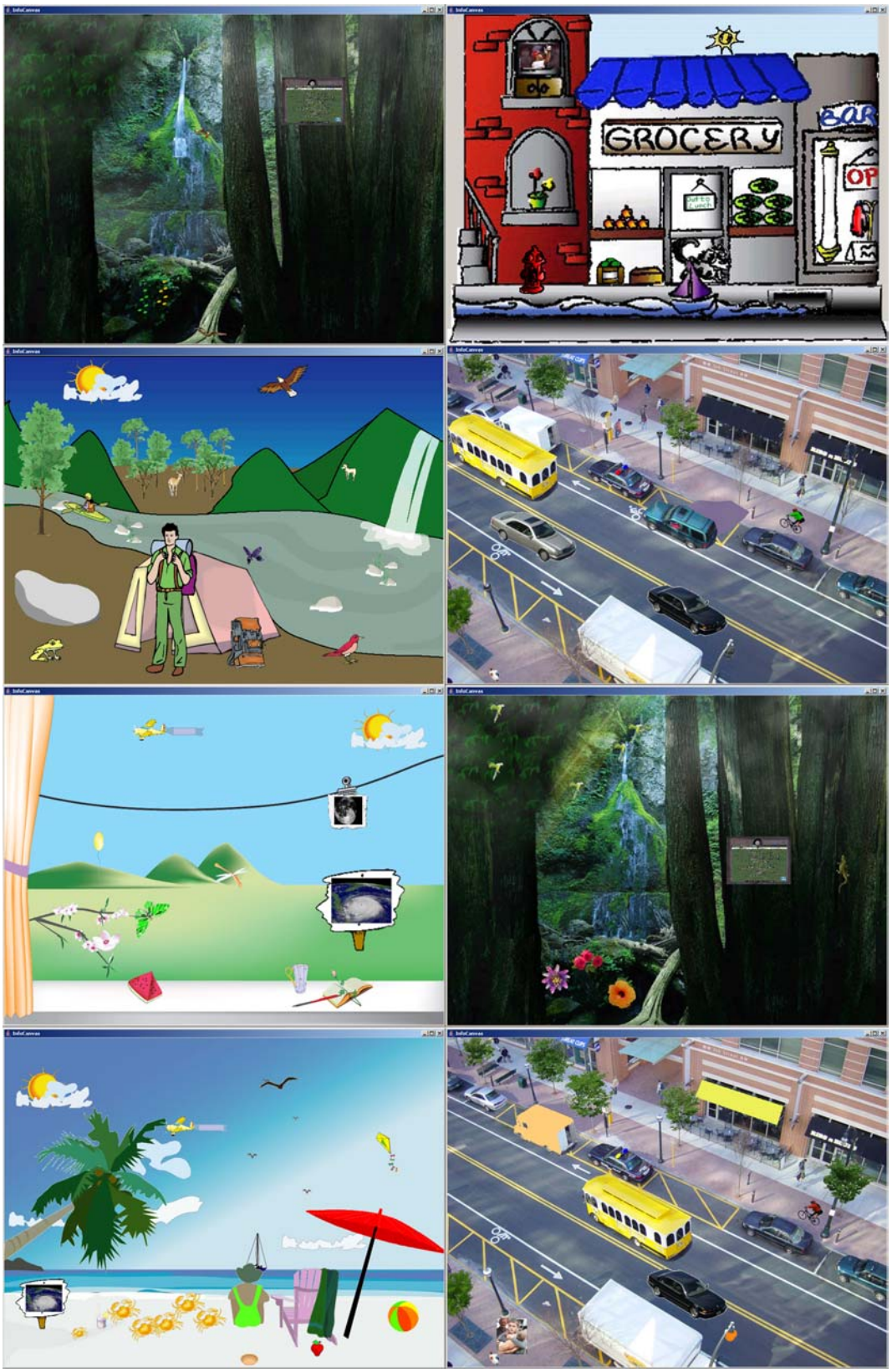

Fig. 2 Sample views from the eight pariticipants' InfoCanvas displays that illustrate the themes chosen by each.

