Animation in a Peripheral Display: Distraction, Appeal, and Information Conveyance in Varying Display Configurations

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ABSTRACT

Peripheral displays provide secondary awareness of news and information to people. When such displays are static, the amount of information that can be presented is limited and the display may become boring or routine over time. Adding animation to peripheral displays can allow them to show more information and can potentially enhance visual interest and appeal, but it may also make the display very distracting. Is it possible to employ animation for visual benefit without increasing distraction? We have created a peripheral display system called BlueGoo that visualizes R.S.S. news feeds as animated photographic collages. We present an empirical study in which participants did not find the system to be distracting, and many found it to be appealing. The study also explored how different display sizes and positions affect information conveyance and distraction. Animations on an angled second monitor appeared to be more distracting than three other configurations.

CR Categories: H5.2. Information interfaces and presentation (e.g., HCI): User interfaces – evaluation/methodology, graphical user interfaces, screen design.

Keywords: Peripheral display, animation, evaluation, information visualization

1 INTRODUCTION

Most people enjoy maintaining awareness of information such as news, weather, and entertainment, as well as other personally relevant information such as friends' activities or their child's lunch menu. A variety of ambient information systems [18] have been created to convey this kind of information to people [3, 4, 5, 6, 7, 10, 11, 13, 17, 20, 21, 23, 25]. Such displays typically seek to communicate information to people while also adding to the sense of aesthetics or fun within one's environment. The key benefit of such peripheral awareness systems is that people are able to opportunistically examine these displays at their leisure. Thus, they provide an instance of Weiser's calm computing [25] where technology smoothly and seamlessly transitions from the background to the foreground and then back to the background.

Many of these ambient information systems, such as the Dangling String [25] or Water Lamp [13], use physical devices that are placed within in a person's environment. Although a few peripheral awareness systems have been commercialized, such as the Ambient Orb [1], most systems require specialized hardware and thus are not widely deployed.

A number of peripheral awareness systems use computer displays for conveying information to users rather than special-purpose hardware, however. Examples of such systems include Kandinsky [6], Digital Family Portrait [17], Informative Art [20], InfoCanvas [21], Sideshow [3], and various information tickertapes [15,16]. The increasing presence of multiple monitor computer systems, in particular, has provided many more pixels for communicating information and thus makes systems such as these very realistic. When a person uses a multiple monitor configuration, one display typically serves as a primary display while the non-primary display(s) reside in the periphery. Such secondary displays represent an opportunity for individuals to maintain peripheral awareness of information. Grudin's study of multiple monitor computer systems identified that many people indeed do use extra monitors to contain peripheral information awareness aids [9].

Because peripheral display systems such as the ones described above are not meant to be attention-grabbing and should not distract users, they are typically static or only make infrequent updates to a small portion of the display. Unfortunately, this restricts the amount of information they can present to what can be shown in one view. In addition, static displays that do not ever change their fundamental appearance may become boring or may lose interest over time. In a longitudinal, in-situ study of the InfoCanvas, several participants remarked that they might tire of the same electronic display and wished to change elements of the display, or to try different themes in the future [22].

What, then, can be done to 1) show more information on a peripheral awareness display and 2) make the display more appealing and interesting? Incorporating animation or motion into such electronic display-based peripheral display systems is one possibility. Motion is already an integral part of many physical ambient displays such as the Dangling String [25], Information Percolator [10], pinwheels [5], and several Phidgets-based displays [7]. In addition, subtle animations are increasingly incorporated into all parts of daily life, ranging from checkout kiosks in stores, to the slideshows shown before movies in theaters, to the over-the-shoulder graphics found on newscasts.

Designers have largely avoided the use of animation in peripheral displays on computer monitors, however. Maglio and Campbell explicitly state that peripheral display designers should minimally use motion or animation in their displays, and when used, it should not be of a continuous nature [15]. Conversely, McCrickard et al found that animation can be used in desktop tickers, minimally impacting users from certain primary tasks [16]. Bartram et al conducted a series of studies examining animation in the periphery, establishing a set of guidelines for motion-based techniques [2]. They found that traveling and zooming motions are most distracting and recommended slow linear motion for good detection with minimal distraction. This study focused on secondary tasks that share screen real estate with the user's primary task though. In other domains, such as ubiquitous computing, researchers actually have explored animation as a mechanism for inducing change blindness [12].

2 THE BLUEGOO SYSTEM

To explore the issues discussed above, we have created BlueGoo, a peripheral information display system that visualizes Really Simple Syndicate (R.S.S.) news feeds in the form of dynamic, animated photographic collages (Figure 1). Collages have been used in several peripheral display systems to convey information on secondary displays [8, 26]. When a collage is active, its images continually pan and zoom as well as fade in and out via alpha-blending. The combined slow pan and zoom effects resemble a technique Apple Computer uses in screensavers and has coined the "Ken Burns effect" in homage to the American documentary maker. Similar to CollageMachine [14], no two collages are identical in BlueGoo; each new collage is created by randomly calculating coordinates and vectors, as described below.

