ORIGINAL ARTICLE

From interaction to performance with public displays

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Abstract Interacting with public displays involves more than what happens between individuals and the system; it also concerns how people experience others around and through those displays. In this paper, we use "performance" as an analytical lens for understanding experiences with a public display called *rhythIMs* and explore how displays shift social interaction through their mediation. By performance, we refer to a situation in which people are on display and orient themselves toward an audience that may be co-located, imagined, or virtual. To understand interaction with public displays, we use two related notions of collectives—audiences and groups—to highlight the ways in which people orient to each other through public displays. Drawing examples from *rhythIMs*, a public display that shows patterns of instant messaging and physical presence, we demonstrate that there can be multiple, heterogeneous audiences and show how people experience these different types of collectives in various ways. By taking a performance perspective, we are able to understand how audiences that were not physically co-present with participants still influenced participants' interpretations and interactions with *rhythIMs*. This extension of the traditional notion of audience illuminates the roles audiences can play in a performance.

Keywords Public displays · Performance · Groups · Audiences

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1 Introduction

The very term "public displays" implies a large public, but this brings up questions of what the "public" for a "public" display is, and what the consequences of particular kinds of commitments to ideas of "publicness" are. There is a large literature in CSCW and HCI on public displays and how they can provide awareness information [4, 6, 9, 10, 18–20, 25, 26]. Looking at this corpus of work, we can begin to see what constitutes a public display.

Much work in CSCW and HCI draws its inspiration from the work of Goffman [17], who defines "public places" as "any regions in a community freely accessible to members of that community". A public display, then, is a display that is installed in a space that is openly accessible to more than one person. By openly accessible, we mean that people do not need to be granted explicit permission before they can enter the space. There is the potential for an audience to appear at any time, because a display, as well as any person who interacts with it, can be visible to anyone passing through the space. A design tension that emerges from the practice of publicly sharing awareness information is the trade-off between privacy and awareness. The issue of privacy is often framed as the lines between "public" and "private" spaces being blurred, and how users should be able to control what information is captured about them and presented to others [19, 21].

We extend this work by demonstrating that multiple, heterogeneous collectives engage with public displays and that people experience these collectives in different ways. We argue that not only are people influenced by physically co-present audience members, but that they are also influenced by "imagined audiences"—that is, they are conceiving of the potential audience for the display as imagined others who may not necessarily be co-present with a public display or its users.

When interaction takes place in public spaces, as it inevitably does in the case of public displays, the experience is more than what happens between the user and the system, and more than the results of the user's actions. Participating in an interactive experience also produces a context that shapes how someone else experiences what you do, and how you are aware of other people seeing and experiencing that you are experiencing something. Dalsgaard and Hansen [7] refer to this as "performing perception," in which the user is simultaneously engaged in interacting with a system, performing for others to observe and actively perceiving that a performance is taking place. Our work seeks to use performance as an analytical lens for understanding experiences with a public display. By performance, we are referring to a situation in which someone's experience (the performer's) with an object or another person is affected by the presence of others (the audience). Along this vein, we align ourselves with Dalsgaard and Hansen [7] and Reeves et al. [31], among others, to examine the role of the audience, both co-present and imagined, in shaping a performer's experience with a public display.

Previous work in public displays has shown that public displays can engender serendipitous and spontaneous interactions [6, 25, 26]. These works assume that such interactions generate feelings of connectedness across larger audiences or that the public encountering the display is a single homogenous collective of people. However, we demonstrate that interactions around and through public displays are more complex. To analyze these phenomena, we rely on two related but independent concepts to highlight how people actively orient themselves toward different types of collectives mediated by displays: audiences as they are conventionally understood and groups as defined by McGrath [27]. Drawing examples from *rhythIMs*, a public display that visualizes patterns of instant messaging and physical presence for a group of collocated people, we extend the notion of audience and demonstrate how imagined audiences influence the experience of the performers. We explore the dynamics of how audiences and groups reveal themselves around *rhythIMs* and show how the relationships between these concepts—their different scopes and different modes of participation—help to illuminate different aspects of people's experiences of public displays.

The structure of this paper is as follows. First, we review the related literature that motivated our work. Then, we describe the design and implementation of *rhythIMs*. We discuss our findings, focusing on how participants oriented toward different types of audiences and groups. We then present an extended notion of audiences to examine how imagined audiences affect one's experience of *rhythIMs*. In this, we demonstrate how *rhythIMs* mediated different types of collectives and audiences, which in turn, influenced people's interpretations of the system and its interactions. Finally, we end with concluding remarks and offer a direction for future work.

2 Related work

Temporality plays a large part in structuring our everyday lives, especially in our interactions with others. When people arrange social gatherings, everyone must agree upon a suitable time. Even impromptu gatherings can necessitate temporal sequences, e.g., "I'll meet you in the lounge in 5 min." Begole et al. [2] found that visualizations of computer usage reflected meaningful patterns in people's activities, both on and off the computer, as they went about their day-to-day lives, suggesting that the knowledge of other people's rhythms is useful for coordinating activities or initiating contact. Visualizations of email activity have also revealed the social and temporal structures that exist in our communication with others [13, 35]. The results of these studies indicate that a shared sense of time among a group of people facilitates the coordination of interaction.

