

Being in Public and Reciprocity: Design for Portholes and User Preference

Andreas Girgensohn

Alison Lee

Thea Turner

FX Palo Alto Laboratory
Palo Alto, CA 94304
andreasg@pal.xerox.com

IBM Research
Hawthorne, NY 10532
alisonl@us.ibm.com

Motorola
Schaumburg, IL 60196
thea@acm.org

ABSTRACT We found that Portholes users want to know about being in public, who can see them (audience) and who is looking at them (lookback). We developed one 2D and two 3D theater layouts of the display and different amounts of audience information to address these concerns. Different layout sections display core and non-core team members and lookback information. A survey of and a preferences experiment with 28 first-time users revealed two key results. First, there was a strong preference against the use of blue rectangles for audience information but preferences were varied on the amount of detail. Second, layout preferences matter but were varied.

KEYWORDS Audience, awareness, cluster, lookback, place, portholes, preference, public, reciprocity, usability, unfolding, video, visualization, World Wide Web.

1. INTRODUCTION

As we become better connected by communication networks, geographically-distributed individuals and groups are using mediated communication technologies (e.g., video conferencing) to support work collaborations. Group and collaboration *awareness* tools (Cool 1992, Narine 1997, Tang 1994) have been proposed for enabling non-co-located people to be aware of their coworkers and of the potential for collaboration. They largely use video images as the information kernel for awareness. *Portholes* is one flavor of such a tool that provides an integrative view of one's community through a matrix of still video images. These images are snapped periodically (e.g., every 5 minutes) and updated automatically. As a result, users can get a background and peripheral sense of co-workers and their activities.

Over a three year period, we developed, and deployed a Web-based version of this tool within

NYNEX (Lee 1997). The objective was to explore how it improves communication and facilitates a shared understanding among distributed development groups. We chose this tool because of the positive experiences at Xerox with using Polyscope and Portholes (Borning 1991, Dourish 1992). However, despite our efforts to involve users throughout and to make it accessible and useful, it was difficult to gain adoption by all users or to recruit new groups. In discussions with people ambivalent about this tool, we found at least two design limitations:

- Sense of being in public — cues about being in public that help users frame their behavior,
- Reciprocity — information about who can see a user and who is currently looking at the user.

The next section elaborates on the two limitations. The third section proposes a redesign of the Portholes display to include critical information along with the rationale. The fourth and fifth sections describe a preference experiment and results exploring users' initial impressions which have been so critical in influencing their adoption of the tool. The last section discusses the implications of this study on not only Portholes but other communication tools.

2. PORTHOLE LIMITATIONS

2.1 Sense of Being in Public

In an effort to lower the barriers to communication and collaboration posed by physical distance, awareness tools have created new channels of access to distant co-workers. However, these channels have brought many formerly private and public situations found in a person's office into a new unitary public setting (Meyrowitz 1985). This blurring of public and private situations changes their structure and reveals information once exchanged only among people under each other's direct observation. That is, Portholes users have gained a "sidestage" view into their co-workers' offices. Meyrowitz (1985) suggests that when new electronic media widens the onstage (public) region onto the backstage (private) region, a new "middle region" is formed which leads to new social behaviors.

While the effect of Portholes has been to make offices more public, many who used it are uncertain whether this places them in a public forum. The image matrix display did not clarify their concerns (e.g., Figure 1). If anything, some drew an incorrect association between the layout and a security-monitor setup. This resulted in negative impressions that amplified rather than clarified their concerns about surveillance and privacy.

Such uneasiness supports Meyrowitz' argument that electronic media has "undermined the traditional relationship between physical setting and social situation." People no longer seem to "know their place" because "they no longer have a place in the traditional sense of a set of behaviors matched to physical locations and the audiences found in them." Similarly, Portholes users do not know that they are in a public place and feel disembodied from the context of interaction (Bellotti 1993, Harrison 1996). They are at a loss about what the interactional setting is. Such uncertainties highlight the need to make the situation, being in public, more explicit in a social interface.