Our goal was to create a system with high visual appeal and interest that could communicate many different news stories, but would do so in a calm, non-distracting manner. Many R.S.S. or news service feeds provide on the order of 50-100 stories, so we wanted to develop a system that could show this many articles. Additionally, BlueGoo can be run on a person's second or third monitor as a peripheral display or on a large plasma or LCD display in a public area where many people pass by. Our intent explicitly was not to have the system draw attention. Instead, it should work in a peripheral manner, affording intermittent viewings throughout a day.

A BlueGoo collage is generated in five stages: image selection, image manipulation, textual cues, background color, and collage transition.

Image Selection: BlueGoo uses a technique introduced by the Kandinsky system [6] to select images. Each keyword in a news headline is sent as a separate query to an image database which returns a set of images associated with that term. BlueGoo randomly selects one of the largest images from that set to be used in the collage, and it also retrieves any images that accompany the news story.

Image Manipulation: The size of the images selected during the previous process influences the set of possible animation techniques BlueGoo will perform on the image. Thresholds based upon the resolution of the target output device are defined, allowing each image to be classified as large (the image is approximately the size of the output device or larger), medium (between 1/3 of the output device screen area and the full area) or small (less than 1/3 of the output device screen area). BlueGoo then randomly selects a series of animation effects for an image depending on its size. Large images, for example, are either

- scaled down substantially during the initial display and subsequently scaled up as the animation progresses;
- scaled down from their initial size as the animation progresses.

Medium images are manipulated in one of five manners:

- no scaling occurs during the animation process;
- the image is scaled up from its original size during the animation process;
- the image is scaled down from its original size;
- the image is initially scaled up and then is subsequently reduced during the animation process; or
- the image is scaled down initially and is subsequently enlarged.

Small images are manipulated in one of three manners:

- the image is scaled up from its original size during the animation process;
- no scaling is performed throughout the animation; and
- the original image is scaled up initially and is subsequently scaled down.

BlueGoo then calculates the initial random scaling factors and movement deltas corresponding to each image's classification. Initial transparency levels and deltas are determined as well.

The initial layout of the images is determined next. The screen canvas is divided into quadrants and BlueGoo assigns images to each quadrant, as well as randomly determining if an image should be enlarged and placed as a background image. Vectors for panning movement are also calculated at this time. The movement vectors are random but are weighted to make it more likely that an image's path will not move off-screen quickly. All of these values are random, so each BlueGoo collage is unique.

Textual Cues: Representing words and phrases solely by images introduces several issues and problems. Images returned to match particular keywords are often ambiguous and they may not clearly communicate the notion of the keyword. BlueGoo provides additional content cues by adding text to the collages. Isolated keywords or headlines are stylized, placed in the displays, and animated along with the image elements. Textual elements also receive panning, zooming, and transparency effects, like images.

Background Color: The background color of each collage is selected randomly from a palette of predetermined colors. This palette is easily extensible via a configuration file to allow user customization. BlueGoo ensures that the same background color is never used in two consecutive collages, thus providing a cue

Figure 1. Example frames of automatically generated BlueGoo collages visualizing news stories from an R.S.S. feed. Note that the static nature of the printed page does not convey the dynamic and expressive nature of these collages.

that the topic of the collage has changed. In addition, the use of a color palette allows users to choose color schemes that may accentuate an environment or mood.

Collage Transition: Individual collages fade in and out gradually. Initially, the alpha values are manipulated to create a slow dissolve-in effect. Subsequently, all the elements proceed to pan and zoom along the randomly calculated vectors, and each element randomly varies its alpha values. After a user-defined time interval has passed, all elements within the collage slowly dissolve out. The background color slowly transitions to a new color, and the next collage's elements slowly dissolve in.

Unfortunately, the static medium of paper cannot adequately convey this entire process. To see example BlueGoo collage animations, please visit *http://www.cc.gatech.edu/gvu/ii/bluegoo*.

3 Evaluating Animation in the Periphery

We used the BlueGoo system to explore a variety of different research questions. Can animation provide increased visual appeal in peripheral displays? Does that animation necessarily also increase distraction? Can people infer the topic matter of the kind of collages shown in BlueGoo? Furthermore, with the increasing use of multiple monitor systems and large flat panel displays, we were curious if display size and location would influence people's perceptions of aesthetic appeal and distraction. Evaluating peripheral displays is inherently difficult because of their unobtrusive premise and nature. If an experimenter draws attention to a peripheral display, then participants are likely to focus on it more than they naturally would. Conversely, if no reference to the secondary display is made, participants likely will ignore it.