Helping people to identify their own rhythms and patterns may also be useful in managing—or at least understanding—the inferences other people make. This is especially salient for online interactions, which can feel shapeless, because the interaction is intangible and the presence of other people and their activity is often opaque to the user. Although visualization tools already exist for online interactions, such as email [13, 35] and online communities [12], instant messaging remains largely unexplored as a source of data for visualizations.

Most visualization approaches typically revolve around the individual, with the visualization acting as a tool for information retrieval on a dataset generated by an individual user. The mail, for example, visualized the content of a single user's email archive [35], while Begole et al. [2] examined a single user's computer activity. These tools enabled users to navigate through large amounts of data and to make sense of their own patterns of behavior. However, much of our interaction with others online is not one-to-one but rather, with multiple people simultaneously. These visualizations, then, would fail to capture the

patterns of interaction that would emerge from a many-to-many dynamic in a group setting.

To make the recent activity of the members of an online community more transparent to its users, Erickson et al. [12] introduced a group-centric approach to visualization in their work on "social proxies," which are dynamic graphical representations of online presence and activities. This work focused on making visible individuals' activities in a collective format of a group of people, which is our interest here as well. Although the Babble system provided people with a sense of recent activity, it primarily visualized real-time online activity. This provided people with an immediate awareness of others who were currently active on the chat system. However, it did not reveal the longer-term patterns of activity. Although the visualization afforded opportunistic interactions when people were using the system at the same time, interaction was predicated on synchronous use. Thus, users needed to have prior awareness of when others were likely to be using the system in order to facilitate "opportunistic" interaction.

Supporting awareness has driven a great deal of CSCW research [4, 10, 21]. Although these systems were meant to support distributed work groups, they highlight the importance of awareness and connectedness in facilitating communication, aiding in collaboration, and strengthening social bonds. Although collocated groups have the distinct benefit of sharing a physical space, which allows them to glean awareness information and social cues, these social functions are important for enriching group interactions.

Researchers have noted the advantages of IM as a tool for lightweight interaction in the workplace, supporting informal communication, coordination, and scheduling [20, 29]. Current methods of obtaining IM presence information, however, require the user to explicitly retrieve a status message or periodically monitor and scan a buddy list. These methods require the user to switch tasks and to place full attention on the IM client, suggesting that a peripheral means of supplementing this information may be useful, especially for users who have IM continually running in the background. Huang et al. [20], for example, demonstrated the value of a public IM system for supporting awareness and facilitating workgroup interactions. (At the time of this study, push technologies for status notifications, such as those used in WhatsApp, Twitter, or Facebook, were not yet widely used).

3 rhythIMs

3.1 Motivations and design

We extend the research described in the previous section by taking a group-centric approach to visualization and to
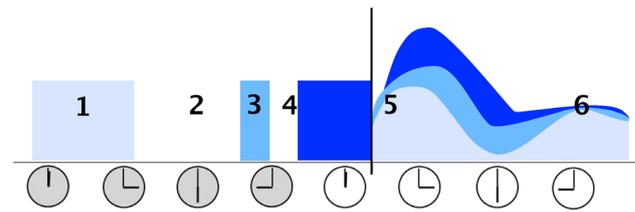
Fig. 1 The *rhythIMs* visualization for a single person

provide awareness information about a group's presence. *rhythIMs* publicizes opportunities for informal and spontaneous communication by reflecting information about a group's presence back to all members of the group. We decided to focus on instant messaging presence and physical presence as the source for awareness information. We wanted to explore how people become present to themselves and each other in different ways.

The goal of *rhythIMs* is to give people a picture of what their recent IM and physical presence activity looks like, alongside their past patterns (see Fig. 1). Each user is represented by three layers: remote IM presence (e.g., on IM while not collocated with the display), physical presence, and simultaneous IM and physical presence (e.g., on IM while collocated with the display). To distinguish between the three types of presence information for each user while indicating that they are related as a set, we used the same color for each user but colored each presence at a different saturation level. IM presence is shown at 33 % saturation, physical presence at 66 %, and simultaneous IM and physical presence at 100 %.

The thickness of a layer is proportional to the frequency with which a user has been present on IM or in the physical office space in the recent past. A series of clock images is laid out across the bottom of the visualization, each representing a different hour of the day. Because many people are accustomed to reading analog clock faces quickly and to avoid the perception that the visualization is a graph, the time axis is labeled with clocks rather than numbers.

An example scenario of how the visualization is generated is illustrated in Fig. 1. The regions are labeled as follows:

1. The user, Lucy, is logged on to IM at home between midnight and 3 a.m.
2. She goes to sleep and signs offline.
3. Early in the morning, she heads to her office. She does not log on to IM, but *rhythIMs* registers her presence through her mobile phone.
4. She leaves her office briefly but returns and signs on to IM.
5. From her past history, she is likely to be on IM but working remotely until approximately 1:30 p.m. She
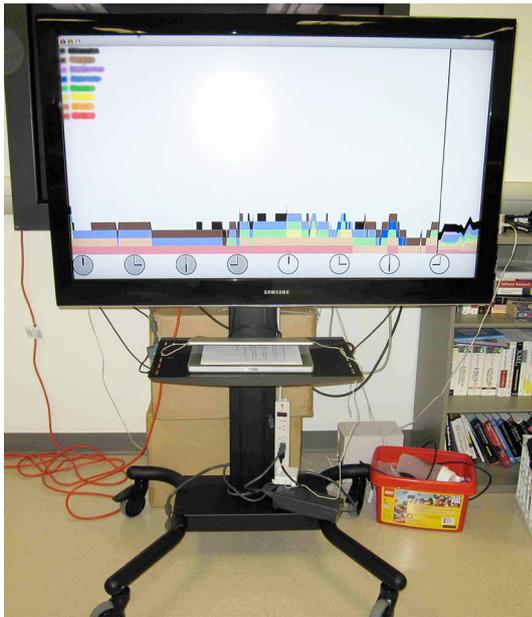
Fig. 2 The *rhythIMs* display

normally goes home for lunch after class, but today she works from her office where *rhythIMs* is installed.