Visual element	Transformation type	Represented information
Open/Out to lunch sign	Swapper	Time of day
Weather in sky	Swapper	Tomorrow's conditions
Awning color	Swapper	Tomorrow's high temperature
Stripes on barber pole	Population	Traffic speed on local road
Number of watermelons	Population	Specific airfare price
Boat mast position	Slider	Specific airfare price
Color of coat on rack	Swapper	NASDAQ stock exchange daily change
Presence of fire hydrant	Appear	Specific stock value below a set amount
Color of flowers in pot	Swapper	Specific stock change percentage for day
Number of apples present	Population	Specific stock change percentage for day
Color of fruit in basket	Swapper	Specific stock change percentage for day
Dog's nose position	Slider	Specific stock value
Television screen	Display	Image from baseball website

Figure 3. An example view from P2's IC display along with the set of mappings from information to visual objects.

With respect to the different types of transformations, participants most used the swapper, slider and image display transformations. The scaler, population, and appear transformations were only used a few times each across the entire study. When a data source was strongly viewed as state-based (e.g., weather conditions), participants primarily used an image swap. Conversely, continuous-valued data sources such as airfares, temperatures, and stock values were portrayed relatively evenly by sliders and swappers. Traffic, although identified by a continuous value (average speed) was clearly thought of in a state-based manner (good, fair, bad) and portrayed almost exclusively with an image swap. Time was the one continuous value where a slider was the clear representation preference. Images from news (twice), sports, and weather radar (twice) websites were displayed, as was the NASA image of the day (twice).

Both direct and symbolic visual elements were used to represent data with a moderate preference for more direct mappings, or at least meaningful ones when available. For instance, participants represented weather by conditions shown in the sky or traffic by cars, except when a theme had no sky or cars present, respectively. Less obvious meaningful mappings were used too. P7 used an apple "slider" on the beach to represent the value of Apple Corporation's stock. P8 represented the cost of an airfare by the number of people on the street, where each person present represented the first digit (hundreds) in the price. She commented, "More direct mappings are easier to remember." Data without any natural representation (stocks, temperature, time) required participants to be more creative and many unusual mappings were employed.

At the midpoint interview session, each person could modify their IC, and seven of the participants chose to do so with only P7 making no changes. Modifications ranged from a simple change making one static background object become a slider element (representing a stock market index) to the addition/change of five different visual elements.

When asked about his representations at the midpoint interview, P2, who routinely monitors a great deal of information, said: "I'd love for everything on there to represent something. I look at everything that doesn't represent something as kind of wasted. That bar sign—change it to something else, or the brick color, or are the shades up or down." He then requested a number of modifications to his representations for the final two weeks of the study. When asked about the changes at the final interview, he felt that the modifications were a mistake because he had already established the mappings clearly in his thoughts, but then they were changed. His newly established mappings were not viewed so negatively, however, presumably because there was no pre-existing representation to cause cognitive interference. No other participant expressed this desire to have every visual element represent some information.

On the technical side, participants had to restart the IC application from time to time because of system and network connectivity issues, but no major technical difficulties arose except for P5 whose IC would exhaust memory and stop inconsistently. Around the midpoint session of the study we discovered that simply allocating more memory at start-up to the java virtual machine running this particular IC solved the problem. Once that change was made, the participant's IC system did not stop in that manner.

At the midpoint and final sessions, we asked the participants if they needed to examine a reminder sheet that listed their information-to-graphics mappings. All but one of participants said that they initially did, but each remarked to learning most of the mappings quickly and generally not referring to the card thereafter. P7 represented seven different stocks by seven

contiguous objects and he was not able to remember which icon corresponded to which stock. Otherwise, recall did not appear to be a problem.