Our study design explored both cases in order to span the different possibilities. Participants performed a main Web browsing task on a standard 17" LCD display while BlueGoo ran on a secondary display. Half of the participants were told about the system running on the secondary display while the other half were told nothing about the second display. After participants completed the primary task, we assessed recall of the information from the BlueGoo collages on the secondary display. We also interviewed participants about the perceived distraction of the secondary display.

Participants: Thirty-two (6 female) people participated in the study and were compensated $5 for their time. All participants, except for one freelance designer, were university graduate students.

Materials: Since peripheral display and multiple monitor systems may be placed and configured in a variety of ways, we also wanted to explore the effects of animation at various positions in a person's periphery. Figure 2 illustrates the four display configurations used in this study: dual side-by-side LCD displays, a main display with a secondary 17" LCD display angled

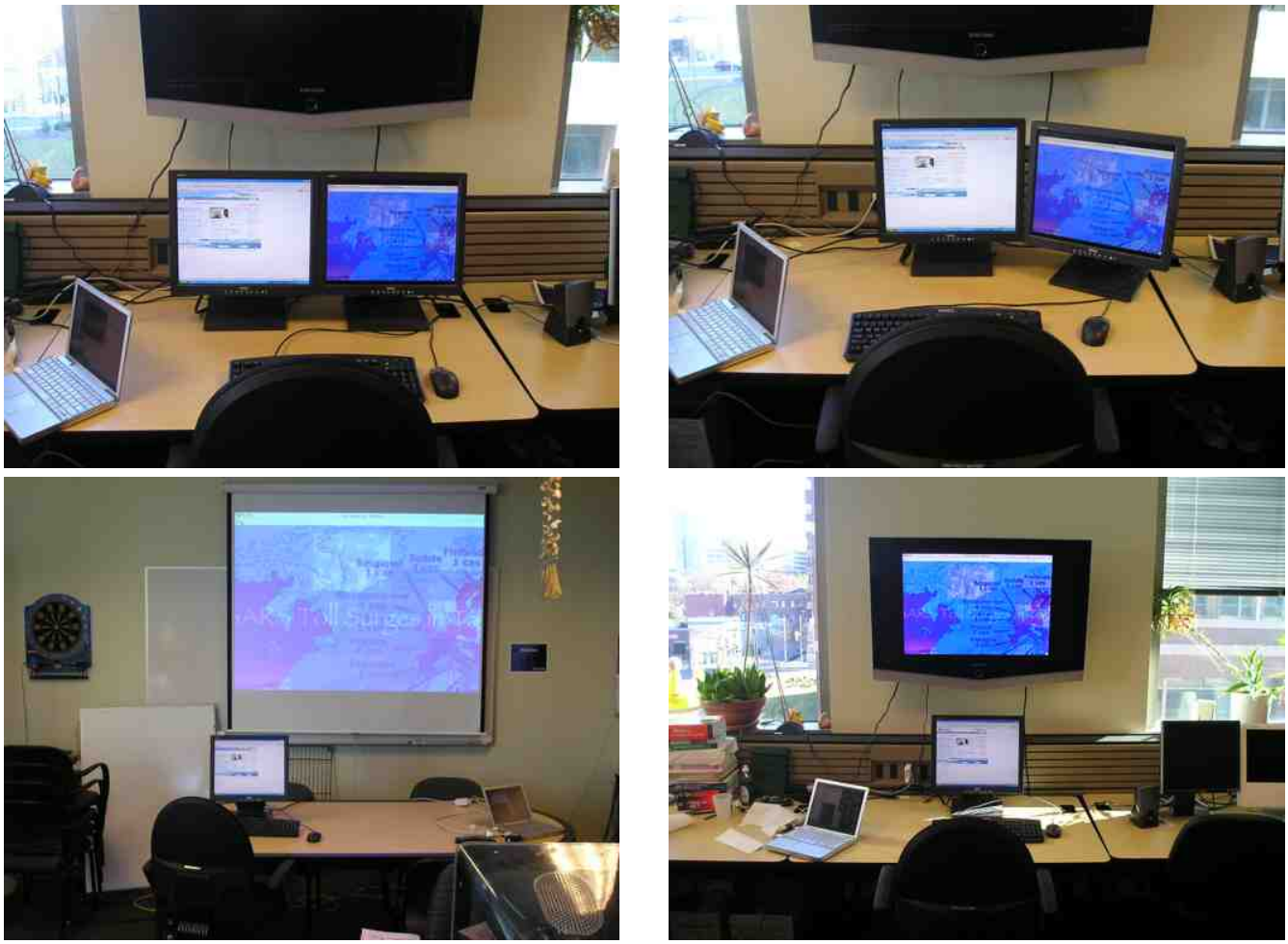

Figure 2: Study secondary display placements. Starting in upper-left then clockwise: side-by-side main and secondary display; single main display with same-size secondary display angled; single-main display with large secondary display mounted overhead; and single-main display with large projected secondary display.