6. In the evening, she is usually on IM remotely. She is rarely in the office late at night.

To emphasize the group as a collective, we designed *rhythIMs* to be a public display, making it a shared resource and encouraging communication between the people in the space (Fig. 2). Grasso et al. [18] found that displays can be beneficial to peer groups, or "communities of practice," by providing visibility of the community to its members. People who share a working environment are presumably interested in maintaining awareness information about each other since they may need to communicate, collaborate, coordinate, or otherwise interact with each other. Because many office work environments allow for flexible and independent work schedules, co-workers may not necessarily be present in the same space at the same time. In this case, historical information detailing when someone has been present and will likely be present again could potentially be useful to people who often interact (e.g., co-workers who share a workspace). Collocated groups could find such tools useful if people are not always co-present at the same time. This information could be especially useful in the early stages of a working relationship, when people's temporal rhythms are converging with the rhythms of their collaborators.

We wanted to give people a sense of the current presence of a group of people but also enable them to see presence patterns at the current time of day. To achieve this, we created a dynamic visualization that consists of two parts split by a vertical line (illustrated in Figs. 1, 3).

The layers to the left of the line indicate the presence activity that has occurred so far within the day since midnight. This information is only based on 1 day of data. Thus, all of the layers are of the same height and represent binary information; the person was either present or not. The layers to the right of the line indicate the patterns of presence activity that have aggregated throughout one's history. IM presence is detected by monitoring IM status (e.g., if someone is offline or online). Physical presence is detected by monitoring the presence of Bluetooth devices that people can register with the system.

The visualization updates every minute. As the vertical line moves across the screen from left to right over a 24-h period (the far left being midnight and the start of a new day, while the far right is 11:59 p.m.), the visualization reveals the presence activity that has taken place so that people can get a sense of daily patterns. Splitting the visualization in this manner also enables people to see and reflect on breaks in the patterns. It provides a picture of what people's recent IM and physical presence activity looks like and compares it to what their historical activity has looked like in the past.

To give people an overall sense of the collective's online presence and temporal patterns, while also showing how the individual contributes to the collective's patterns, we represented a group of people as the aggregation of everyone's layers stacked on top of each other, with each person assigned to his or her own color (see Fig. 3). The idea of using layers was inspired by the Artifacts of the Presence Era installation, which visualized patterns of people's evolving presence by using layers formed from video images [36]. Layers can make it easy to see one entity with respect to a larger whole, a benefit in both that system and in *rhythIMs*. People can examine the patterns exhibited by the individual and see how they contribute to the collective by comparing one layer to the mountain formed by the accumulation of the other layers.

3.2 Implementation

rhythIMs consisted of a visualization displayed on a 52" LCD flat screen display, connected to a Bluetooth scanner via USB. The Bluetooth scanner detects devices registered to *rhythIMs* profile owners as a proxy for physical presence. By using Bluetooth-enabled devices that many people own already, such as mobile phones and laptops, *rhythIMs* does not require users to carry additional devices for identification or interaction.

The majority of the system was written in Java. When the application is started, a Jabber client is instantiated on the computer connected to the display. The Jabber client connects to an Openfire server and uses the Echomine Muse library to process presence messages that it receives

**Fig. 3** The *rhythIMs* visualization for a group of eight people
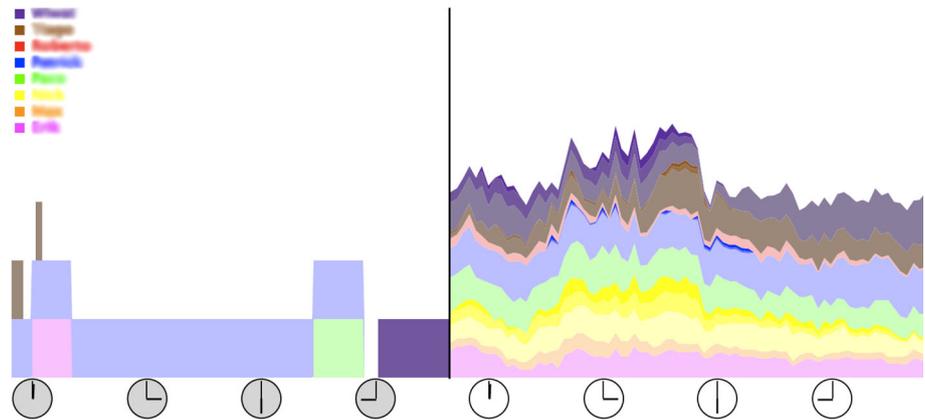
from the server. Once logged into Jabber, the client signs into all of the relevant IM networks through the IM gateway plug-ins installed on the server. The *rhythIMs* users' screen names are added to the buddy lists of the IM accounts we designated for *rhythIMs*. When a buddy's instant messaging status and availability changes, the commercial server notifies the Jabber server, which, in turn, notifies the Jabber client. When the client receives these Jabber presence messages, it parses them to determine the buddy's updated status and updates the *rhythIMs* display.