We also asked participants whether they had ever used the mouse-over feature to acquire details about an information source. Four (midpoint) and five (final) participants stated that they did, but described the frequency with terms like "occasionally", "a couple times", or a "a little". This was a dramatic difference from an earlier pilot study of the system [18] in which the mouse-over capability was heavily used. In that study, IC displays were simply placed on normal LCD monitors on people's desks. Users thought of the displays much more as normal monitors running a computer application (the IC). In the present study, the use of picture frames and position of displays in the periphery appeared to lead participants to think of the IC displays more as stand-alone entities.

5.2 System Objectives

In this section, we discuss participants' use and impressions of the IC with respect to the five evaluation dimensions identified earlier. At the end of each section are summaries of the responses from the midpoint (white) and final (gray) survey questions relevant to that dimension. Responses are all from a scale 1-*strongly disagree* to 7-*strongly agree*.

Usefulness

Perhaps the key characteristic of the IC being evaluated was whether participants felt it was useful. Did they stay aware of information better? Did it save them time and reduce interruptions resulting from checking information via traditional means (e.g., web browsing)?

The general sentiment of participants, as reflected by the survey data below, was that the system was useful. Opinions ranged from mild agreement to strong confirmation. We noted that the information awareness characteristics of the individual seemed to be correlated with opinions, however. For instance, P3 was clearly the person who felt the least enthusiastic about the utility of the system. He acknowledged, however, simply not having much information (that could be monitored by IC) of personal interest. P7 felt it was useful but stated that he still routinely examined his prior information sources. For his work, he needs to know exact stock values, news headlines, announcements, and so on. Thus, he used the IC as an informal alert but still reverted to web pages for the details. The other six participants strongly felt that the IC was useful. They had more information to monitor than P3 but did not require details like P7, thus occupying a kind of "information awareness sweet spot" in between the two extremes that seems to be an appropriate position for IC utility.

P3, who was least enthusiastic about the system, also expressed the desire for more direct representations of information, even suggesting a display of four quadrants with traditional information representations (e.g., weather and traffic maps). Because of its deployed position, his display was noticed frequently by members of his group, the majority of whom are engineers. He noted that a few of them did not understand the value of the symbolic representations and wondered why the system just did not show the actual values, traffic, and weather maps.

Conversely, participant remarks as to why the system was useful focused on the IC's presence lessening the need for time-consuming information checks into other sources such as the WWW. P1 felt that the IC was most useful for "…the stuff that it takes some time to look up." She described how long it would sometimes take her to find a weather radar image, something she could have constantly available on the IC.

P4 remarked, "I found it really helpful to be able to just glance at it and know it's [traffic is] OK." Even though a website detailing local traffic was available, he had not used it due to the time and effort it would take. He described how websites are set up for lots of people to query, but he just wants answers for his particular situation. P4 further commented, "It's useful without being irritating…this doesn't feel heavy. Now of course one of the reasons it doesn't feel heavy is because it's sort of out of my normal line of sight. It's in a sort of natural place where when I lean back and I'm staring off so I can kind of get it. So my eyes kind of drift there through the natural course of things when I'm not particularly concentrating on something else. So it's been positive—it's been useful without being terribly distracting. It hasn't been distracting at all. It's there when I need it, but doesn't require me clicking and mousing."

P8 stated that checking airfares on the web could require too much "digging around" but the IC assisted this task. She remarked that she did not check airfare websites (as before) during the study's duration because of the IC.

P2 commented that the IC was "…good because I get it [information] at a glance." P6 remarked, "I like the fact that I can look at it in one quick glance and get it OK, then return to what I'm doing. With a website, I can take a half hour there." P1 stated, "I could just glance over and check out something without searching for it like going to Yahoo weather. It saved me time. It was quick. It was easy to learn for me, what things meant, kind of quick."

