ArtLinks: Fostering Social Awareness and Reflection in Museums

Dan Cosley, Joel Lewenstein, Andrew Herman, Jenna Holloway,
Jonathan Baxter, Saeko Nomua, Kirsten Boehner, Geri Gay
Human Computer Interaction Group, Cornell University
{drc44, ash47, jh382, jtb42, sn339, kab18, gkg1}@cornell.edu, joel9@stanford.edu

ABSTRACT
Technologies in museums often support learning goals, providing information about exhibits. However, museum visitors also desire meaningful experiences and enjoy the social aspects of museum-going, values ignored by most museum technologies. We present ArtLinks, a visualization with three goals: helping visitors make *connections* to exhibits and other visitors by highlighting those visitors who share their thoughts; encouraging visitors' *reflection* on the social and liminal aspects of museum-going and their expectations of technology in museums; and doing this with *transparency*, aligning aesthetically pleasing elements of the design with the goals of connection and reflection. Deploying ArtLinks revealed that people have strong expectations of technology as an information appliance. Despite these expectations, people valued connections to other people, both for their own sake and as a way to support meaningful experience. We also found several of our design choices in the name of transparency led to unforeseen tradeoffs between the social and the liminal.

Author Keywords
Social computing, visualization, museum, reflective design, spiritual computing

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

INTRODUCTION
Technology has the power to transform visitors' experiences in museums. From portable tape players to handheld computers, museums have used technology to supplement the information "tombstones" that sit beside exhibits, adding multimedia content and interactive, personalized learning experiences (e.g., 11131622 23242728). Implemented well, these tools support educational aspects of the museum experience.

However, learning is not the only goal of museum visitors. Researchers have identified three primary museum ecologies to describe the visitor experience: the learning ecology 621, the museum as sacred space or *liminal* ecology 11219, and the social and recreational ecology 129, each of which describes a distinctive set of experiences for visitors 1. In other words, visitors don't just come for knowledge—they also come for meaningful and social experiences. Technologies that focus strictly on the learning goals of visitors may actually impoverish their experiences by drawing attention away from these other important aspects of museum-going.

Our research program, then, is to design systems that address visitors' needs across all three ecologies. Because a number of systems already support learning goals, we focus on the social and liminal ecologies. Our general strategy is to use social awareness to help people create meaningful experiences. For example, in the Imprints system, visitors created personalized marks that they left at exhibits; people could see the marks of others and find, as one participant put it, "kindred spirits" 4.

In this paper, we present ArtLinks, a visualization that explicitly represents other visitors, their reactions to an exhibit, and connections among visitors through these reactions. This work has three main goals, which we call *connection*, *reflection*, and *transparency*.

The first goal is *connection*: leading people to be more aware of the presence of others in the museum, to see themselves as connected to these others, and through those connections, to create for themselves more meaningful and memorable experiences with the exhibit. This goal explicitly targets the social and liminal ecologies.

The second goal is *reflection*: helping people reflect on their expectations of museum experiences. The social and liminal ecologies of the museum are often not as visible as the learning ecology, and in fact, visitors usually cite learning as a primary motivation for visiting museums 10. This, combined with the usual role of technology as supporting information goals in museums, is likely to shape museum visitors' expectations of new technologies: they are likely to expect them to support learning or provide

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.
CHI 2008, April 5–10, 2008, Florence, Italy.
Copyright 2008 ACM 978-1-60558-011-1/08/04…$5.00

knowledge. Designs that focus on the social and liminal aspects of museum-going may confuse or even alienate people unless the system helps them move beyond their expectations and engage with the design on its own terms.

This leads to our third goal, *transparency*: learning how the aesthetic elements we used to create an attractive, engaging design supported—and hindered—people's ability to understand the system and foster connection and reflection.

We evaluated our progress toward these goals by deploying ArtLinks at the Herbert F. Johnson Museum of Art at Cornell University. Through contextual interviews and observation, we found that people do have strong expectations of technology's role in museums as a tool for providing information about exhibits. Once they realized the system's goal was to reveal connections between people, however, many people reported that they were interested in others' thoughts and that they did feel connections to other people through the visualization. Some visitors believed that the visualization helped them think about the exhibit and about museum-going in ways they otherwise would not have. Finally, our aesthetic choices, especially around the sounds made by other visitors, had strong effects on how well ArtLinks achieved its goals.

TECHNOLOGIES IN MUSEUMS

In principle, technologies can support all three of the museum ecologies described in the introduction. Museum visitors can encounter objects that uplift the mind and spirit and take them away from the routine of everyday life (the liminal ecology), they can have fun or interact and participate with others (the social ecology), or they can learn something (the learning ecology) 1. Computer technologies can support all of these goals: technology is used for education and information, for communication and social interaction, and even for supporting spiritual practices and experiences 22631.

In practice, the dominant model of technology in museums focuses on the learning ecology, supplementing information provided in the physical space with rich multimedia content 24, guidebooks that organize exhibitions 27, maps 7, personalized recommendations 27, robotic guides 22, and similar elements that help people choose exhibits to view. These systems are often straightforward adaptations of earlier techniques used to support museum visitors such as audio tours and brochures. These technologies imitate their predecessors in two undesirable ways.

The first problem is that most of these technologies follow a one-way model where museum experts provide information and visitors consume it. Much of the educational literature suggests that active learning strategies that require learners' engagement are more effective than traditional structures such as lectures—which many digital tour guides resemble. More recent museum technologies attempt to engage users through interactions such as making choices about whether to run a given story in a news museum 13, or asking visitors to provide ratings 27 or opinions 11 of exhibits.