A second Jabber client is used for data storage and performs the same monitoring functions as the first client. At each minute of the day, a buddy's current instant messaging status is sent to a MySQL database that stores all of the presence data. Two separate Jabber clients were used so that the visualization could run independently of data collection.

3.3 Installation

rhythIMs was installed for a group of eight participants over 5 weeks in a user study. We used convenience sampling to select a group of graduate students at our institution, all working full time on research. Participants were recruited via an email sent to the research group's mailing list and received a $20 incentive for participating. Eight of the eleven students who regularly work in the office volunteered to participate. They were all computer science graduate students, worked in the same lab, and were members of the same research group. They worked in the office where *rhythIMs* was installed but maintained flexible working schedules, with the exception of one participant, Nathan, who worked in the office next door but frequently visited the other office to interact with his colleagues. The display was placed at the front of the office next to the door to attract people's attention as they entered and left the room (Fig. 4). When seated at their primary workstations,
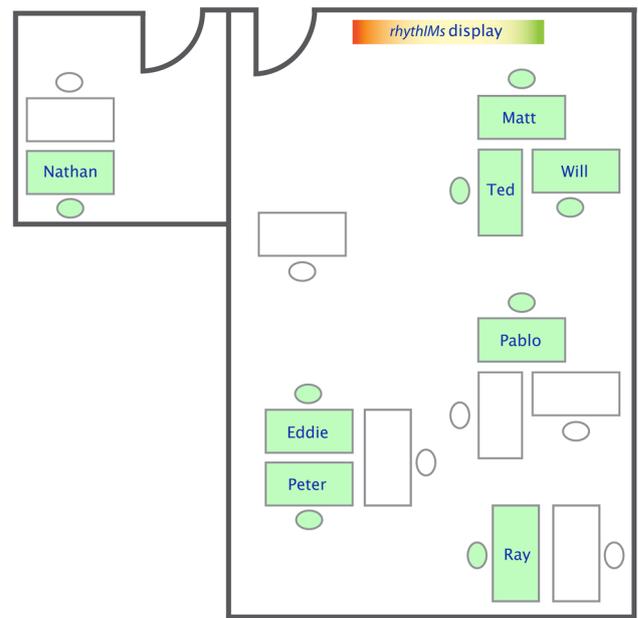
Fig. 4 The layout of the participants' office and placement of *rhythIMs*

three people faced the back of the room, two the front, and two others the side. However, people often looked toward the front of the room when they were sitting at their desks, as well as when they entered and left the office.

We collected IM presence information for all participants and Bluetooth presence information for four people. The remaining four participants did not use Bluetooth-enabled devices or their devices were not compatible with *rhythIMs*. Participants completed a pre-study questionnaire in which they were asked to describe their current IM usage and patterns, when they were typically in the office and how they usually communicate with each of the other participants. They were also asked to describe the IM and physical presence patterns for each of the other participants. At the end of the study, we conducted semi-structured interviews with each

participant. The interviews averaged 53 min in length, ranging from 23 min to just under 2 h. They were conducted in a conference room near the participants' office. During the interviews, we asked participants to complete a pattern identification task where we generated individual *rhythIMs* visualizations and asked each participant to label them with the person whose presence patterns they believed matched each one. This exercise was intended to encourage participants to reflect on how their initial assumptions in the pre-study questionnaire compared with actual patterns. We also asked them about when they looked at the display, their motivations for doing so, and how they made sense of the visualization. We examined the interview data using grounded theory.

4 Results

The participants shared an identity as members of the same research group and had shared the office space for several months. However, they rarely interacted with each other aside from brief face-to-face interactions in the office. Only a small subset of the participants communicated outside the office. According to their pre-study questionnaires, each participant only had one to three other participants on their IM contact lists. Communication over IM was rare and generally reserved for urgent matters that necessitated immediate responses.

What was particularly interesting to explore with *rhythIMs* were the different levels of performance that it produced, such as the interaction of giving data to the system, looking at the display, watching people who are looking at the display, or the interaction between members of the research group caused by information shown on *rhythIMs*. Previous work in public displays explored performance through the act of sharing information [9, 30]. We focus on performance from the perspective of looking at the display and reading the information, and how the interactions between the research group affected and were affected by *rhythIMs*.

4.1 Performing for an audience

The participants already had a good sense of their own presence patterns and were able to describe their patterns accurately in the pre-study questionnaire. All participants reported looking at the display on a regular basis, usually as they walked past the display when entering and leaving the room or while sitting at their desks.

4.1.1 Performing for oneself

When speaking with the participants, they often used words such as "reflection" and "reaffirmation" to describe their experiences with *rhythIMs*. Implicit in this is the idea that *rhythIMs* was mediating performances in which the performers—the participants whose presence was on display—became their own audiences when they looked at the display.