Consolidation of information, a design principle for the IC, also was noted by participants. P4 commented, "It really does give me a lot of useful information at once," and P6 said, "What's important here is the aggregation of information." P7 had been using the Ambient Orb, a product of Ambient Technologies that glows shades of different colors top indicate stock values [3]. He stated that, "[The IC] is much more useful than the Orb. The Orb is simple and colorful but it's only tied to one variable."

In order to asses utility more specifically, we asked participants to recall any incidents where the system influenced their behavior. Three participants, like P8 above, remarked that they visited certain information-providing web pages less frequently or not at all. Interestingly, all participants reported having the IC cause further investigation into information too, but all in a positive light. Half the participants wanted to learn more about displayed images from websites (news and sports headline pictures or the NASA image of the day). Participants also reported seeing stock, weather, and traffic data (typically of some exceptional condition) and then delving deeper via web pages.

P2 commented, "I looked up one time, saw full red [barber pole signifying slow traffic] and decided to work for another half hour." P8 learned that indications of slow traffic meant a concert would be taking place that night and thus she would use a particular lane of traffic upon entering the freeway to avoid drivers lining up at a nearby exit.

	1	*2*	*3*	*4*	*5*	*6*	*7*	*Avg.*
A			|	|	||	||||		5.1
				||	|	||||	|	5.5
B		|	||	|	|||	|		4.1
				|||||	|	|		4.4
C				|	||	||	|||	5.9
					||||	|	|||	5.9
D				|	||	|||	||	5.8
					||||	|||	|	5.6
E				||	|	|||	||	5.6
				|	|||	|||	|	5.5
F		||||	||	|	|			2.9
		|||||		|	|			2.6
G				|||	|	||	||	5.4
			|	|	|||	|	||	5.3

A. The IC is a useful addition to my work area.

B. The IC helps me to be more efficient in my daily tasks and work.

C. The IC helps me to access information more *quickly* than my previous methods.

D. The IC helps me to access information more *easily* than my previous methods.

E. Having all the information together in one place is important to me.

F. I have difficulty interpreting the visual display.

G. The IC accurately reflects the state of information.

Table 1. Summaries of the responses from the survey questions relating to the InfoCanvas's usefulness. Each tick mark represents a participant response, taken from a scale of 1-strongly disagree to 7-strongly agree. The upper white line of each question lists responses from the midpoint survey and the lower gray line lists responses from the final survey.

Personalization and Flexibility

A key objective of this evaluation dimension was to determine whether the system flexibility and the ability of individuals to customize a display to their preferences, as hypothesized in the system design [18], truly are important characteristics.

Evidence supporting the importance of personalization is provided by the number of different themes chosen by participants, the diversity of information being monitored (even with the restricted IC capabilities), and the variety of information-to-graphics mappings employed. Participants' choices and designs simply varied significantly. Furthermore, survey responses confirmed that view.

Personal circumstances mattered too. P2 chose a mountain backpacking scene because that is an activity and environment he enjoys. P5's office does not have a window, so he chose a theme of

looking out a window. Other participants chose the different scenes primarily because they liked the theme's appearance best.

Even though participants could not personally modify their IC, we asked about that potential ability. All felt that would be useful, with sentiments ranging from mild agreement to stronger importance. P4 stated a desire for a graphical IC editing tool to make changes. A number of participants remarked that after a few days of use, they "learned" the concept and wanted to make some changes in representations and mappings.

Another aspect of personalization is the privacy afforded by abstract graphical mappings. Other people do not know what a person's IC "means." We asked participants if this was important. Seven of the eight participants indicated that it did not matter or was not important. P1 was the lone dissenter and felt that the privacy aspect of the system was important, stating, "I like the fact that it means something to me and not someone else."

	1	*2*	*3*	*4*	*5*	*6*	*7*	*Avg.*
A					|	|||	||||	6.4
					||	|||	|||	6.1
B		|||		||	|	||		3.9
	|	|||		||	|	|		3.3

A. The ability to display information that is *personally* relevant to me is important.

B. The fact that other people don't know my information-to-graphics mapping is important to me.

Table 2. Survey responses relating to the InfoCanvas's personalization and flexibility.