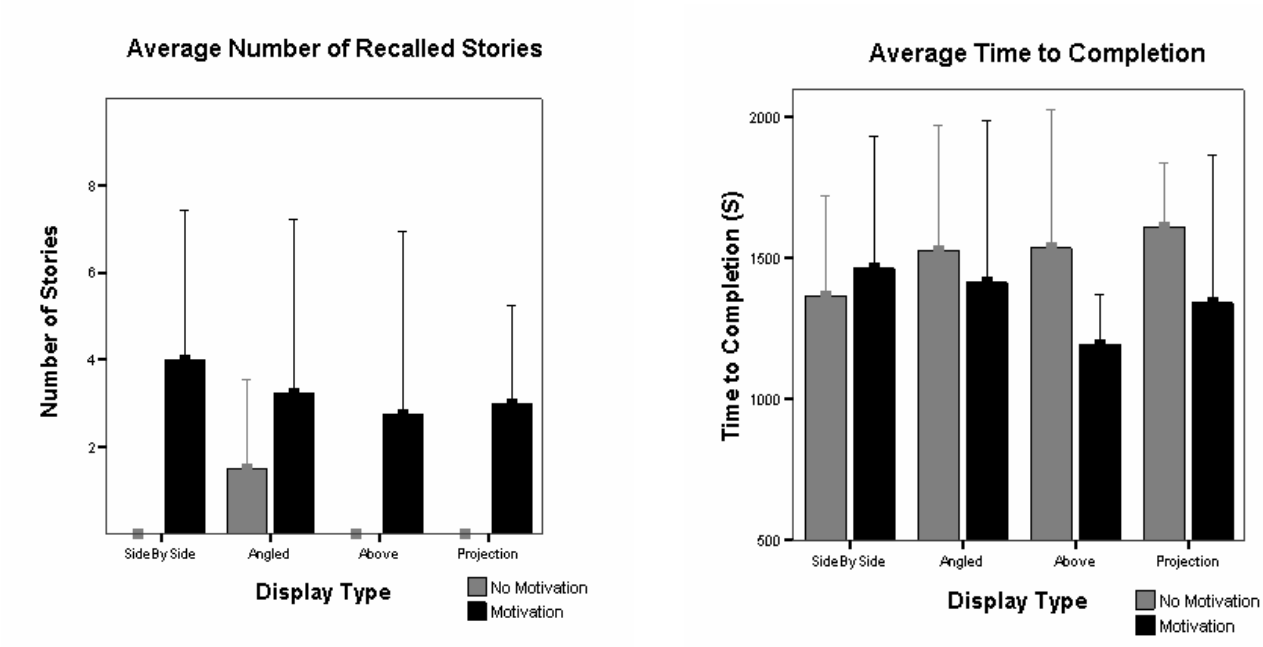

Figure 3. Graphs of the average number of news headlines recalled (left) and the average task completion time (right).

on the right-hand side, a main display with a large 40" secondary display mounted over it, and a main display with a large projected (approximately 70" x 67") secondary display. Each secondary display's resolution was 1024 x 768 pixels, with the exception of the large overhead display. Due to its widescreen aspect ratio, this device ran at 1360 x 768. For this display, BlueGoo ran at a resolution of 1024 x 768 in the middle of the screen with black bars on both sides.

Procedure: Participants were pre-tested for handedness and to determine which side of the keyboard they use a mouse on. To be consistent and to avoid confounding variables, in the side-by-side and angled display configurations, BlueGoo ran on the display that was located on the same side of the keyboard as the mouse.

After participants completed the web browsing tasks, they were asked to rate how distracting they found the secondary display. In addition, they were asked to recall the number of news stories observed on the secondary display and to complete a free recall information sheet, writing down any information or characteristics they noticed about the display to jog their memories. We then presented the participants with a list of 30 news headlines, including the 8 news headlines presented in the BlueGoo collages on the secondary display as well as 22 additional headlines. The 22 distracter headlines were chosen to not conflict with the actual news stories presented. Since BlueGoo is a peripheral display technology, it seemed prudent to learn whether or not participants were able to get a sense of a particular news story, rather than focus on wording nuances.

Participants also completed a demographic questionnaire and rated the secondary display system on several dimensions including distraction, visual interest, aesthetics, and information conveyance on a 1-10 Likert scale.

The final portion of each experimental session investigated whether participants would be able to understand what is being conveyed in an animated BlueGoo collage if the textual cues are missing. Each participant was presented with five collages of news stories, and was asked to summarize the message being conveyed.