> It helped make the lab more lively. Like I said, you see a chunk of blocks and then you see, "Oh wait, there's a lot of people."… Even if the visualization is running in my background, but it does bring to my attention that there are a lot of people in the background… When I saw there was a lot of stuff, immediately I have this notion: Okay there's a lot of people around me, and I hear a lot of background noises. —Peter

For Peter, the visualization was a confirmation of what he saw and heard in the office but had become tacit to him over time. Because he had been working in the same office with mostly the same people for over a year, the people and noise around him had begun to fade into the background of his attention. Seeing the group's activity on the display influenced him to re-experience the space, making him more aware of when there were others around and reminding him of their presence.

For the most part, participants did not report being particularly surprised by any of the information revealed by *rhythIMs* about their own patterns. However, even when predictable, the system served as a commentary on their activities. Despite reporting that they had a good sense of what their own patterns were, the participants described enjoying seeing what they already knew being reflected visually on the display. *rhythIMs* became a way for them not only to confirm their self-images but to have what they thought about themselves confirmed by others. *rhythIMs* provided a concrete metric for comparison with others, as illustrated in Eddie's surprise when he realized during the pattern identification task that it was Peter and not himself who was on IM the most:

> That was really surprising to me that [Peter] was online [all the time. It's]… incredible. Yeah I definitely have a better idea of when he's online and now I think I'll be more likely to actually get his screen name because now I know how he's presumably available. —Eddie

Peter was also struck by this realization when he completed the pattern identification task as well. Although he had reported in his questionnaire that he was almost always on IM, the information shown on *rhythIMs* caused him to self reflect. This reflection was due, in part, to the drastic visual confirmation of how much more he was on IM compared to the other people in his research group:

It's just a really fat line there. And I was like, "What is that thing?" And I looked at it because I was trying to figure out who it was. And then I was like, "Oh that's me!" —Peter

Although the participants did not report being influenced to change their IM habits because of other people's presence information, Peter revealed that the pre-study questionnaire influenced him to consider when and why he turned off his computer and, consequently, his instant messaging client. After taking the questionnaire, he decided to leave his IM on all the time and, as a result, reported that the amount of time he spent chatting with friends and contacts increased.

4.1.2 Performing for an imagined audience

rhythIMs mediated performances that took place across space and time. Participants read the display after an interaction with someone influenced them to look at it or while the other participants were not co-present. An implication of *rhythIMs*-mediating performances across spatial and temporal boundaries is that there is the potential for an expanded audience, beyond the immediate group, to appear at any time. The performer conceives of the potential audience for the display as imagined others. The imagined audiences are diverse and could be comprised of specific people that the performer anticipates might see the display at a later point in time (e.g., the participants' advisors, the other participants who work in the office or the colleagues who work in the office but are not participating in the study) or an ambiguous population (e.g., any person who passes by the hallway when the *rhythIMs* office is open, visitors to the office or the building's janitorial staff). We found that despite participants claiming that they either enjoyed or were indifferent to sharing their presence on *rhythIMs*, there was an undercurrent of anxiety about who could potentially see the displays.

If I see that a lot of people are there and I'm not, and if, say for example, my advisor could find out, then that would be a privacy concern. —Peter

I like, for example if people wanted to say that I'm not in the lab, I'm not doing work or I'm not contributing or something like that, I could go back to this and say, "Hey I am in the lab a lot, and I am working." —Eddie

Here, Eddie and Peter were concerned about potential imagined audiences who might view *rhythIMs*—or its data—in the future. Although it was not institutionally or formally acknowledged, being logged into IM or being physically present in the office was considered a good thing, because it meant that the participants were accessible

to the other members of their research group. In this way, *rhythIMs* made visible actions that were judged positively. Eddie and his colleagues felt accountable to each other for their presence and absence at the office, at least during normal business hours. Troshynski et al. [34] referred to this as "accountabilities of presence," in which people are accountable to each other for their presence in specific places at specific times. *rhythIMs* became a way for people to fulfill their accountabilities by reaffirming to imagined audiences that they were accessible and that they had a presence. If they were not physically in the office, being on IM was one way of remaining in contact with their colleagues.

Accountabilities are associated with the ways in which people understand and participate in space and presence. It is often through exchanges of information that those accountabilities are negotiated. Information is shared so that people know for what and to whom they are accountable, and others can see how they are fulfilling their accountability. Although *rhythIMs* did not necessarily influence participants to change their behavior to match the presence of their officemates, the display facilitated exchanges by broadcasting information for actual and imagined audiences. *rhythIMs* became a way for participants not only to confirm their own self-images but to have what they thought about themselves confirmed by others.

4.2 Performing for the group

Previous work in public displays has typically treated a display's audience as a homogenous collective [6, 25, 26]. However, from our interviews, it became evident that not only were participants orienting toward audiences, but they were also orienting toward specific subsets of people. Because the participants experienced and were influenced by various subsets of audiences in different ways, we found it useful to differentiate between notions of collectives. We found McGrath's [27] definition of groups to be particularly insightful for understanding how participants related to these smaller sets of people. He defined groups as social aggregates that involve mutual awareness and potential mutual interaction, "the instruments for influencing, shaping, changing the individuals who are their members" [27, p. 5]. People are influenced as they take into consideration the groups to which they belong and what they think other people expect of them.