Aesthetics

Along with usefulness, aesthetics plays a key role in the IC. In the study, we sought to determine whether participants felt the IC was an appealing addition to their office.

Comments from the majority of participants were positive. P2 stated, "I love the way my picture looks." P8 commented, "Even if it wasn't the IC, it would still be a nice picture to look at."

Some participants were not so positive, however. P2 liked the camping motif, but felt the graphics and scene were simple and primitive. P7 felt that the scenery in his IC would "get old after a while," and commented that the aesthetics would have to improve greatly if the system were to become a real product. In addition to commenting on the picture views, multiple participants felt that the display cords significantly detracted from the system.

P1's theme initially did not stretch to the horizontal borders of the display, which greatly bothered her, and she disliked the title bar at the top of the IC window. She commented, "It's a make or break thing for me with the form factor." Both of those complaints were remedied at the midway point and she felt more positive about the system then: "For me the form factor that I had such a hard time with in the beginning, some of these got fixed and I treated it more like a picture and I looked at it more because it wasn't bothering me. And so when you treat it like a picture, then you kind of use it for the information that it's more for." That stated, in the final

interview she also commented about wanting an even nicer frame and a larger display: "I would very much like a slicker form factor."

Of the themes chosen for use, half were cartoon or clip-art style and half were more photorealistic in appearance, taken from actual pictures. Participants were divided on their preferences. P2 commented, "I like the way it's kind of cartoony." P1, P4, P6, and P8 all preferred the more realistic scenes, however. P4 commented that many visitors to his office thought that his IC was a live video feed from the street in front of his office building. P8, who used the same scene, felt that people could relate to her (local) picture and that made them more interested in it.

	1	*2*	*3*	*4*	*5*	*6*	*7*	*Avg.*
A			|	|	||||	|	|	5.0
				|	|	|||||	|	5.8
B		|	|	|	|	|||	|	4.9
			|	||		||	|||	5.5

A. I like the way my IC looks.

B. Other people say nice things about the way the IC looks.

Table 3. Survey responses relating to the InfoCanvas's aesthetics.

Distraction

The ever-present characteristic of the IC could potentially be a distraction to users. We sought to determine whether participants felt the system was intrusive or whether its presence had some other effect.

When queried about this characteristic, participants responded in a notably consistent fashion. Six of the eight participants stated that the IC was not distracting at all, and the other two expressed relatively similar views. P5 said that it was a little distracting the first week because it was a new thing, and P3 stated that it was "…distracting at times when I needed to be distracted."

In one interview question, we posited that the IC could be positioned along a spectrum with calmness on one end and anxiety on the other end. We asked participants to appropriately position the IC on that spectrum. All felt that it was more of a calming influence. More specifically, P7 believed that the IC caused less anxiety than the Internet or TV due to its lack of dynamics (notable visual changes). He felt this was good—it does not replace these other information sources but rather complements them. P6 stated that the IC is calmer than a live news feed. He cited the system's abstractness of representation and also the "…fact that it's always there versus sometimes. You don't have to keep looking for it."

A number of participants commented that the system elicited so many inquiries that it became almost distracting. P5 said that he explained its purpose so many times the first week that he put a piece of paper next to the display on the wall in order to describe what it is and how it works.

Survey data further confirmed participants' views about distraction. Note how opinions became even stronger after the entire month, suggesting that with time participants became more comfortable with the system.

	1	*2*	*3*	*4*	*5*	*6*	*7*	*Avg.*
A	|	|||	||	|	|			2.8
	|||	|||	|	|				2.0
B			||	|||	|||			4.1
				|||	||||		|	4.9
C		|	||		|||	||		4.4
		||||	|||		|			2.8

A. The IC is a distraction.

B. The IC decreases my anxiety about the information I am monitoring.

C. I check the IC more often than is necessary or informative.

Table 4. Survey responses relating to the InfoCanvas's distraction.