The second related problem is that most museum technologies focus on providing factual information about exhibits. This focus can marginalize the social and liminal ecologies, leading people to attend only to informational goals. Further, the technology can become the star of the show, drawing attention away from the exhibits (a common fear of curators 23) and from the presence of other people. Just as someone walking down the street listening to their iPod is detached from the local context, so too is someone whose ears are covered by an audio tour's headset or whose eyes are busy attending to a video about an exhibit.

Social Technologies in Museums

We argue that effective museum technologies will often support interaction with people as well as with information. People who visit museums as part of a group experience museums differently than individuals 81823. During their visit, social groups can discuss the exhibits as a whole, or each piece individually.

A few systems explicitly support groups in museums. Sotto Voce 16 provides a shared audio channel allowing pairs of visitors to communicate with one another and share experiences remotely. The Museum Detective 28 includes interactive activities and puzzles that children both worked on collaboratively and used to share their experiences with other children. Hornecker & Stifter suggest that museum technologies should explicitly afford communication among groups of visitors 20, based on their own experiences and the success of this "museum groupware."

The majority of people in a museum, however, are strangers, and little is known about how strangers affect each others' museum experiences. In prior work, we found that interactions tended to occur within pre-existing groups of people such as families and tour groups, while direct communication across groups was not common 3. However, people would often overhear others' comments, whether or not they attended to them; further, people are influenced by the presence and activities of others 23.

A common communication medium between strangers in a museum is guestbooks. Ferris et al. used a guestbook-like feature in their work, capturing audio opinions of visitors about a collection of objects 10. They physically separated the social and learning ecologies, placing learning activities in a "Study Room" and collecting and visualizing visitors' opinions in a "Room of Opinion". They report that visitors and curators liked the exhibition overall but did not provide details on how people reacted to the social features.

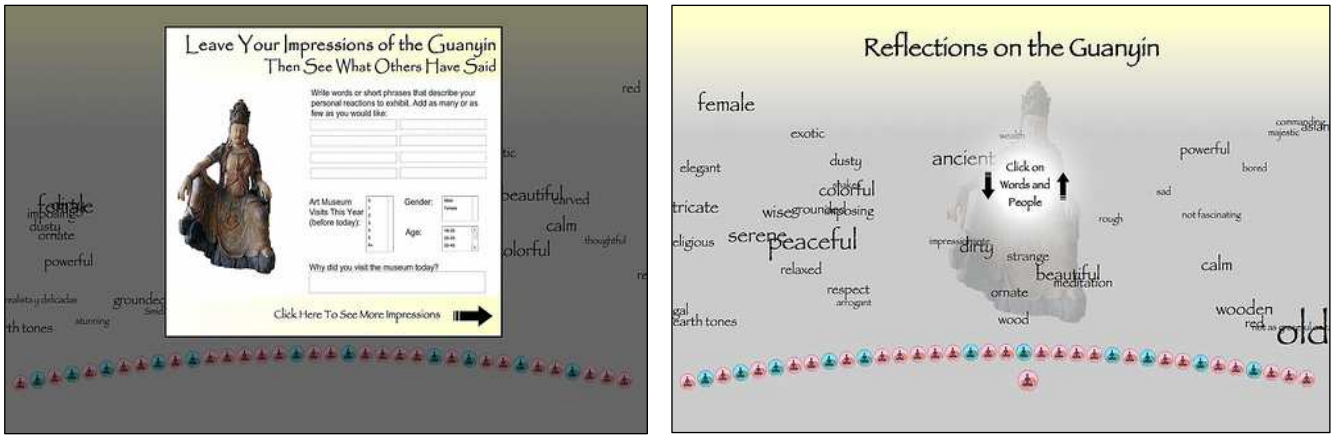

Figure 1. The initial screens of ArtLinks. As users approach, they see the left screen, asking them to add their reflections. After adding their thoughts, users see the screen at right. Visitors appear as meditating orbs along the bottom, with the current user at center. Their reflections on the exhibit float across the screen in a literal "tag cloud"; more common words are larger.

MUSE 15 is a context-aware guidebook that also incorporates aspects of a guestbook, including the ability to leave comments on pieces. People primarily saw it as a way to ask questions of curators, rather than as a tool for connecting to other visitors. Users of another context-aware system designed for college campuses were much more willing to interact socially and share their experiences, suggesting that in the museum, people may have been inhibited from commenting because they expected and desired expert information from the guidebook 15.

The Imprints project 4 focuses on the social aspects of the museum experience, asking users to create an icon to represent themselves and attach that icon to museum exhibits. Unlike MUSE, Imprints resents social presence in an indirect way that precludes explicit informational goals. Imprints users were very likely to use the social features, both creating icons for themselves and seeking out the traces of other visitors.

These findings suggest the value of exploring designs that support the social and liminal museum ecologies without emphasizing the learning ecology. Marrying all three ecologies would be ideal, but visitors' expectations of museum technologies are likely to lead them to focus only on the learning aspects.

THE ARTLINKS SYSTEM

ArtLinks follows on both MUSE, in that we ask visitors to remark and reflect on exhibits, and on Imprints, in that we focus on foregrounding social connections between museum-goers. However, unlike both MUSE and Imprints, which were embedded within a handheld tour, ArtLinks is a standalone display associated with a particular exhibit. In this section, we present the interface and discuss how both our goals and users' experiences with early prototypes shaped the final design.

The ArtLinks interface

The ArtLinks interface, shown in Figures 1 and 2, has four main elements: people, words, connections, and sounds. When people approach the visualization, they are asked to enter information about themselves and their reactions to the exhibit (Figure 1, left). The information includes their age range, gender, museum visit frequency, and reason for their current visit. The reflections take two forms: words that represent their thoughts about the exhibit and a sound they associate with the exhibit.[1]

After entering their information, users are taken to the main visualization (Figure 1, right). People are represented by a meditating person inside an orb. The current user is placed at the center of an arc of icons representing other visitors. The words that visitors have entered float slowly and randomly from right to left, above the people and across a large picture of the exhibit. Words normally only appear if they have been said by at least two people, while a word's size reflects how many people have said it.