Primary Task: Individuals performed a series of Web browsing tasks on a primary display. They used Air France's U.S. Web site to answer 13 questions about flight departures, airfares, and policies.

We chose the Air France Web site since it is not one that is commonly used where we live; none of the participants had used the site recently. Furthermore, the included questions represent common tasks that individuals perform routinely, such as looking up departure dates and times, airfares, and locating airline policy information.

To motivate individuals to perform well, we rewarded a $50 bonus to the person who answered the most questions correctly. In the event of a tie, the person with the fastest completion time would receive the bonus. (A 30-minute time limit was imposed on the Web browsing task.) Pilot testing found that people typically completed the tasks in about 18-25 minutes.

Secondary Task: While participants performed the browsing tasks, 8 distinct news headlines were presented via BlueGoo on the secondary display. The total amount of time required to display and transition all of the collages was approximately 18 minutes. Each collage was on screen for approximately 1 minute and 45 seconds with some transition time between collages. Once all the collages had been displayed, the BlueGoo system paused on a blank screen. No participants finished the airline task before all BlueGoo collages were displayed.

Each participant was placed into one motivational category, motivated or non-motivated, and used one of the four secondary display configurations. Non-motivated participants were not told anything about the secondary display, which started showing BlueGoo collages once the participant began the browsing task. Participants in the motivated condition were told that the secondary display would be showing news headlines in the form of photo and text collages and that they would be tested for recall at the end of completion of the browsing tasks. To provide them with some motivation to occasionally look at the display, a $20 bonus was offered to the individual who recalled the most number of news headlines. This bonus was intentionally less than the

Motivation	Block	Tasks Completed		Completion Time		
		Mean	S	Mean	S	N
No	Side/Side	9.75	2.217	1365	225.5	4
	Angled	11.00	.000	1525	280.6	4
	Above	11.00	.000	1535	310.4	4
	Projection	10.75	.500	1609	144.0	4
	Total	10.63	1.147	1509	240.5	16
Yes	Side/Side	10.25	1.258	1464	293.1	4
	Angled	11.00	.816	1415	358.6	4
	Above	10.75	.500	1196	108.8	4
	Projection	11.00	1.826	1342	327.6	4
	Total	10.75	1.125	1354	278.7	16
Ctrl		10.50	1.000	1451	376.4	4

Table 1. Number of tasks successfully completed and completion time by condition as compared to a control condition.

browsing task bonus of $50, yet still enough money in order to simulate a task of secondary importance.

4 RESULTS

Figure 3 shows the mean number of recalled stories per motivational condition as well as the average time to complete the browsing tasks. Participants in the motivated conditions recalled about 3 of the 8 headlines, but in the non-motivated conditions almost none. Table 1 shows the mean number of primary tasks completed. This number was roughly equal across conditions at about 10 out of 13. Completion times varied more, however. Table 2 shows the mean self-reported rankings of the BlueGoo display for distraction, visual interest, aesthetics, and information conveyance. Overall, participants rated the BlueGoo display low on distraction and moderate on visual interest and appeal.

Effect of Motivation: Unsurprisingly, individuals in the motivated condition recalled more news stories correctly than individuals in the non-motivated condition (averaging 3.3 vs. 0.4 respectively). Using a two-way ANOVA, there is a main effect of motivation ($F(1,24)=24.605$, $p=0.00$) on the number of news stories correctly recalled from the BlueGoo collages. There is also a main effect for motivation on several of the self-reported items: ability to interpret the BlueGoo display ($F(1,24)=12.670$, $p=0.002$), ability to remember information shown via BlueGoo ($F(1,24)=12.991$, $p=.001$), and visual interest ($F(1,24)=7.155$, $p=.016$).

This information is also confirmed in the survey results presented in Table 2. Individuals in the motivated condition also tended to rank higher an ability to remember information on the BlueGoo display (4.4 vs. 1.7) than in the non-motivated condition. Likewise, motivated individuals also ranked their ability to interpret the secondary display higher than individuals in the non-motivated condition (5.4 vs. 1.6). Motivated individuals also reported a higher level of visual interest than non-motivated individuals (5.3 vs. 1.9) as well as ranking the BlueGoo display higher for aesthetics (6.3 vs. 3.6).

Effect of Display Placement: There is a main effect for display type with respect to self-reported distraction ($F(3,24))=5.176$, $p=.007$). Individuals who had BlueGoo running on the angled secondary display reported a higher level of being distracted by the secondary display in both motivated and non-motivated conditions (2.75, 2.50). There was no statistically significant effect of display placement on the recall of news stories.

Effect of Display Placement x Motivation: The interaction between display placement and motivation on recall of the news stories presented via BlueGoo was not significant, nor was the interaction between display placement and time to complete the tasks. Graphs of this data are shown in Figure 3.