2.2 Reciprocity

Users are also uneasy about the absence of information reminding them that they are in public. In the physical world, we have access to cues that other people are around when we are out in public (Bellotti 1993, Goffman 1959). These cues let us regulate our behavior accordingly. However, Portholes designs focus on making users aware of their coworkers and opportunities for collaboration but not on the reciprocal information about when and which of these people are seeing the user.

Reciprocity describes the situation where all communications are two way. If you are able to see or hear others, they can see or hear you, at the same time. It is an essential element of communication, allowing users to monitor behavior and to control how others perceive them (Cool 1992, Tang 1994).

Our Portholes provided reciprocity information in the form of two lists. As we began to show the system to more people, we were told that they wanted to know "the people who can view their images." In fact, they really wanted see the information not in a list but in the main display. This was contrary to most Portholes systems which used the display to present images for a user's personal workgroup.

As we expanded our user base, we heard objections along the lines of "I want to know who is looking at me." We initially misunderstood these comments and thought that they simply did not know about the second list; the people who selected the user's image in their own Portholes display. In actual fact, they wanted to know who was looking at them NOW! In effect, as an electronic analog of looking in through co-worker's offices, it has lost an important but subtle reciprocity property; letting the observed know who is looking in.

This feedback highlights the need to prominently display two pieces of reciprocity information:

- Audience — people who can see a user's image,
- Lookback — people looking at a user's image.

3. NEW PORTHOLE DESIGN

Harrison and Dourish (1996) suggested that a meaningful location can be useful to frame behavior. They argued that the notion of a place is in fact based on a cultural and social understanding of the behavior and actions appropriate to the space. This idea that "we act in a place" is not unlike Goffman's view (1959) that a setting and an audience shape people's behavior in public situations. However, this should not be confused with the notion that the physical setting is a large determinant of behavior (Meyrowitz 1985). It is the social information (i.e., being in public, audience, lookback) that can be perceived within the setting, its access and its flow within the setting that determines the nature of the interaction.

Building on the notion of a place to frame behavior (Harrison 1996) and in particular the theater (Goffman 1959), our screen layout recreates a theater setting. This setting is a metaphor for a public forum and conveys a sense of being in public. People are familiar with it and what it represents. Also, this setting provides a context for the situation and the placement of certain social information. The the-

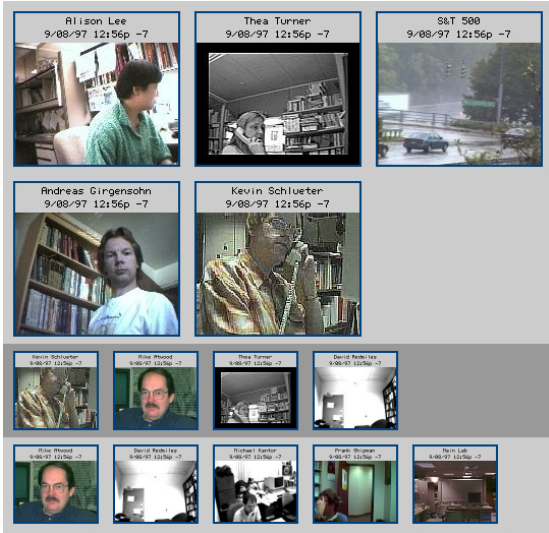


Figure 1: Traditional Design with Pictures for Non-Core Team at the Bottom (541x525)



Figure 2: Theater Design with Orchestra for Reciprocity and Blue Rectangles for Non-Core Team (601x496)