Figure 2 shows how connections appear when users hover over people and words with the mouse pointer. When the pointer hovers over a person's icon (Figure 2 left), lines appear between the icon and words that person said while the icons light up for other people who said those words. Further, words said only by that person appear. When the pointer hovers over a word (Figure 2 right), lines appear between the word and the icon of each person who said it, while other words fade into the background. In both cases, information boxes appear for each of the highlighted icons, presenting demographic and museum-going information for the associated person.

Sounds play when users click on people or words. Clicking on a person causes that person's sound to play. Clicking a

[1] The current version of ArtLinks does not collect the sounds; we seeded the system using a pre-survey to be described later.

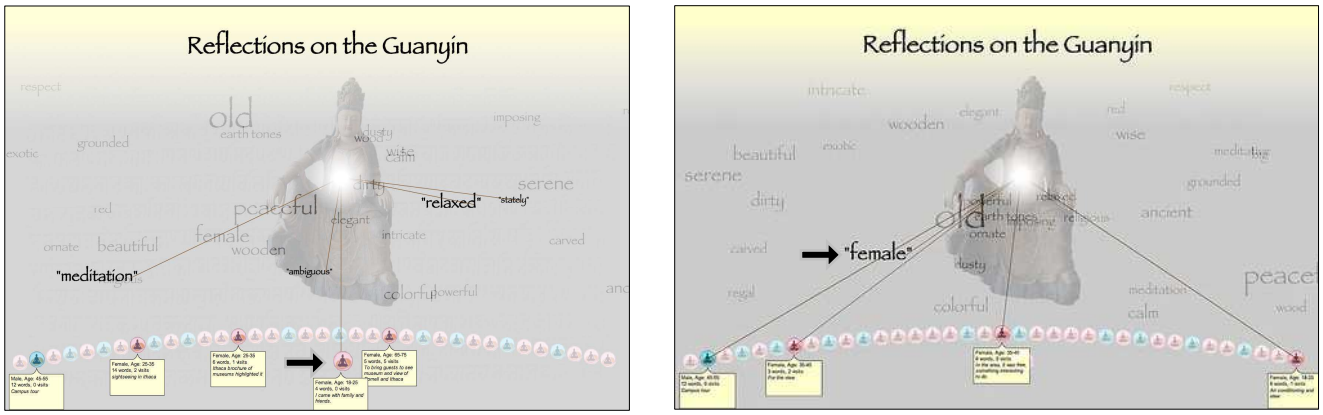

Figure 2. Showing connections. At left, the user has the mouse over their own icon. Lines connect the icon to words the person said, while icons light up for other people who said those words. At right, the user has moved the mouse over the word "female". Lines connect the word to people who said it. In both cases, information about the highlighted people appears.

word plays a "composite sound", which is composed from the sounds made by everyone who contributed that word.

Design goals shaping decisions

Here we describe how our goals of connection, reflection, and transparency shaped our design.

Connection: supporting sacred experience through people.

One of our goals was to support the social and liminal museum ecologies, revealing connections between visitors both for their own sake and to connect people more deeply with exhibits. Visitors often spend little time with a given exhibit. We hoped that inviting visitors to see connections with others would lead them to stop and think more deeply about both their relationships to other visitors and to the exhibit. By foregrounding the impressions of others, we hoped a visitor would give their own impressions of the exhibit more explicit consideration. This process of engagement and reflection would ideally lead to a more meaningful and memorable experience with the art, producing thoughts and feelings that would stay with the visitor after leaving the museum.

The goal of foregrounding connections between people naturally led to our decision to foreground individuals as an important element of the design. We supported connections along a number of dimensions: words, demographic information, and sounds. Words allow users to connect at the level of conscious experience. Recognizing people who think in the same ways we do, who share our thoughts and interests, is a powerful force that can bring people together. Choosing single words and short phrases, rather than narratives, increased the system's ability to make explicit connections and reduced the cost of participating. Providing demographic and museum-going information allows people to make connections based on similarity of circumstance. People might, for instance, feel closer to someone who is of about the same age, or who visited the museum for similar reasons. Finally, we included sounds because they are both more visceral and distinct than sounds or demographics, in the hopes of making people both salient and unique. Sounds are also underused in most visualizations, and we wanted to explore that part of the design space.

We also hoped to use those connections to support liminal experience. The recent literature on spiritual computing focuses on how people use technologies to support their religious practices 22631. We think of spiritual computing more broadly, in terms of helping to create meaningful experiences. Ludic design is one approach to building systems to help users find their own meaning for activities, meditative or not 1417. It prescribes exploration and reflection, openness and ambiguity, and a healthy aversion to explicit goals. Our design supports these prescriptions. We ask users for an open-ended set of reactions to the exhibit and give them the opportunity to view others' reactions (supporting reflection). We provide a number of ways to connect to others (supporting openness). We also avoid instructions that might bias people's perceptions of the system.

Reflection: making people aware of their expectations.

The practice of reflective design involves creating systems that explicitly help users notice and perhaps change their unconscious notions of how technology is used in their lives 25. The place of technology in museums is fraught with assumptions. We argued earlier that most people see the main goal of museum-going as learning, and see the role of technology in museums as a provider of factual information. Further, we thought people might be reluctant to interact with ArtLinks because, especially in art museums, exhibits are usually not supposed to be touched (Figure 3). Finally, we thought people might be reluctant to use the system if they felt they lacked expertise 15.