Novelty and Fun

One reason for creating the IC was to provide an information communication tool that provided more than just "the facts." In addition to being aesthetically-pleasing, hopefully the system would generate a sense of fun or whimsy. Reactions from participants indicated that it did.

P4 called the IC a "nice gizmo." P8 said, "It's just cool…I don't want you to take it away." All the participants noted one way that the system functioned as a novelty—it evoked curiosity in visitors. P1 remarked that many office visitors asked, "What's up with that?" or "What in the world is that?" P2's job function includes meeting many new people and acting as a kind of ambassador for a local technology organization. He stated, "Everybody's interested in it. Their eyes are immediately drawn to it." Some visitors thought that it was a picture done by his child. He commented further, "I catch people glancing up there. I have to stop what I'm doing and explain it. But it's also been a very good ice-breaker when someone comes in and we're chitchatting. I see them glance up and say, 'Oh, let me tell you about this.'"

To confirm the novelty characteristics further, we asked participants whether they had told people other than their work colleagues about the system. All stated they had done so with a rough average of about three or four people told. Most participants told their significant other and some friends about it.

	1	*2*	*3*	*4*	*5*	*6*	*7*	*Avg.*
A				|	|||	|	|||	5.8
					||||		||||	6.0
B				||	|	||	|||	5.8
				|	||	|	||||	6.0

A. The IC is a fun addition to my office.

B. I enjoy having the IC in my office.

Table 5. Survey responses relating to the InfoCanvas's novelty and fun.

Summary Impressions

In the final interview we asked each participant if their experiences using the IC were positive or negative. All characterized their experience as positive. We asked if they would continue to run the system if given the opportunity and whether they would recommend other people to run it. Again, all participants responded positively to both questions. We also asked the participants to provide two or three words that would best describe the system. The words "interesting" and "fun" were provided four times each; "informative" was mentioned three times; and the words "potential," "novel," "encompassing," "benign," and "cool" were given once.

A few hypothetical questions in the final interview asked participants to speculate about further use. Would the participants change their IC theme if they continued to run the system? Four said they would change (P3, P4, P6, P7) but one (P4) stated he would do it just to try another. P3 said he would keep the same motif (camping/outdoors) but wanted a better picture. P5 said he might change. All participants felt that the ability to change or add new information being monitored would be an important feature.

We also asked the participants to imagine a similar deployment (location, picture frame) but with the display only showing textual labels and values for the same information being monitored. What would they think of such a system? All speculated that they would prefer the graphical IC. P8 stated, "That just sounds like it will be boring. This is pleasing to the eye." P2 concurred, "I wouldn't want it. This is art." P7 had slightly different reasons as he stated, "The more text it gets, the more it's going to morph into a web page," and, "I think that graphically it's easier to get the information."

So, in general, participants reacted quite positively to the system. But why and what characteristics most stood out? Participant comments seemed to resonate most strongly on two key themes. First, as mentioned earlier in the discussion on usefulness, the system was viewed as a time-saver. P6 commented that the IC was a kind of "push" technology that succeeds where other earlier ones (e.g., scrolling tickers) did not: "Everybody became so overloaded with information that they didn't know how to organize it, and this is also some sort of organizational tool where you pick information. Instead of some fire hose, you have a bunch of little garden hoses that direct it efficiently, that you can pay attention to."

The second main theme emerging from the interviews was that the lack of details provided by the abstract/symbolic representations actually was a benefit. P6 felt that people get too carried

away with details, but he often just wants to know general values. If details are subsequently necessary, he will take the time to uncover them. P2 also expressed this view: "I can't even tell you what XYZ stock is now. I can tell you a range. It's probably around 13 and that's good enough for me. But if it's [actual value in text] up there and then I know it's 13.04 or 13.08 or 13.09, and so it's almost like more for me to remember. Oh it's 13.09. What was it yesterday, 13.08? So I think it's more the trendiness. Just like the dog up there [on his IC]. I guess it's around the same spot. It's close enough for me. But having numbers will give me exact numbers and that might be just too much for me. And I don't care if traffic is 20 miles per hour or I don't care if traffic is 50 miles per hour. What I care is that it's moving."