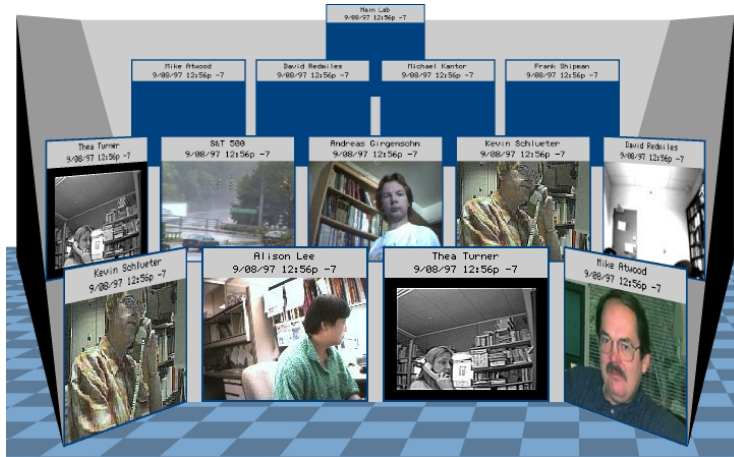


Figure 3: Theater Design with Side Rows for Reciprocity and Named Rectangles for Non-Core Team (727x447)

ater’s various regions contain the audience and look-back reciprocity cues that other people are present and looking in. The combination of the theater setting and reciprocity cues addresses the two primary user concerns. They remind users that they are in a public setting with an attendant audience and this helps them frame their behavior accordingly (Goffman 1959). This design blueprint was used to construct several designs that differ in two characteristics:

- Screen layout of the various regions of a theater,
- Detail of the audience information.

3.1 Screen Layout

Each user has a customized Portholes display containing a 3D presentation that places the user on stage and looking out to an audience encompassing

all the Portholes users that can view the user’s image (see Figures 2 and 3). The theater metaphor makes it explicit that use of Portholes positions them in a public forum; albeit to their co-workers only. Furthermore, their view is from the stage looking out at their audience and this allows them to see how public the distribution of their images is (e.g., size of their audience) and to whom they are being distributed to.

The images in the front and back rows reflect different *audience* reciprocity information (see Figures 2 and 3). The images in the front rows include the people in a user’s core workgroup (i.e., images appearing in the traditional image matrix). The images in the back rows are the remaining people in a user’s formal workgroup (i.e., people whom the user does not consider to be in her core workgroup — non-core team members). These non-core team members have access to a user’s image just as the

user has access to their images by virtue of being in the same formal workgroup. Hence, images in the front and back rows provide the complete audience for a user's own image.

We explored two configurations of the theater layout for presenting the *lookback* reciprocity information; one with images placed in an orchestra pit and the other with angled images at the sides (see Figures 2 and 3). These images represent the people in the user's workgroup that are currently running Portholes and thus, looking in on the user. The first layout, *Theater/Orchestra*, localizes the images in one place — orchestra pit — to allow an efficient visual scan of the lookback information (see Figure 2). The second layout, *Theater/Side*, positions the images at the sides to differentiate lookback information from audience information (see Figure 3). More importantly, the images are angled and not face-on and positioned at the periphery to reflect the fact that this lookback reciprocity is not a two-way exchange.

3.2 Secondary Audience Information

An important goal of the redesign was to provide users with information about their complete audience. However, the addition of many images can be distracting. Hence, we explored the notion of providing pictures for core team members and using one of four alternatives for representing non-core team members: *None*, *Size*, *Names*, and *Pictures*. Each successive option presents additional information.

The first option excludes the display of one's non-core team members (*None*). The second option presents the size of one's non-core team (*Size*) using a collection of blue rectangles to represent occupied theater seats. In keeping with the graphical and theatrical metaphor, the occupied blue seats provide a Gestalt of the non-core team member size (see Figure 2). The third option adds name labels to the blue seats (see Figure 3) to allow the user to find out who is seated in the back rows. The fourth alternative uses pictures to provide views into non-core team member's offices (*Pictures*).