Our design dealt with expectations of expertise and factual information by explicitly foregoing them. ArtLinks provides no factual information about the exhibit, no information delivered by the authoritative voice of the curator. In ArtLinks, only visitors speak. We also attempt to

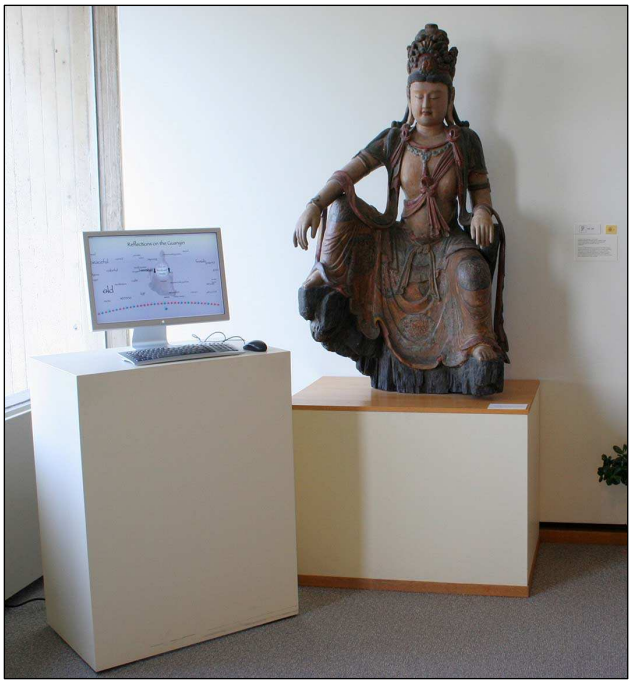

Figure 3. ArtLinks and the Nanking Guanyin. A sign with information about her is on the wall. The pedestal sign reads "please do not touch". At the left are windows with a signature view of Ithaca and Cayuga Lake.

help people notice other assumptions they make about museums. Foregrounding visitors as a primary component of the visualization does not just support the goal of making connections. It also calls attention to social aspects that people might otherwise not attend to. Sounds violate the assumption that museums are quiet places.

We note that reflective design also requires designers to confront their own assumptions. For instance, our belief that people would focus on social and liminal aspects if we did not provide exhibit information is an assumption—and, as we will see, it was not entirely successful. Likewise, we chose to deploy ArtLinks alongside the Nanking Guanyin, part of the Johnson Museum's permanent collection of Asian art (Figure 3). Her size, prominence in the museum, uniqueness, and spiritual significance in the Buddhist tradition were all very attractive in supporting our goal of encouraging liminal experience. However, Buddhism does not have strong spiritual connotations to most Americans.

Transparency: effectively relating aesthetics and function.
As we were designing ArtLinks, we began referring to it as a visualization, as this seemed to capture many of its important characteristics. However, it is not an information visualization in the sense of Card et al. 5; rather, it is more related to abstract visualizations of social interaction such as Babble 9 and Chat Circles 30. These abstract visualizations often exhibit tension between aesthetics and communication. Beauty matters: it attracts and engages attention. For example, the dangling string at Xerox PARC is visually appealing[2]. However, the information it provides about Ethernet traffic is opaque unless you know its secret.

Although technology can act as art in its own right, in our case technology serves the art. We did not want visitors to puzzle out the visualization at the expense of reflecting on the exhibit. As one early tester put it, "you don't want *two* enigmas." Thus, we generally chose more literal as opposed to abstract representations: people icons for people, text for words (as opposed to representing comments by swirling lines, as in 10), lines for connections, and so on.

Other aesthetic decisions supported other goals. To try to focus attention on the exhibit, we placed a large picture of it at the center of the display and routed all connections through a glowing orb centered on the picture. We wanted people to make connections using others' thoughts; the random placement of the words (versus a static tag cloud) was an attempt to help people see new connections between words through physical proximity.

Initial deployment

ArtLinks is designed to be used with any exhibit with minor modifications. It is built in Adobe Flash CS3 Professional, with extensive use of ActionScript 2.0. User data is stored in a MySQL database and dumped to XML files that the visualization reads at run time. The visualization can run in a web browser or in a standalone player.

In the museum, ArtLinks ran on a 23-inch Apple Cinema Display. A standard keyboard and mouse were connected to a hidden MacBook Pro laptop. The monitor, keyboard, and mouse were placed on a pedestal, provided by the museum, set to approximately 4 feet off the ground and a few feet to the side of the exhibit.[3]

To facilitate testing and development, we seeded ArtLinks with reflections garnered through surveys conducted early in the development process. This allowed us to avoid the startup problem that social systems in general face: who wants to own the first telephone, or write the first Facebook profile? It also provided us with real data that helped with both development and user testing of our early prototypes.

We collected the seed data by recruiting visitors to fill out a brief paper-based survey that captured their experience of the Guanyin in words and sound. The first page of the survey collected gender, age, visit frequency, and reason for their current visit to the museum. The second page asked for words and short phrases that described their personal reactions to and impressions of the exhibit. After the paper survey, participants were asked to record a short sound which they associated with the Guanyin.

---

[2] From Mark Weiser's Designing Calm Technology at http://sandbox.xerox.com/hypertext/weiser/calmtech/calmtech.htm

[3] Initially, we put the laptop directly on the pedestal. An early user pointed out that people might think the laptop belonged to someone who had forgotten it, and thus avoid interacting with it.

People	Sample words
4+	serene (4), female (4), peaceful (5), old (8)
3	beautiful, wooden, ancient, wise, colorful, dirty
2	respect, relaxed, religious, wood, elegant, ornate, earth tones, exotic, dusty, red, grounded, carved, regal, powerful, intricate, imposing, meditation
1	gratitude, free, open, contentment, tantric, mesmerizing, lifeless, listening to the suffering cries of humanity

Table 1. Words people used to describe their reactions to the Guanyin. Words in the "1" row are a sample of the 169 words and phrases said by exactly one visitor.