Comparison Against a Control Condition: After this portion of the study was completed, we wanted to examine whether the presence of the secondary display influenced completion time or the number of airline Web site questions answered correctly. Four new participants performed the browsing tasks and received the same instructions as the individuals in the non-motivated condition along with the same financial incentive for completing the task in the shortest amount of time. Results are shown in Table 1. Performing an independent samples t-test between the control condition and participants in the side-by-side, no-motivation condition (the experimental cell most similar in display arrangement and motivation to the control condition) did not yield a statistical significance in the number of tasks completed or completion time.

Rankings: Participants' rankings of the BlueGoo display for distraction, visual interest, aesthetics, and information conveyance are shown in Table 2. Generally, participants ranked the BlueGoo display relatively low on distraction. Participants expressed mixed opinions regarding the aesthetics and visual interest of the BlueGoo display.

Individuals also selected up to three adjectives from a list of 30 that best described their experiences and impressions of BlueGoo. The list contained an equal number terms with positive and negative connotations. Participants were also able to write down their own term(s) if they desired. The most frequently chosen terms were easy-on-the-eye (13), tranquil (13), artistic (10), and informative (7). Terms that individuals added included interesting (1), irrelevant (1), unobtrusive (2), and invisible (1). The only negative term chosen was disruptive (1).

Qualitative Findings: Participants also were asked about their experiences with the secondary display. Many of the individuals who did not notice BlueGoo asked the experimenter to run the

(1 = Strongly Disagree; 10 = Strongly Agree)	*Motivated*		*Non-Motivated*		*Total*	
	Mean	**S**	**Mean**	**S**	**Mean**	**S**
I felt I was able to interpret what the secondary display was showing	5.4	2.7	1.6	1.6	3.5	3.0
I remembered information shown on the secondary display	4.4	2.6	1.7	1.4	3.0	2.5
The secondary display was distracting	1.8	0.9	2.1	1.9	1.9	1.4
I liked how the secondary display looked	6.3	1.9	3.6	2.9	4.9	2.8
I found myself looking at the secondary display often	3.2	1.8	2.1	2.0	2.7	1.9
I noticed the information changing on the secondary display often.	3.1	1.9	2.3	2.4	2.7	2.1
The way the information was shown on the secondary display was interesting.	5.3	2.7	1.9	2.4	3.6	3.0

Table 2. Summary statistics for self-reported scores.

system again to see what type of content was displayed. One participant remarked, "*I completely did not see it*." Another participant in the non-motivated condition remarked that "*I noticed the display changing from time to time, but that the content wasn't relevant to the task I was working on. Still, I'd check back from time to time to see if there was context-related information.*" Another participant in the non-motivated condition remarked: "*I looked at the second display when I was stuck on a task. I was like, 'Gosh, I can't find the information on the Web page, so maybe it'd be over there…I didn't notice the display at first, and when I was stuck on a question for the first time, I saw the display and said to myself 'hey, I didn't notice you.'*" One individual in the motivated condition justified his ranking of non-distraction by saying, "*The second display was not distracting because I was able to choose to not look at it when I didn't want to*."

Participants generally had positive remarks about the BlueGoo display. One participant said, "*I like that it's not just telling you flat out [the story] is about pirated software. I like that there's a bit of artistic spin that you need to look at it to see what is being expressed to see if you want to attend to it more..*" Another said that "*once I noticed something was going on over there, I liked it…it's smooth and tranquil…*" One participant was intrigued by the novelty of the system: "*The fact that the display was opaque made it kind of fun—like what's going on here? It's almost like a game and I could see it being fun in other domains*", suggesting specifically work project updates and traffic on email lists.

The incorporation of textual cues into the collages were also noted. One individual, after completing the final portion of the study that did not include text cues (described in the next subsection), remarked, "*The text greatly aided in the interpretation of the collages*."

Information Conveyance Findings: Recall that at the end of a session, we presented five image-only collages to participants and asked them to describe the message being conveyed. We transcribed their responses and sent them to two independent raters who judged the accuracy of participants' responses on a 1-10 scale, with 1 being not accurate and 10 being highly accurate. (By accuracy, we mean the closeness of the participant's summary to the actual topic matter of the collage.) The two reviewers' ratings were highly correlated and thus their scores were averaged to provide an overall rating. Table 3 shows the reviewers' mean accuracy ratings along with standard deviations and the highest and lowest ratings for a participant's description of the particular news story.

	Mean*	S	High	Low
China fears girl died of bird flu	4.8	1.8	8.0	1.5
Pope on the road to sainthood	3.9	2.4	9.5	1.0
Malaysia warned over pirated CDs	5.4	1.3	6.5	4.5
Internet phone calls on the rise	2.7	1.8	10.0	1.0
No trade deal at Americas summit	2.0	1.4	7.0	1.0

* *Mean score refers to the average of two independent reviewers' rating of accuracy of participants' interpretation of each collage.*

Table 3: Average recall (1-10) of news headlines presented via BlueGoo collages with no textual cues present.