4. PREFERENCE EXPERIMENT

A preference experiment was conducted to see which of the different screen layouts and audience options a first-time user would like. The reason to examine people's first-time preferences is because our experiences with recruiting users have shown that their initial perceptions and reactions play a critical role in the impressions they formulate and their willingness to use the technology (Lee 1997). Thus, our redesign is an effort to make Portholes not only useful and usable but also more acceptable to first-time prospects (Lee 1997). The first evaluation of the

design is to examine its effectiveness in guiding new users to formulate appropriate impressions and expectations about Portholes and thus to improve its uptake. If people use it, then it would be appropriate to conduct a longitudinal study of its impact.

4.1 Evaluators

28 evaluators (14 males and 14 females) were recruited through an electronic call for volunteers. All evaluators worked at NYNEX S&T and willingly volunteered for the experiment. None of them used Portholes but a few heard about it from their colleagues. Some of them worked together on past projects and others were unknown to each other. This is not unlike the situation of how workgroups are assembled at NYNEX and elsewhere. It is also not unlike the context in which we intended NYNEX Portholes to be used (i.e., among people who knew each other and those who did not). As compensation for their time and feedback, each evaluator was rewarded with a Swiss chocolate bar.

4.2 Layout and Audience Effects

There are two principal effects examined in the experiment through the different design options: layout and audience.

Three different layout options for organizing the information differently in the Portholes display were compared: *Portholes*, *Theater/Orchestra*, and *Theater/Side* (Figures 1 to 3). The *Portholes* layout displays images in a two-dimensional grid, with sections designated as core team members, lookback and non-core team members. Its layout is simpler, but is ambiguous about the issue of being in public. It was included to see if evaluators would prefer it over the theater designs. This layout is essentially the same as the one used in NYNEX Portholes, except that the non-core team member information was added at the bottom of the layout; differentiated from the other quarter-size, lookback images by having the same background color as the images for the user's core group members.

The two theater designs were described in the previous section. They use perspective cues to create a 3D appearance and place the lookback images in different locations. The theater setting conveys a sense of being in public and on-stage. The *Theater/Orchestra* is in between the other two layouts; it is visually simpler than *Theater/Side* but more three-dimensional than *Portholes*.

Four different audience options were shown for presenting people who were not explicitly selected by the user (non-core team members). These four options correspond to the four audience options presented earlier: *None*, *Size*, *Names*, *Pictures*.

4.3 Materials

Nine co-workers (5 males and 4 females) permitted us to use their pictures as part of the collection of video images used to assemble the various screen designs used in the experiment. We took color JPEG pictures (160x120 pixels) just like Portholes would take them. Also, we took a color picture of each evaluator in the same fashion at the beginning of the experiment. The evaluator’s picture appears among the images of co-workers who were part of the evaluator’s core team. From past experiences, we learned that including the individual’s own picture into the Portholes display subtly affected the individual’s perception of the tool; from one of looking in at others to one of being among the group of people who can view as well as be viewed. We wanted the evaluators to experience a group awareness tool as an insider and not as an outsider.

The ten pictures were used to assemble the twelve different screen designs (3 layout and 4 audience conditions). Evaluators were told which co-workers filled the role of core team and non-core team members. They were told that all co-workers had access to Portholes. The various options for the display of the information about the non-core team members were introduced to the evaluators. Evaluators were shown the three layouts and where the information about core and non-core team members and lookback would appear in each of the layouts.

4.4 Procedure

In the first part of the experiment, 72 pairs of designs were shown to the evaluators. An initial warm-up block of comparisons was presented, in which all twelve designs were displayed as six pairs. Then evaluators saw each design eleven more times over 66 paired comparisons, once with each other design. To avoid biases, each design was shown five times on one side and six times on the other. Also, each design appeared only once within every blocked sequence of six comparisons.

Each design pair was shown at the same time. A button, labelled “I like this better,” appeared below each design. Clicking on a button recorded the choice. Then the next design pair was presented.