Over the course of ten non-consecutive days, we interviewed a total of 36 people (25 females, 11 males). Table 1 shows that reflections consisted of a mix of descriptive words (e.g., "old", "dirty") and contemplative words (e.g., "peaceful", "relaxed"). Many of the most interesting reactions, such as "listening to the suffering cries of humanity", were said by only one person. People mostly made meditative "om" noises; some provided lyrical narrative, melodies, and blowing noises.

Lessons from deploying prototypes

During development, we visited the museum four times to deploy prototypes for usability testing. Below we talk about three cases where we found we had trouble striking a balance between aesthetics and use: the representation of people, the organization of people and words, and the presentation of instructions.

Our first prototype represented people as mandalas. The mandala supports meditation in the Buddhist tradition, which fit well with our goals. However, users never clicked on them or realized they were people, even when the visualization drew lines connecting the words to the mandalas. The mandalas were relatively small and, in fact, users often asked if they were flowers. This led us to less abstract representations of people, such as silhouettes and various "bathroom-style" icons, but these did not fit the aesthetics of the design (Figure 4). In the end, we chose the meditating person inside an orb icon, tinted pink for female and blue for male visitors, as a way to balance the themes of Asian art, reflection, and transparency.

The layout of people and words onscreen was another difficult issue. The first prototype (Figure 5) placed people and words randomly, with words moving diagonally and bouncing off the edges of the screen. People found this aesthetically pleasing, but cognitively confusing and hard to use. They would try to hover over one word but a different word would zoom in from an unexpected direction and become the focus. Further, the words, by moving across the icons for people, became the focus rather than the other visitors. Eventually we found the solution of placing people at the bottom of the screen in an ordered fashion and floating their reactions across the top of the display.

Figure 4. The evolution of person representations in ArtLinks. Finding a representation that was appropriately abstract, represented museumgoers, and fit the theme of Buddhist spirituality was difficult.

Figure 5. An early version of ArtLinks, showing the unconstrained placement of people and words. The random motion of words obscured the people.

Providing instructions was also a struggle. We wanted to test whether ArtLinks would help people feel connected to others and we were afraid disclosing this would bias their reactions. We also wanted the purpose of the visualization to be ambiguous, to encourage exploration and reflection. We added a button that would present instructions, but no one clicked it. In our final implementation, we added a pulsing orb of white light that said "Click on Words and People" to the center of the screen that faded away once a user started interacting with the display. This helped, though in the end users still wanted more instruction about the system. Providing appropriate help was a frustrating problem for what felt like a simple design.

MUSEUM VISITORS' EXPERIENCES OF ARTLINKS

To understand how ArtLinks affects visitors' experiences, we conducted a series of contextual interviews at the Johnson Museum between August 22 and 28, 2007. The fieldwork was held from the late morning to the afternoon on three weekdays and a weekend day. We hoped the range of times and days would broaden our sample of people and motivations for visiting.

We conducted open-ended contextual interviews with 17 visitors who interacted with ArtLinks (13 female, 4 male; 8 aged 18-25, 9 older than 25). People's reasons for visiting varied: 5 were mainly interested in the view, 3 were there to enjoy the museum, 2 wanted to see a particular exhibition, 1 each wanted to learn about the art and to show the museum to their family, and 5 people did not answer.

Our interview method used to engage the subjects is as follows. First, we observed people interacting with ArtLinks from a distance, out of their field of view. Either during the interaction with or as they were leaving the

display, we approached the informants and asked if they would consent to an interview.

In the interview, we asked the informants to show us how they used ArtLinks from the beginning, re-enacting what they did and telling us their thoughts as they interacted with it. We then asked a series of questions about their expectations of ArtLinks before and during the interaction, their reactions to specific aspects of the interface, and their thoughts about technologies in museums.

After collecting data, we created an affinity diagram, extracting observations made by the informants onto Post-It notes, grouping the notes into related sets, then creating a hierarchy among the groups to help us discover appropriate interpretations of the data. Below, we present a general picture of how people interacted with ArtLinks, then outline the main interpretations that emerged from their comments.

Discovering ArtLinks. Ten people who interacted with ArtLinks said that they were intrigued by this unusual computer display among ancient Asian exhibits. As they used it, most visitors turned toward the Guanyin to admire it while they formed impressions for the initial screen. Some casually added multiple impressions, while others took time and moved back and forth between ArtLinks and the Guanyin while registering their impressions.

On the main screen of ArtLinks, informants were attracted to the floating words first. Typically, they would watch the words for a while and then hover over a couple of words. This would lead them to discover the links between the words and the pink and blue icons at the bottom of the screen. Users then started reading demographic information attached to the icons. This allowed users to realize that the icons represent former visitors, and the floating words their corresponding impressions of the Guanyin.

Expectation and realization. When they first saw ArtLinks, ten informants anticipated it to be some kind of information kiosk. They thought it would explain the exhibit, provide a floor guide, or give recommendations of other exhibits. One informant thought ArtLinks was an educational tool and expected a quiz about the Guanyin. Three informants said that they had no idea of its purpose but thought it looked interesting.

After the initial interaction with ArtLinks, however, people quickly realized that this does not provide information from the curators, but instead from former museum visitors. One visitor said, *"Oh, it's cool that I am a part of this system"* (Female, 46-55, 10 visits), when she realized the center icon at the bottom of the screen represented her. They became conscious of other visitors and curious about what other people thought and felt, as well as why people came to the museum. Four informants used "guestbook" as a metaphor of the system at this stage, mapping the system to familiar museum experiences they had in the past.