5 DISCUSSION

The significant effects of motivation, especially in regards to recall of the information presented on the secondary display, are not surprising. It seems intuitive to expect individuals to examine a secondary display if given instruction and motivation to do so. However, such instruction and motivation turns the secondary task into more of a monitoring task than an awareness task. Thus, studies such as ours are relatively delicate and challenging to conduct.

We were primarily concerned with three main characteristics or attributes of the BlueGoo displays: the distraction they caused, the visual interest or appeal they exhibited, and their ability to communicate information (the news headlines). Below we address these attributes in order.

It is interesting to note that individuals who were not told about the BlueGoo display (unmotivated condition) did not recall any news stories in the side-by-side, above, and projection display configurations. However, participants in these conditions did acknowledge in post-experimentation interviews noticing the secondary display: 3 out of 4 noticed the display in the side-by-size and above conditions, 2 out of 4 noticed the display in the projection condition. The same participants ranked the BlueGoo display quite low for distraction, average 1.8, 1.5, and 1.0 out of 10, in the same respective conditions. None of these participants were able to recall any news stories.

Combining the participants' low subjective ratings of distraction along with the lack of any significant difference in task completion time, particularly when compared against the control condition, leads us to conclude that BlueGoo was largely non-distracting. This result is meaningful for designers of peripheral technologies, showing that it is possible to incorporate animation into a peripheral display without being overly distracting. It echoes the findings of McCrickard et al [16] that differ from those of Maglio and Campbell [15], but our result is for animation at a much larger scale than the ticker studies of those works. Further research, as discussed in the preceding section, is needed to explore which types of animation in the periphery are most calm/distracting.

All four participants in the non-motivated, angled display condition, in contrast, reported noticing the secondary display, ranking the display an average of 2.75 out of 10 for distraction. Three of the four participants in this condition were able to recall several of the news stories presented (3, 2, 1, and 0 stories were recalled by these participants.) Therefore, it appears that individuals were most sensitive to being distracted by animation in the periphery when the secondary display was angled from the main display, although the distraction level was still relatively low. This result is similar to that found by Su and Bailey regarding angled displays [24].

Note in Figure 3 the average completion times for the main task are lower (although not significantly) for individuals in the motivated condition for three of the four display configurations. Intuition perhaps would suggest the opposite; individuals splitting their attention amongst two tasks should result in an increase in time being spent on the primary tasks. The award system used in this experiment might account for this discrepancy. Participants in the non-motivated condition had a single bonus of $50 as a performance incentive, while participants in the motivated condition had the same $50 bonus, plus an additional $20 reward for the individual who recalled the most news stories presented by BlueGoo. By increasing the financial incentive, participants might have been inspired to perform better overall—and there is some evidence that just the addition of the second task can lead to a state of nervous system arousal, where performance for both tasks increases as drive or motivation increases [19]. Another possible explanation of the slower average completion times for

individuals in the non-motivated condition might be distraction of which the participants are not consciously aware. Further testing is needed to explore this more.

For the second characteristic examined, visual interest and appeal, BlueGoo's use of animation and transition effects appeared to yield mixed or moderate effects. The total mean rating for visual interest was 3.6 out of 10, but individual participant rankings varied widely from 1 to 8. Also, the level of motivation had a statistically significant effect on the mean ranking for visual interest (motivated-5.3 to non-motivated-1.9). This is a reasonable finding; individuals motivated to look at the display actually did so, noting the dynamic nature of BlueGoo and finding it moderately interesting. Individuals who were not motivated to look at the display likely ranked visual interest with few or no views of the display.

Overall rankings for aesthetics of BlueGoo also were mixed with some individuals finding it very appealing (ranking a 9) and some not (ranking a 2). This, perhaps, is best accounted for by personal taste—not everyone enjoys similar artistic work—and this is an overall challenge for peripheral display designers. Still, *artistic*, *easy-on-the-eye* and *tranquil* were the most frequent terms chosen by participants to describe their impressions and interactions with BlueGoo. Only one participant chose a negative term (*disruptive*). This individual, however, did remark during post-study debriefing that he has been diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) and he is easily distracted. We, however, did not pretest for propensity for distraction and did not collect any information regarding ADHD in our demographic survey. Other negative terms such as *boring*, *offensive*, *ugly*, or *wild* were not chosen by participants at all. Individual comments gathered in the post-study interviews generally communicated favorable impressions of interest and appeal.