At the conclusion of the paired comparison phase, evaluators were given a three-part survey. Parts 1 and 2 will not be discussed here. Part 3 assessed the importance of a set of eighteen design requirements.

5. PREFERENCE RESULTS

The data from the warm-up block was discarded. Preference scores were calculated for each evaluator by totalling the number of times a design, layout

option, or audience option was preferred, normalized to a range between 0 and 1. As well, the “dissimilarities” between evaluators and designs were described as the rank of the design preferences for each evaluator, based on the number of times a design was chosen. In a few cases, an evaluator did not exhibit a clear preference for one design over the other or was inconsistent. These ties were resolved based on the choice made by the evaluator in the direct comparison between the two designs.

Most evaluators exhibited a strong internal consistency in their preferences. An interaction between Audience and Layout was seen in three evaluators.

5.1 Audience

Preferences were significantly influenced by the audience information ($F_{(3,81)} = 11.59, p < 0.05$). However, it was not the case that preferences increased as the amount of information provided about the audience increased (see Figure 4). Evaluators overwhelmingly disliked the use of blue rectangles to represent seats occupied by non-core team members. The sum of these images and those of the core team members represents one’s audience size. The survey results underscored the undesirability of the use of blue images to indicate audience size (26% preferred the use of blue images while 67% preferred the use of a number — see Q3 and Q14 in Table 1). Evaluators preferred Names over None, but were mixed as to the desirability of Pictures over Names or None.

5.2 Layout

Personal preferences were expected to surface in the reactions of the evaluators to the three layouts. Patterns of preference were varied, resulting in a statistically insignificant effect of Layout ($F_{(2,54)} = 0.906$). We used multidimensional weighted unfolding (MDU) (Shepard 1972) to analyze the underlying structure in the individual preferences.

Unfolding was originally suggested by Coombs (1950) for a single dimension and has since been

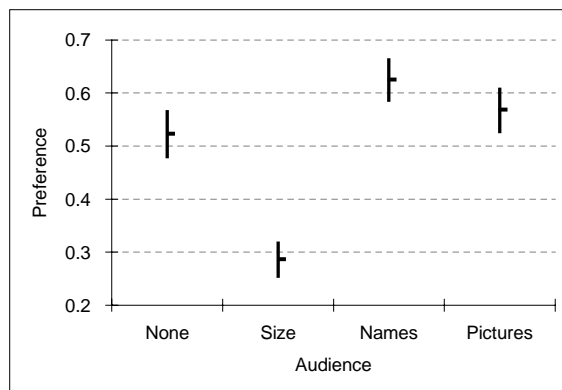


Figure 4: Audience Preferences

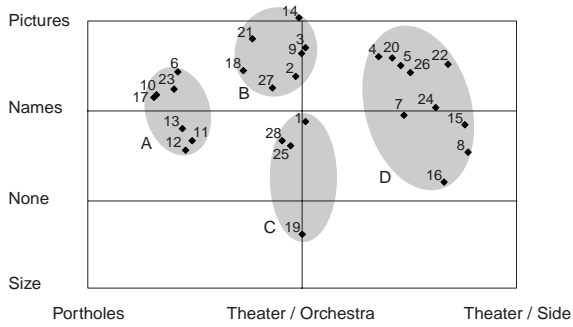


Figure 5: 2-Dimensional Unfolding of Preferences

extended to multiple dimensions. Unfolding assumes that stimuli are aligned along one or several dimensions and that individuals observe the experimental conditions from their own perspectives. It places objects, conditions and evaluators, in a spatial model in such a way that the significant features of the data about these objects are revealed in the geometrical relations among the objects.