Discovering connections. People often discovered their connections to past visitors through their reflections. They wanted to find people who shared the same thoughts and tried to see if their words matched up to former visitors' words. Reasons for visiting and demographic information also supported connections to other visitors. Two visitors from out of town were interested in the impressions of other out of town visitors because of the coincidence of visiting the same exhibit at the same museum. Others were more interested in words written by those in the same age range.

People found the idea of connections unusual, but interesting. Art museums are seen as tranquil and relatively solitary environments. Even if they are crowded, visitors tend to admire the art quietly by themselves, without sharing their impressions.

"Many times when you're in a museum it's quiet. You express yourself to yourself. But here, this is nice to come up and to see what others have felt and thought. … But it's still silence, because you're not really talking. So you maintain that… space." (Female, 56-65, 20 visits)

"You see other people walking around looking at things and you don't know what they're thinking. A lot of these [words] don't tell what people are thinking and that's what I'm interested in." (Female, 18-25, 3 visits)

These comments suggest that ArtLinks did support visitors' social interactions without distracting from the cultural environment of the museum. The second quote, however, suggests that many of the words which people provided were not deep enough to help her understand what they were thinking.

Discovering meaning. Five informants felt ArtLinks was an inventive way to express themselves, and several said that ArtLinks helped them become part of the museum by adding their thoughts. ArtLinks encouraged visitors to think about how to express their reactions to other visitors as well as absorb other visitors' reactions.

"I'm more likely to try and find a way to sum up what I actually think, in words, as opposed to just thinking about it in my own head. How I would explain it to someone else." (Female, 18-25, 3 visits)

Three visitors described the experience as "ethereal", "relaxing", and "spiritual", suggesting that the system did support their liminal experience of the museum.

Aesthetic elements of ArtLinks. People enjoyed the motion of the floating words. People found the way the words floated through the screen made the display relaxing and almost meditative. One woman's comments suggested that seeing the words in this way makes you think about the art in a new way.

The audio component of ArtLinks generated strong reactions, both positive and negative. Twelve informants liked the sounds and found them playful, laughing as they explored the various sounds people made. Six informants also reported that the sounds made other people more salient. However, another group of informants were less enthusiastic, saying that the sounds were odd, or distracting, or that they did not go with the words.

Expectations are strong. Although feeling that ArtLinks is a pleasant, fun, and playful tool, almost all informants wanted more background information or expert opinions. They wished that ArtLinks could give them information such as "recommendation of related exhibits", "history of the artist", "something you felt that you learned specific", "a little detail or two", and "expertise about Buddha". This highlights the strength of visitors' expectations: they tend to remain committed to the idea that digital technologies serve the goal of providing information.

Some considered ArtLinks to be out of place, a piece of modern technology that does not fit alongside Asian art.

"I don't really like technology in museums. Technology can have a place but I personally appreciate the presentation of an old form of art. Technology in a museum tends to be outdated." (Female, 18-25, 3 visits)

"...if [this museum] was like the Guggenheim in like some kind of exhibit dealing with technology, I'd expect [ArtLinks], but not in like an ancient art [gallery]." (Female, 18-25, 1 visit)

These comments regarding technologies in an art exhibit, especially in an ancient art exhibit, show how people have strong stereotypes regarding the museum. Computers are seen as modern, suggesting that different contexts such as a technology museum or museums where computer displays are common would likely change people's reactions.

Visitors enjoyed ArtLinks. Despite their expectations, most visitors liked interacting with ArtLinks. Children especially appreciated ArtLinks, and it occasionally prompted conversations between children and parents about the exhibit. Overall, with very few exceptions, informants seemed to enjoy the socially connected aspect of the visualization, giving some new ways to think about the exhibits, and helping others come up with words to describe what they saw and share them with others.

"[My husband] laughed at it. ... I think it's pleasant, I think it's fun, I think it's playful." (Female 55-65, 20 visits).

DISCUSSION

Our results show that ArtLinks made progress toward its goals. People did report that it helped them feel connections to other visitors and think about the exhibit, supporting social and liminal experiences. It also encouraged people to be more aware of their expectations of technology, though not necessarily to change these expectations. Finally, our design choices resulted in an aesthetic experience that also supported our goals of connection and reflection.

Creating connection and meaning. ArtLinks had a strong, positive effect on how people perceived social aspects of the museum. A number of informants reported that the visualization caused them to be more aware of other visitors, to be curious about what others thought, to feel connections to other people, and to like the idea of being connected to them. It also had a positive effect in supporting the liminal experience of the museum, though fewer informants remarked on this than on the connections between visitors. These informants described the system as helping them to be more reflective or stimulating spiritual feelings. However, the system also damaged the experience for two users who felt that expressing their reactions to the Guanyin in words caused them to have a more cognitive and less emotional reaction than they otherwise would.

Focusing on common words, those that the system could use to make connections among people, might have harmed the system's ability to support meaningful experience. Words that were said by multiple people tended to be descriptive (e.g., "old", "female", "dirty", "wooden"). Most of the more interesting reactions ("more visual time lines", "sacred yet lighthearted", "commanding", "listening to the suffering cries of humanity") were said by only one person and so were normally not visible. Displaying everyone's reactions would have crowded the display, but displaying only words said by multiple people caused ArtLinks to support social aspects at the expense of the liminal. This problem is not unique to ArtLinks: common words provide little value in contexts such as search, recommender systems, and tagging systems. Providing instructions that guided people toward less descriptive and more reflective words might have supported more meaningful connections.