The ways in which participants discussed their interpretations of *rhythIMs* indicated that the display influenced them to identify with groups and think about how much they see themselves as part of a particular group (or see themselves as being an outsider to a group). *rhythIMs* was situated within a pre-existing group: the institutionally defined research group. One participant, Eddie, saw

rhythIMs as a means of reinforcing and reaffirming the presence of his officemates:

> The visualization kind of reinforced that there is this group of people in this lab, working together… I think maybe that way, there's more of a connection. These people, yes they're in the lab, but they're also participating in this study. So I think it kind of reaffirmed who's who in the lab. —Eddie

Here, Eddie drew a boundary around a group of people who are working together in his lab and participating in *rhythIMs*, and he included himself as part of this group. Will, on the other hand, did not feel the same sense of membership in a group that Eddie did, despite there being a group defined on the display:

> Even though in our visualization, you have the group but to me, you have to have some sort of interaction outside the visualization to feel like in the same group. —Will

These quotes highlight two important points. First, they revealed that assumptions of what it means to be a group were built into *rhythIMs*. By listing the names of the people on the display, *rhythIMs* created a group and drew an explicit boundary between the people whose presence information was included in *rhythIMs* and those whose presence information was excluded. Other public displays such as Nomatic*Viz [9] and the context, content, and community collage [25] created similar groups, which drew boundaries between the people who shared content and those who did not. However, as Will's statement indicates, a group is more than a collection of two or more people, speaking back to McGrath's argument that a group involves mutual interaction. Participants did not necessarily feel like they were in a group together simply because *rhythIMs* defined them as one.

Second, Will and Eddie's statements show that people can relate to groups as either seeing themselves and others around them as being part of them or not. In other words, groups have boundaries and criteria for membership. Both Eddie and Will saw themselves as part of different subgroups with the other occupants of the office space, while also being members of the same research group. What we see here is that not only can subgroups exist and groups overlap, but membership in a group is not uniformly understood among all of the people involved. People have idiosyncratic ideas for what constitutes a group and membership in that group.

What these characteristics mean is that membership in groups requires maintenance and reinforcement. A similar phenomenon has been observed in research focused on distributed and collocated organizations, in which task force membership and team borders are fuzzy [23, 28].

These studies focused on working groups in organizational contexts, whereas we are using groups as a way of describing how people orient themselves to people around them. The groups to which we refer do not necessarily have to be organizational or institutionally defined. However, the ambiguity of team borders has implications for connectedness, social awareness and how people make sense of each other.

4.2.1 Connectedness

The participants often spoke about subsets of people around them as though they were part of a group, but they did not articulate feelings about being a group as a whole or of cohesion despite their overall orientation as a "research group." For example, when we asked Will about how he related to other people in his research group, we had the following exchange:

> Will: Because I don't have any intimate interaction with those four [people]… To me, at this point, I don't have any particular [connection].
> Researcher: So you didn't feel any more connected to them?
> Will: No… Even though we are the same group but actually we don't have some kind of interaction because me and Ray, we doing [sic] the same project. That would make the difference.

Although Will recognized the way in which *rhythIMs* defined a group of people, he did not consider them to be a group without any explicit, direct interaction. Being in a group, then, can be formally defined (e.g., the participants whose presence information was captured and shown on the visualization or the students in the research group), but it can also be an experience that is felt via connectedness to others in a group.

Group boundaries influenced how much information participants wanted to know about others. Will identified groups based on collaborations and how closely he was working with others, and primarily looked at *rhythIMs* to see information about the people in those subgroups. He felt a connection to Ray, demonstrating that there can be varying degrees of connectedness among the members of a group. *rhythIMs* did not create and build the strong rapport that researchers sometimes claim public displays can build. However, it could strengthen pre-existing social connections.

4.2.2 Legibility through social context

Zerubavel [37] described shared temporalities as a means of building a group identity. One aspect of this is the emergence or perception of a social pressure to conform to

the standards set by one's community, to avoid social scrutiny by one's community. Systems such as *rhythIMs*, which display information about individuals alongside each other and facilitate comparisons, can intensify a fear of being "abnormal" because by being different, you draw attention to yourself and make it known that you stand out. Part of being a member of the group meant that there is an expectation that one participates in the shared temporality. This is why the participants, as members of a research group, were expected to work in the office when others were also there, or at least to be accessible via some form of communication (e.g., instant messaging) when people might need to contact them.

One motivation for looking at the display was curiosity about what the display said about others:

> I saw Nathan once, and I was talking to him, and I left, and I looked at [rhythIMs] because I wanted to see how long he had been there because he looked very tired. —Pablo

The interaction between Pablo and Nathan indicated that there is a broader context to be considered when there are other pieces of information that people know about each other. The three forms of presence information that *rhythIMs* provided leverages the idea that physical context matters. One may interpret a friend's online activity differently if he knows that his friend is on IM at work or if his friend is on IM at home. However, location is not the only piece of information that is factored into interpretations of *rhythIMs*. The fact that Nathan looked tired could have been interpreted as being up late partying, but because Pablo knew that Nathan was in the middle of a research project, he concluded that Nathan's tiredness was the result of working many long hours in the office (which it was).