The MDU analysis was performed using ALSCAL (SPSS 6.1.4 for Windows) which yielded a RSQ of .870 — the amount of variance in the data accounted for by their distances. The inputs to the analysis were the positions of the layout and audience conditions and the “dissimilarities” between evaluators and designs. The screen layout conditions were positioned on the grid based on our assessment of the dissimilarity among the conditions. The Portholes condition is more dissimilar than the Theater/Side because of the 3D nature of the design while the Theater/Orchestra was placed between them because of its hybrid 2D/3D design. The placement of the audience conditions made use of the observation that Size was the least preferred condition and thus placed at one endpoint. The other three conditions were then placed in the order of increasing information value with the Pictures condition being placed at the other endpoint.

Using the positions produced by the unfolding analysis, we performed a hierarchical cluster analysis using the Ward method. This produced four distinct clusters. An examination of the results from both analyses (see Figure 5) showed that people did differentiate the layouts. As expected from unfolding theory, the cluster analysis revealed that there was not one single preferred view but rather four.

Figure 6 shows the average layout preferences for each of the clusters. Individuals in Clusters A and D clearly prefer Portholes and Theater/Side, respectively. However, the placement of Clusters B and C near the center of the Layout dimension (see Figure 5) does not necessarily imply a preference for Theater/Orchestra; they include people who based their preference more strongly on the audience

conditions (see Evaluators 14 and 19 as extreme examples of this). Overall, individuals in Clusters B and C have similar preferences for layout and could be combined if Evaluator 19 was treated as an outlier.

5.3 Requirements Survey

Participants rated the importance of 18 design requirements for a Portholes display (see Table 1). The five-point rating scale was 1 for No Way, 2 for Should Not Have, 3 for Don’t Care / Either Way, 4 for Nice to Have and 5 for Important to Have.

The requirement Q3 to use blue rectangles to complete the audience size information, was the only one generally rejected by evaluators, rated a 1 or a 2 by eighteen out of twenty-eight people. This corroborates the objective preference selection for the audience Size option, reported earlier (see Figure 4).

The universally agreed upon requirement was Q16; to be able to “look in one place to see the team members looking back right now,” rated “Important to Have” by twenty-three evaluators. Interestingly enough, this includes all individuals in Cluster D — Theater/Side — whose most preferred design required the user to look to the right and to the left to see who was looking back (see Figure 7). Almost as highly rated was requirement Q15 to “see team members looking back right now at all times.” Evaluators in Cluster C rated both of these requirements significantly below Clusters A and D. Meanwhile, evaluators in Cluster B rated Q16 higher than Q15.

Three questions addressed the issue of the non-core team member images: Q1 (show the images), Q5 (show as pictures), and Q7 (show with names and pictures). Clusters B and D evaluators wanted to see as much as possible (average preference = 3.95 and 3.77, respectively) while Cluster A evaluators were indifferent. Individuals in Cluster C did not want to see any of the information (average = 1.92).