Fostering reflection. People had strong expectations about technology's place in a museum. Most people expected ArtLinks to provide information about exhibits before they started using it. Even after they realized its goal was social and liminal—and found value in that goal—they wished, in the end, that the system had provided information about the exhibit as well[4]. Not providing information was an explicit choice we made to focus attention on other aspects of museum-going. This might have been a mistake. Using informational elements to set up or lead into social and reflective elements—as the Hunt Museum's exhibit used the Study Room (informational) to lead to the Room of Opinion (reflective and social)—might have helped people move beyond their expectations.

We did help people move beyond the expertise barrier that Gay and Hembrooke observed. The power of expert information comes at a price, potentially inhibiting visitors from using systems that solicit their thoughts 15 or even from going to the museum at all 1. Although a few people were reluctant to contribute opinions because they felt they had little to add, most shared their opinions. And, though people expressed a strong desire for information, the visualization helped them realize social connections were a valuable aspect of museum visits. Reflective design doesn't have to change opinions and expectations and assumptions to be effective: it just needs to help people realize that they exist and consider whether they are good.

[4] The curators we worked with were convinced that the system should have an informational aspect, although they too thought it was interesting to see how visitors reacted to the art.

Designers, too, should challenge their expectations of technologies in museums. Our skill sets and mindsets shape the technologies we build. Personalization and context-awareness are important research topics in computer science, leading to systems such as PEACH 27 that focus on the personal and informational at the expense of the social. Meanwhile, design methodologies such as value-based, reflective, and critical design emphasize questioning the underlying values, habits, and assumptions that drive both users and designers. This sometimes leads to systems (including, we believe, ArtLinks in its explicit rejection of providing exhibit information) that fall short of their goals by diverging too far from users' needs and expectations.

Supporting transparency. Most of our design choices worked to support our goals. People liked the motion of the words and understood the representations of people and connections with minimal instruction. Sounds supported some goals and hindered others. The sounds were engaging: people found them interesting and fun and they did make other people more salient. However, people also found the sounds distracting and odd, especially the composite sounds that were attached to words. For some, the sounds reduced their ability to derive meaning from the visualization.

We believe people found the composite sounds distracting because they were an inappropriate, inaccessible abstraction for users. The idea of a composite sound attached to a word has a strong abstract design meaning: it is a connection between everyone who said that word. But this is a bad abstraction. When a sound plays because someone clicks on a person's icon, it is easy to infer that person made that sound. When a composite sound plays because someone clicks on a word, however, it is not obvious that the system is playing the sounds of all the people who said the word. Further, the sounds made by people are not usually related to the individual words they said. Rather, they represent their overall reaction to the exhibit. So, composite sounds are perceived as a set of unrelated sounds with no relationship to a given word; the idea that these sounds came from all the people who said the word was too abstract, even with lines explicitly showing the connections.

Likewise, our effort to find an appropriate representation of people revolved around the problem of finding accessible abstractions. Representing people as mandalas fit well with our goal of matching the style of the gallery and the idea of spiritual experience, but users didn't see the relationship between mandalas and people. We needed a less abstract representation to convey our meaning. Programmers have a (well-deserved) reputation for ignoring users when building interfaces, designing systems that only a compiler could love in the name of "technology as tool." Visualization designers should be careful not to make the same mistake under the banner of "technology as art."

Limitations and future work. It would be useful to study longer-term effects of ArtLinks with more people. The Johnson is a low-traffic museum, which shaped our study design. Collecting 17 interviews required about 40 person-hours of observation, much of which was spent waiting for people to approach the exhibit. It would also be interesting to see if ArtLinks leads to long-term changes in people's behavior or reactions to exhibits—do they spend longer with an exhibit, or remember more about it later, if they use the visualization? Traffic at the Johnson is too low, and the distribution of time spent at the exhibit is too skewed to do statistical analysis on measures such as exhibit dwell time, but this kind of analysis should be done in the long term in a more suitable context. Deploying ArtLinks with other works and in other museums would also buttress our results. For example, people produced a much more varied set of sounds for a music-related piece of art than they did for the Guanyin. Their feelings about the value of ArtLinks might change with context as well.

CONCLUSION

We conclude by outlining our contributions, again, organized around our goals. With respect to transparency, the tension between form and function is nothing new, but we believe that our experiences in balancing the two are useful stories to add to that conversation. Further, the strength and polarization of informants' reactions to sound in ArtLinks suggest that sound in visualizations is an interesting part of the design space.

With respect to reflection, we claim one main contribution with two implications. Our contribution is to confirm just how strong user expectations and assumptions can be. We knew people would expect information but were surprised by just how strong this expectation would be. This implies that any single design is unlikely to make large changes in these expectations, which in turn implies that if change is the measure of success for reflective design, most designs will fail. Most of the value must be in causing reflection on assumptions, not in causing those assumptions to change.

Finally, with respect to connection, ArtLinks succeeded in helping visitors see connections to other visitors and the exhibit in new ways. Leveraging social connections to support meaningful experience is a promising approach for designers to explore, one not limited to museums. On the web, interaction has evolved from one-way information push to interactive information seeking to explicit social interaction. We expect a similar trend in other computing contexts. Tools and services for sharing, recording, and distributing social information in physical contexts will become more common. When this happens, we expect people's expectations of what computers do "in the wild" will move from informational goals toward social ones. This may happen slowly—expectations can be strongly held—but it will happen. Designers should be ready.

ACKNOWLEDGMENTS

Special thanks to Cathy Klimaszewski, Ellen Avril, and the other folks at the Johnson Museum who helped us make this project a reality. We would also like to acknowledge

Emily Fleishaker and Kirsten Wentworth for their hard work in interviewing subjects. Finally, we would like to thank the IMLS, which supported this work under grant number MA-02-06-0406-06.