Dey [8] defined context as any "information that can be used to characterize the situation of a participant in an interaction." Context, then, is more than just location and presence. The background knowledge that people have about each other influences how they read and interpret information and cues. The participants in our study created complex interpretations for what they saw on *rhythIMs*, based at least in part on their shared understandings of each other's lives. Because they had been working together for a while, they interpreted the *rhythIMs* data based on their existing relationships and what they already knew about each other. For example, when asked about the thin layer of presence that Ray exhibited, Peter explained that Ray had a family, so he preferred to work from home to spend more time with his family.

> I just know them… I have a sense of how their routines [go] by deducing from because [Ray is] married. And they have this sort of set routine schedule that

they have to follow… Ray is basically at home. —Peter

Because Peter's knowledge of Ray's life framed his interpretations of *rhythIMs*, he did not interpret Ray's presence information as a sign of non-productivity, but that he was being productive remotely. By being situated among a collocated group of people, *rhythIMs* allowed for different interpretations of the data, because the participants know each other and have a context for everyone's actions. Even if two people have never directly interacted with each other before, their collocation provides a shared physical context for their activities. In Goffman's terms, "unfocused interaction" takes place through mere copresence, and people glean information about each other, even when there is no direct communication or "focused interaction," involved [17]. This is not unlike "cultures of secrecy" [11], in which social settings give meaning to how information is shared and understood. Similarly, *rhythIMs* data had more meaning when it was interpreted as part of one's larger social, physical, and temporal context.

4.3 Limitations

We are unable to discuss the participants' interactions with the remaining students who worked in the office but did not participate in the study. The non-participants in the office declined to be interviewed. We focused our interviews on the participants' interactions with each other, as well as on the performance of looking at and reading the display. It is worth noting, however, that in their experiences with *rhythIMs*, the participants were also making sense of the non-participants in the office and that the non-participants comprised of an actual audience who was looking at the participants' information on the display.

The participants were graduate students conducting research in a similar field as the authors. As a result, they were potentially highly sensitive to the usage and impact of research prototypes. Because the participants were graduate students, unstructured and flexible schedules were the norm, and they were not as concerned with maintaining a regular presence in the office. At the time of the study, the participants were not working on projects together, so they did not regularly depend on each other's presence in the office or on instant messaging. If *rhythIMs* had been installed in a more structured environment such as a corporate office, it is likely that people would be more concerned about accountability and performing the role of "model employee" through *rhythIMs*.

Although it was not formally acknowledged, there was also a sense of hierarchy among the participants. In this structure, the students who had been in the graduate

program longer were considered to be more "senior." This could have influenced participants to be more generous toward the senior students in their interpretations out of respect.

5 A performance perspective

5.1 An extended notion of audience

Audience is a natural way to think about experiences and encounters with public displays, in which the audience consists of the people who see the display or watch the people interacting with a display. Previous research has used performance to understand the role of the audience in an interaction with technology in public spaces. Jacucci et al. [22] argued that a performance perspective orients toward experiences where participants are more aware, consider the artifacts around them, and engage in a situation in reflection or perception in action. We have found a performance perspective insightful for understanding engagements and interactions around *rhythIMs*, because it shifts the focus away from the user's relationship with the display and, instead, examines the role of the audience in shaping the performer's experience.

By virtue of the presence of an audience, the performer's actions are influenced by the awareness that her perception of the system is a performance for the audience [7]. Reeves et al. [31] focused on the audience's experience of a performer's interaction with a system, noting how a spectator perceives an interaction as a direct result of a performer's actions. They present a framework that emphasizes the importance of considering what aspects of interaction are made available to the audience.

Benford et al. [3] extended Reeve et al.'s framework by using Bateson's notion of a performance frame to distinguish between performers and spectators. In Bateson's terms, a performance frame is the set of conventions, supporting structures, and technologies through which performers and spectators come to understand that a performance is taking place, framing their expectations and understandings of how to act [1]. Benford et al. defined the performer as the constructor of the performance frame and the spectator as the interpreter. They distinguished between two types of spectators: first, the audience which includes the spectators who are aware that a performance is taking place and can interpret the performer's actions as a performance; and second, the bystanders, who are the unwitting spectators outside the performance frame—that is, they might observe the performer's interactions but do not interpret them as a performance and may be unaware that a performance is taking place or its effects on them.

These works maintain a distinction between the performer and the audience, and focus on audiences that are co-present with the performer, a perspective familiar to HCI audiences through the seminal influence of Erving Goffman's work [16]. However, as Ginters [15] noted, the audience is not simply nor always the sum of the individual spectators. Audience members can take on multiple roles in their encounters with performances, including that of active participant and spectator, and can move between these different roles. Drawing inspiration from explorations of how people transition from audience to participant to performer [5, 30, 33], we orient our explorations with *rhythIMs* on the perspective of the performers who became their own audiences during its installation. This perspective, then, brings more to bear on the accounts of participation around public displays than simply an audience/performer perspective.

If, as Goffman [17] argues, the mere presence of an "other" is enough to create a public gathering, it follows that all individuals relate to all others who are present, including bystanders, even when there is no direct acknowledgement or awareness of their presence. However, when participants in the *rhythIMs* deployment expressed concerns about who could potentially misread the display, they were revealing the actors who are not co-present at the performance but are still part of the performers' experiences. Because the performers related to them, the imagined others became part of the gatherings that Goffman discussed. Thus, in addition to the group as audience, we extend previous definitions of audience to include these potential imagined audiences. The audience, from this perspective, is the imagined recipient of shared content on a display or a performance—the imagined others to whom performers are orienting themselves when interacting with the public display.