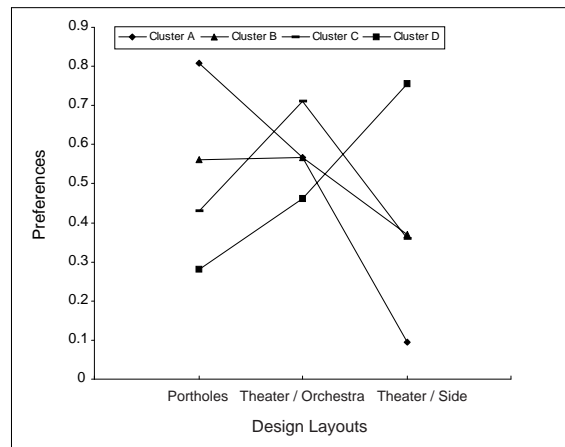


Figure 6: Preferences Grouped by Clusters

Item	Requirement	Important or Nice to Have
Q1	See my non-core team members along with my core team members at all times.	61%
Q2	Assess how many people on my non-core team.	68%
Q3	See a set of blue images for my non-core team members instead of a number for size of non-core team.	26%
Q4	See the names of my non-core team members at all times.	71%
Q5	See the pictures of my non-core team members at all times.	46%
Q6	See not only the blue images but also the names of my non-core team members at all times.	64%
Q7	See not only the names but also the pictures of my non-core team members at all times.	57%
Q8	See my own image in the layout.	64%
Q9	Control whether I see my own image.	89%
Q10	Control the placement of my image.	75%
Q11	Control the placement of core and non-core team member images in the layout.	86%
Q12	Control the placement of images of team members looking back right now.	89%
Q13	Assess how many people can potentially see my image.	71%
Q14	See a number for how many people can potentially see my image.	67%
Q15	See team members looking back right now at all times.	86%
Q16	Look in one place to see the team members looking back right now.	89%
Q17	Display information about team members looking back right now separately.	54%
Q18	Display a marker on the images of the team members looking back right now instead of duplicate images.	68%

Table 1: Results of Requirements Survey

The user’s own image has been a concern to some Portholes users in the past. This issue was explored with three questions: Q8 (in own display), Q14 (on other’s display), and Q13 (how many can see own image). Except for Q8 for Cluster C, these were rated nice to have by all evaluators. The people in Cluster D (Theater/Side preference) were more concerned about their image and who saw it than the people in the other three clusters. Looking at the survey data as a whole, most requirements were regarded as positive additions to Portholes by people in Clusters A, B, and D. Evaluators in Cluster C did

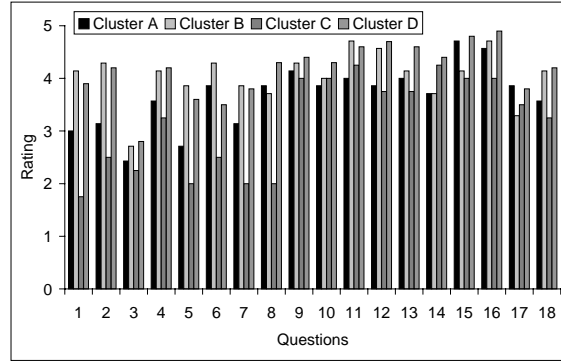


Figure 7: Average Ratings by Cluster

not want to see much information in their display or for that matter, use an awareness tool.

5.4 Summary and Discussion

The results reveal four different clusters of preferences regarding the layout and audience options to use; representing differences in importance of the information to different groups of people. Clusters A and D clearly prefer Portholes and Theater/Side, respectively. However, Clusters B and C based their preference strongly on the audience conditions; it was not necessarily the case that they preferred Theater/Orchestra. Clusters B and D wanted to see as much information as possible.

Evaluators indicated a strong universal dislike for the use of blue rectangles to represent occupied seats for non-core team members; with no information being more preferred. Our intuition is that people reacted strongly to the choice of representation rather than usability concerns; they viewed the blue images as nameless, faceless individuals. This result supports the argument for paying attention to how people relate to technologies (Reeves 1996). This speculation could be validated in a preference study using a number in place of blue rectangles.

The preference and survey results show that there is no universal agreement on the choice of the layout and the level of detail for audience information. Evaluators want to see at least the names of the non-core team members. A large percentage ($\geq 75\%$) want to control the placement of the information. Evaluators differed also on which layout is preferred. This suggests that all three layouts should be provided as user-selectable options.

Finally, among long-term users of Portholes, we have found that the needs for Portholes change (Lee 1997). That is, the customizations for new users differ from those who use it for a long time. This evolution can be, in part, attributed to the emergence of the new “middle region” behavior formed in response to the effect of using Portholes over time (Meyrowitz

1985). See Dourish (1996) for similar observations associated with long-term use of a media space. It would be useful to examine the structure of the users' preferences and its evolution over time.

6. CONCLUSIONS

This paper argues for the importance of the social interface and its design. From a narrower perspective, it provides an understanding of these issues for Portholes and group awareness tools. It illustrates two pieces of information needed in such a social interface and how it appears in the user interface: sense of being in public and reciprocity. The design uses a theater setting to provide a familiar behavioral context and uses different sections to present a user's community, their audience, and who is looking in on the user. We argue that without this information and a way to present and access it, users do not know "know their place."