REFERENCES

1. Bell, G. Making Sense of Museum: The Museum as 'Cultural Ecology': A study. CIMI whitepaper, Intel Corporation, 2002.
2. Bell, G. No More SMS from Jesus: Ubicomp, Religion, and Techno-spiritual Practices. *Ubicomp 2006*, 141-158.
3. Boehner, K., Gay, G. & Larkin, C. Drawing Evaluation into Design for Mobile Computing: A Case Study of the Renwick Gallery's Handheld Education Project. *Journal of Digital Libraries*. 2005, 5(3), 219-230.
4. Boehner, K., Thom-Santelli, J., Zoss, A., Gay, G., Hall, J. S. & Barrett, T. Imprints of Place: Creative Expressions of the Museum Experience. In *Proc. CHI 2005 Extended Abstracts*, 1220-1223.
5. Card, S.K., Mackinlay, J., & Shneiderman, B. *Readings in Information Visualization: Using Vision to Think (Interactive Technologies)*. 1999.
6. Carr, D. The Need for the Museum. *Museum News*. 1999, 78(2), 31-35.
7. Ciavarella, C. & Paternò, F. The Design of a Handheld, Location-aware Guide for Indoor Environments. *Personal and Ubiquitous Computing*. 2004, 8(2), 82-91.
8. Ciolfi, L. & Bannon, L. Learning from Museum Visits: Shaping Design Sensitivities. In *Proc. HCII 2003*.
9. Erickson, T., Smith, D.N., Kellog, W.A., Laff, M., Richards, J.T. & Bradner, E. Socially Translucent Systems: Social Proxies, Persistent Conversation, and the Design of "Babble". In *Proc. CHI 1999*, 72-79.
10. Falk, J.H., Moussouri, T., and Coulson, D. The Effect of Visitors' Agendas on Museum Learning. *Curator*. 1998, 41(2), 106-120.
11. Ferris, K., Bannon, L., Ciolfi, L., Gallagher, P., Hall, T. & Lennon, M. Shaping Experiences in the Hunt Museum: A Design Case Study. In *Proc. DIS 2004*, 205-214.
12. Finlay, I. *Priceless Heritage: The Future of Museums*. London: Faber and Faber, 1977.
13. Friedman, T. From Heroic Objectivity to the News Stream: The Newseum's Strategies for Relegitimizing Journalism in the Information Age. *Critical Studies in Mass Communication*. 1998, 15(3).
14. Gaver, W.W., Bowers, J., Boucher, A., Gellerson, H., Pennington, S., Schmidt, A., Steed, A., Villars, N., & Walker, B. The Drift Table: Designing for Ludic Engagement. In *Proc. CHI 2004 Ext. Abstr.*, 885-900.
15. Gay, G. & Hembrooke, H. *Activity Centered Design*. Cambridge, MA: MIT Press, 2004.
16. Grinter, R. E., Aoki, P. M., Hurst, A., Symanski, M.H., Thornton, J. D. & Woodruff, A. Revisiting the Visit: Understanding How Technology Can Shape the Museum Visit. In *Proc. CSCW 2002*, 146-155.
17. Hallnas, L. & Redstrom, J. Slow Technology: Designing for Reflection. *Personal and Ubiquitous Computing*. 2001, 5(3), 201-212.
18. Heath, C., Luff, P., Vom Lehn, D. & Hindmarsh, J. Crafting Participation: Designing Ecologies, Configuring Experience. *Vis. Comm. 2002*, 1(1), 9-33.
19. Hein, H. S. *The Museum in Transition: A Philosophical Perspective*. Smithsonian Institution Press, 2000.
20. Hornecker, E. & Stifter, M. Learning from Interactive Museum Installations: About Interaction Design for Public Settings. In *Proc. OzCHI 2006*, 135-142.
21. Keene, S. *Digital Collections: Museums and the Information Age.* Oxford: Butterworth/Heinemm, 1998.
22. Kuno, Y., Sadazuka, K., Kawashima, M., Yamazaki, K., Yamazaki. A., & Kuzuoka. H. Museum Guide Robot Based on Sociological Interaction Analysis. In *Proc. CHI 2007*, 1191-1994.
23. Lehn, D.V., Hindmarsh, J., Luff, P., & Heath, C. Engaging Constable: Revealing Art with New Technology. In *Proc. CHI 2007*, 1485-1494.
24. Oppermann, R., Specht, M. & Jaceniak, I. Hippie: A Nomadic Information System. In *HUC 1999*, 330-333.
25. Sengers, P., Boehner, K., David, S. & Kaye, J.J. Reflective Design. In *Proc. The 4th Decennial Conference on Critical Computing*, 2005, 49-58.
26. Sterling, R. and Zimmerman, J. 2007. Shared moments: opportunities for mobile phones in religious participation. In *Proc. 2007 Conference on Designing Pleasurable Products and Interfaces,* 490-494.
27. Stock, O., Zancanaro, M., Busetta, P., Callaway, C., Krüger, A., Kruppa, M., Kuflik, T., Not, E. & Rocchi, C. Intelligent Presentation of Information for the Museum Visitor in PEACH. *User Modeling and User-Adapted Interaction*. 2007, 17(3), 257-304.
28. Thom-Santelli, J., Toma, C. Boehner, K., & Gay, G. Beyond Just the Facts: Museum Detective Guides. *Re-Thinking Technology in Museums Workshop*, 2005.
29. Thomas, S. & Mintz, A. *Virtual and the Real: Media in the Museum*. Washington DC: American Association of Museums, 1998.
30. Viegas, F. & Donath, J. Chat Circles. *CHI 1999*, 9-16.
31. Woodruff, A., Augustin, S., & Foucault, B. Sabbath Day Home Automation: "It's Like Mixing Technology and Religion". In *Proc. CHI 2007*, 527-536.