	1	*2*	*3*	*4*	*5*	*6*	*7*	*Avg.*
A				|	|	||	||||	6.1
B					||	|||	|||	6.1
C			||	|	||	||	|	4.9
			|||	|	|	|	||	4.8

A. I would continue running the IC if given the opportunity.

B. I would encourage other people to use the IC in the future.

C. I would like to have an IC running on a wall in my home.

Table 6. Survey responses relating to summary impressions of the InfoCanvas. Items A and B were only queried on the final survey.

6. CONCLUSION

In this article we have described a study of eight people using the IC system for one month. One of the primary contributions of the work is an in situ study documenting how a peripheral awareness system has been used. Study participants found the IC to be useful, informative, and they expressed a desire to continue to run the system in their office. Especially significant is the fact that the study incorporated a real deployed system, not a simulation.

Accompanying the positive aspects were somewhat mixed reviews of the aesthetics of the IC scenes and device. Roughly half the participants found the IC to be appealing and the other half believed improvement is necessary.

It is important to recognize that the IC is not addressing extremely crucial, life-changing tasks. Avoiding traffic jams, remembering to take an umbrella outside, or saving some money on a plane trip are not critical actions, but they are the day-to-day occurrences that are so pervasive in our lives and that influence our mood and our well-being. If a peripheral awareness system is able to aid such tasks, then it is meeting its purpose.

Below we list several lessons learned from the study that can function as guidance for other peripheral display developers and HCI researchers working in similar areas.

Personalization is important—The different personalities, interests, and jobs of people influence their need for and comfort with awareness techniques. A one-size-fits-all approach is

unlikely to succeed in this domain because interests are simply so varied and because aesthetics play such an important role. Furthermore, personalizing awareness information provides an advantage over general-purpose websites and information distribution mechanisms that are designed for the common good but whose generality can also make identifying specific information more difficult and time-consuming. The importance of personalization applies to both the information being monitored and the manner in which it is presented.

"Push" technology merits reconsideration—Researchers should rethink the movement away from push techniques for information awareness. Push-based techniques can free people from time-consuming information requests, but the information pushed must be personally relevant and the delivery style and representation are extremely important. Techniques that are "calmer" and do not focus attention on themselves may be better received.

Abstractness/symbolism can be beneficial—The use of abstraction or symbolism to hide details and only communicate trends or relative values can be an advantage rather than a limitation. Symbolism can be particularly meaningful, personally relevant, and when the end-user creates the symbol, it is easy to recall as well. Furthermore, actually hiding details through abstraction can better match awareness goals where speed and ease of information acquisition are more important than exact transmission of precise values.

Consolidating information is valuable—By bringing together the presentation of multiple information sources into a consolidated interface or piece of hardware, one is able to provide further value to users of a system. With one quick glance, a viewer is able to assess the state of a number of different items of interest, thus saving time and effort. Moreover, in crowded rooms or offices, extra space for multiple display objects simply may not be available.

Aesthetics should not be overlooked—When ubiquitous computing systems become personal objects and constant companions, the visual appeal of the systems should be carefully considered. In addition to getting the technology right, developers must focus on aesthetics too. This notion is particularly true when a system will be in long-term use. As further evidence of this point, consider the number of different styles of clocks that have been created, arguably the oldest type of peripheral awareness system.

Better customization tools are needed—In order to achieve the above goals of personalization and aesthetics, better end-user customization tools are needed. In an ideal awareness system, the end-user should be able to design or at least refine the representation of information of interest. Such customization tools could facilitate a growing community of developers where people borrow from and make use of the sophisticated designs of others.