From a broader perspective, the paper provokes thinking about what the social information is in other computer-mediated communication tools and how to bring forth this information in the user interface to elicit the desired impressions and reactions. Concerns for surveillance and privacy are not unique to Portholes. Even technologies like television and radio have wrought changes in social behaviors, roles, order, and situations. In grounding the discussion with Portholes, we try to relate the studies of face-to-face and mediated interactions, to make the concepts of "sense of place," social information, and social interface more concrete and applicable to the design of computer-mediated tools and to show that its design can be fraught with issues that we are just beginning to understand (Dourish 1992, Goffman 1959, Meyrowitz 1985, Reeves 1996).

ACKNOWLEDGMENTS

Debbie Lawrence and Jim Kondziela provided valuable suggestions in the design of the experiment. Mike Atwood and John Thomas have supported the Portholes research throughout. This research was performed at NYNEX Science & Technology which is now part of Bell Atlantic.

REFERENCES

- Bellotti, V. and Sellen, A. (1993). Design for privacy in ubiquitous computing Environments. *Proceedings of the Third European Conference on Computer-Supported Cooperative Work (Milan, Italy)*, London, pp. 61-76.
- Borning, A. and Travers, M. (1991). Two approaches to casual interaction over computer and video networks. *Human Factors in Computing Systems, CHI'91 Conference Proceedings (New Orleans, LA)*, New York, pp. 13-19.
- Cool, C., Fish, R.S., Kraut, R.E., and Lowery, C.M. (1992). Iterative design of video communication systems. *Proceedings of the Conference on Computer-Supported Cooperative Work (CSCW'92)*, New York, pp. 25-32.
- Coombs, C.H. (1950). "Psychological scaling without a unit of measurement." *Psychological Review*, 57, pp. 145-158.
- Dourish, P., Adler, A., Bellotti, V., and Henderson, A. (1996). "Your place or mine? Learning from long-term use of audio-video communication." *Computer-Supported Cooperative Work*, 5(1), pp. 33-62.
- Dourish, P. and Bly, S. (1992). Supporting awareness in a distributed work group. *Human Factors in Computing Systems, CHI'92 Conference Proceedings (Monterey, CA)*, New York, pp. 541-547.
- Goffman, E. (1959). *The presentation of self in everyday life*. New York: Doubleday.
- Harrison, S. and Dourish, P. (1996). Re-place-ing space: The roles of place and space in collaborative systems. *Proceedings of the Conference on Computer-Supported Cooperative Work (CSCW '96)*, New York, NY, pp. 67-76.
- Lee, A., Girgensohn, A., and Schlueter, K. (1997). NYNEX Portholes: Initial user reactions and redesign implications. *Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work, GROUP'97 (Phoenix, AZ)*, New York, NY, pp. 385-394.
- Meyrowitz, J. (1985). *No sense of place: The impact of electronic media on social behavior*. New York: Oxford University Press.
- Narine, T., Leganchuk, A., Mantei, M., and Buxton, W. (1997). Collaboration awareness and its use to consolidate a disperse group. *Proceedings of INTERACT'97*, London, pp. 397-404.
- Reeves, B. and Nass, C. (1996). *The media equation: How people treat computers, television, and new media like real people and places*. Cambridge, UK: Cambridge University Press.
- Shepard, R.N. (1972). "Introduction." In R. N. Shepard, A. K. Romney, & S. B. Nerlove (Eds.), *Multi-dimensional Scaling: Theory and Applications in the Behavioral Science*, (Vol. 1, pp. 1-20). New York: Seminar Press.
- Tang, J.C. and Rua, M. (1994). Montage: Providing teleproximity for distributed groups. *Human Factors in Computing Systems, CHI'94 Conference Proceedings (Boston, MA)*, New York, pp. 37-43.