Finally, with respect to information conveyance, BlueGoo provided somewhat modest results. Participants in the motivated condition recalled an average of about 3 of the 8 headlines. Even in this condition, however, acquiring the content of the second display was at best a peripheral activity, so this number may not be as bad as it sounds. In contrast, in the session-ending exercise they performed, most participants were able to grasp the general topic of the news headlines presented without textual cues. The mean accuracy ratings of the independent evaluators, shown in Table 3, indicate that some news headlines were generally conveyed better than others. It is interesting to note that even in collages with lower mean accuracy scores, some individuals scored high for accuracy (denoted as high score in Table 3), obtaining the correct central theme of the news headline being portrayed.

Therefore, the lack of text cues to resolve ambiguities does not necessarily hinder the information conveyance abilities of BlueGoo, and individuals do seem able to gain a general sense of the topic from images alone. This is perhaps due to personal experiences. However, the ability to understand these abstractions corresponds to Streitz et al's findings that individuals are able to quickly master and interpret light patterns, abstracting presence and recency information, in the ambient Hello.Wall [23]. However, the inclusion of textual cues is beneficial in resolving potential image ambiguities.

6 FUTURE WORK

The study's results provide some initial findings about more large-scale uses of peripheral animation, but they also open up many other potential avenues of research. Furthermore, the strength of this study's results can be increased by conducting additional experimentation.

The animation techniques used in the BlueGoo system are limited to a series of alpha-blending, scaling, panning, and zooming effects at a slow rate. Therefore, the findings of this study do not translate to other possible combinations of animation techniques. Further studies are needed to investigate what forms of animation are disruptive to a person in their periphery and offer guidelines for peripheral display designers who wish to incorporate animation into their displays. Much as Bartram et al did for more "atomic" or controlled animation effects [2] and McCrickard et al did for small tickers [16], we could, explore the implications of different types of animations and transitions used on larger, display-sized visualizations in the periphery.

The ability of individuals to disregard animation in the periphery needs to be further explored in more depth. How do physical eye movements (i.e. saccades) vary with different types of animation techniques? Is there a correlation between eye saccades and perceived distraction among different animation techniques? How do these correlations change when the secondary display is moved into different positions?

The results yielded from this study indicate that further work is needed to investigate the effects of animation on distraction on angled secondary displays. As multiple display configurations become more prevalent (as well as VESA stands that wrap displays around a user), more research needs to be conducted to determine thresholds and guidelines for animation with respect to the visual ergonomics of secondary displays.

We explicitly did not include a static collage-style display condition in this study because such a display could only present a portion of the images and text shown on a BlueGoo display. Thus, a direct comparison would be unfair. (The images and text alternately could be shrunk for a static display, but again this would be a different kind of comparison.) Nonetheless, further experiments could more deeply study the particular effects of the BlueGoo animations when compared to static visuals, in terms of information conveyance, aesthetics, and distraction.

A future study also could investigate a third condition, one somewhat between the motivated and non-motivated conditions we used. This condition would involve participants who are told about the presence of the secondary display but are told that its content is irrelevant to the primary task. Such a condition could further indicate whether the presence of the animation in the secondary display is distracting.

In addition, a long-term deployment of the BlueGoo system is needed to assess whether the system's use of constant animation can sustain visual interest over time as well as to investigate habituation towards animation in the periphery. The study described in this paper is of a more controlled nature and participants are only exposed to the BlueGoo system for a relatively short period of time.

7 CONCLUSIONS

In this paper we describe the BlueGoo system, developed to investigate whether animation can be used to increase the visual appeal of a peripheral information display without being distracting to users. BlueGoo visualizes R.S.S. headlines as a collage of the different images, and uses a variety of smooth animation effects to update the collage and transition to the next headline. The contributions of the work include the system itself as well as the empirical study findings below:

- Animation can be used judiciously in large-scale, monitor-sized peripheral displays without being overly distracting to individuals performing a main task on a neighboring display. Participants were not adversely affected by the type of constant animation used in the BlueGoo system when it resided in their periphery. In

fact, participants who were not told about the running system largely did not even notice it.

- Since there was no static BlueGoo display to compare the results against, we cannot concretely determine that animation offers an increased sense of visual appeal. However, interview feedback and survey data indicates that participants found the animation effects appealing and interesting at a visceral level. Participants in our study, particularly those aware of BlueGoo, found it moderately appealing on average, with some rating it quite high.
- Angled secondary desktop displays resulted in higher self-reported distraction ratings than side-by-side, above-mounted, or projected secondary displays. Designers of peripheral technologies should note display location when creating their systems, especially as multiple display desktop systems become increasingly popular.

While the empirical findings involving the BlueGoo system cannot be generalized to all types of animation and peripheral displays, it provides evidence that the use of animation in peripheral displays should be reconsidered. Animation may be used in large-scale peripheral displays in manners that may increase visual interest without being distracting to a user.

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