Our future work with the IC system meshes with the lessons identified above. We plan to distribute the system to an even wider audience of people for use and evaluation; we specifically seek to enhance, refine, and improve the system's aesthetics; and we continue to work on improved authoring tools that will allow end-users to both design and implement IC views.

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REFERENCES

1. Abowd, G.D. and Mynatt, E.D. Charting Past, Present, and Future Research in Ubiquitous Computing. *ACM Trans. on Computer-Human Interaction 7*, 1 (2000), 29-58.
2. Abowd, G.D., Mynatt, E.D., and Rodden, T. The Human Experience. *Pervasive Computing 2*, 1 (2002), 48-57.
3. Ambient Devices. http://www.ambientdevices.com.
4. Cadiz, J.J., Venolia, G., Jancke, G., and Gupta, A. Designing and deploying an information awareness interface. *Proc. CSCW 2002*, (2002), 314-323.
5. Consolvo, S. and Walker, M. Using the Experience Sampling Method to Evaluate Ubicomp Applications. *Pervasive Computing 2*, 2 (2003), 24-31.
6. Consolvo, S., Roessler, P., and Shelton, B.E. The CareNet Display: Lessons Learned from an In Home Evaluation of an Ambient Display. *Proc. Ubicomp 2004*, (2004), 1-17.
7. De Guzman, E.S., Yau, M., Gagliano, A., Park, A., and Dey, A. Exploring the Design and Use of Peripheral Displays of Awareness Information. *Extended Abstracts CHI 2004*, (2004), 1247-1250.
8. Holmquist, L.E. and Skog, T. Informative art: Information visualization in everyday environments. *Proc. Graphite 2003*, (2003), 229-235.
9. Hudson, J.M., Christensen, J., Kellogg, W.A., and Erickson, T. "I'd Be Overwhelmed, But It's Just One More Thing to Do:" Availability and Interruption in Research Management. *Proc. CHI 2002*, (2002),97-104.
10. Ishii, H., Wisneski, C., Brave, S., Dahley, A., Gorbet, M., Ullmer, B., and Yarin, P. ambientRoom: Integrating Ambient Media with Architectural Space. *Proc CHI 1998*, (1998), 173-174.
11. Maglio, P.P, & Campbell, C.S. Trade-offs in Displaying Peripheral Information. *Proc. CHI 2000*, (2000), 241-248.
12. Mankoff, J., Dey, A.K., Hsieh, G., Kientz, J., Ames, M., Lederer, S. Heuristic evaluation of ambient displays. *Proc. CHI 2003*, (2003), 169-176.
13. McCrickard, D.S., Catrambone, R., Chewar, C.M., and Stasko, J. Establishing Tradeoffs that Leverage Attention for Utility: Empirically Evaluating Information Display in Notification Systems. *International Journal of Human-Computer Studies 8,* 5, (2003), 547-582.
14. Miller, T. and Stasko, J. Artistically Conveying Information with the InfoCanvas. *Proc. AVI 2002*, (2002), 43-50.
15. Plaue, C., Miller, T., and Stasko, J. Is a Picture Worth a Thousand Words? An Evaluation of Information Awareness Displays. *Proc. Graphics Interface* 2004, (2004), 117-126.
16. Scholtz, J. and Consolvo, S. Toward a Framework for Evaluating Ubiquitous Computing Applciations. *Pervasive Computing 3*, 2 (2004), 82-88.
17. Skog, T., Ljungblad, S., and Holmquist, L.E. Between Aesthetics and Utility: Designing Ambient Information Visualizations. *Proc. InfoVis 2003*, (2003), 233-240.
18. Stasko, J., Miller, T., Plaue, C., Pousman, Z., and Ullah, O. Personalized Peripheral Information Awareness through Information Art. *Proc. Ubicomp 2004*, (2004), 18-35.