A person does not become an audience member merely by virtue of being collocated with the performer, nor is this necessarily a requirement. Audiences are willed into existence through the performer's imagination. If the performer believes that someone is an audience member, they will render that person part of the audience and orient behaviors with him or her in mind. The audience does not have a choice about involvement nor does the audience need to be aware of or accept this role. Further, a performer can turn someone into an audience member without having to share the same space or time. For example, when Eddie imagined his advisor looking at *rhythIMs*, his advisor was not collocated with him at the time and was not aware of Eddie's vision of him as an audience member. Being an audience member does not require shared knowledge between audience members or acknowledgement between the performer and the audience.

Because *rhythIMs* and other public displays mediate performances that take place across time and space, a performer's audiences can become imagined and ambiguous. The performer's interaction, then, is physically and temporally shifted from what the audience sees. Performers may not have full understandings about how others view them, because they do not know whether, when, or by whom they are being seen through a display nor will they always be able to control who the audience is and when they appear. In our interviews with *rhythIMs* participants, we found that the ambiguity of audiences was a source of anxiety for their interactions and interpretations of *rhythIMs*. Some performers dealt with this by imagining who the potential audience members could be and how they might react to content on the display.

5.2 Revealing factions and abnormalities within a group

Participants' descriptions of how they interpreted *rhythIMs* suggested that each individual experienced other participants through the display in different ways, and these experiences were often asymmetrical. For instance, Eddie reported feeling more of a connection to Ted, while Ted reported not feeling connected to anyone in particular. Further, the boundaries people place around themselves influenced how much information they wanted about others. In our data, the result of this influence was limited interest in people outside their own hazily defined social groups. Instead, participants demonstrated only a passing interest in those in the formal group who are outside an individual's sphere of interest (e.g., Pablo being curious about how long Nathan had been in the office). *rhythIMs* made these disparities more visible to participants as they realized whose information they cared to view and whose they did not. Here, *rhythIMs* revealed the factions within a larger institutionally defined group.

Having a piece of information did not necessarily mean that people would act upon it. Seeing that someone was physically or virtually present on *rhythIMs* did not necessarily entice people to go seek that person out in person or on IM. Although the participants theoretically had access to presence information before the display was installed, *rhythIMs* aggregated and presented it in a way that confirmed patterns that had been speculative assumptions before. Showing this information on a public display forced people to make decisions about whether or not they wanted to act on it. Even if they chose not to act, they still had to take into account that this information had been seen, and they may be held accountable to that knowledge. Thus, visibility not only engenders accountability to others, it suggests new forms of accountability to oneself and one's choices to interact with others.

Because *rhythIMs* facilitated the comparison of information by displaying information about a group of people alongside each other, it could intensify fears of being abnormal or standing out from the rest of the group. For example, Ray's thin layers of presence were especially noticeable against Peter's layers. The fear of being abnormal reflects the "dual nature of surveillance data" of being simultaneously protective and invasive [24]. People have both a desire and fear of being monitored: there is a desire to be included in the data surveillance net and to be creditworthy; yet, they fear how they are represented in data banks. The dual nature of the *rhythIMs* data was reflected in the ways in which the participants related to the display. *rhythIMs* was described as being protective in the sense that it gave participants credibility for working and being in the office. Looking at the display could also be an indication that someone was concerned or cared, rather than one of surveillance, as illustrated by Pablo's encounter with Nathan. Yet, at the same time, participants reported feeling like they were being "watched" or "exposed" through the display. There is an undercurrent of social accountability in this dual nature of data. If people are accountable to their bosses for being productive, then they may experience anxiety about their information being misinterpreted or taken out of context. At the same time, the presence data on *rhythIMs* could also validate them if their performance is ever questioned, as Eddie pointed out. People wanted to be visible in particular kinds of ways to particular kinds of people.

One might imagine that *rhythIMs*, along with other systems that monitor, log and display people's activity, could be perceived as a "technology of power," especially in a setting where people are using it to track the temporal patterns of their institutional subordinates. Foucault [14] refers to "technologies of power" as techniques through which power is exercised; a dystopian approach to one-sided social control. Technologies of power can define power relations in everyday life. What defines a surveillance system is the unequal power relationship between the watcher (the audience) and those being watched (the performer).

The environment where *rhythIMs* was installed was not characterized by the interdependency and task accountability features that characterize many workplaces. Such factors would intensify the fear of surveillance and monitoring. In our study, however, the participants were of equal power and status (colleagues in the same research group), so they did not express serious concerns about surveillance.

Rather than framing systems such as *rhythIMs* that monitor, track, and record presence information solely in terms of surveillance and privacy, it is, instead, useful to reflect on them in terms of social accountability to

understand the relationship between presence and sociality. When people become their own audiences on public displays, they can see how it is that they, or others in their groups, are different from everyone else. When people viewed their own individual data on *rhythIMs*, they were examining themselves in terms of how others were represented and thinking about what they needed to do to be a successful actor in a particular social sphere. Robertson [32] argued for the importance of enabling awareness of an individual's perception of their own actions in supporting interaction between people. People continually imagine how they are perceived by others, including imagined audiences and the actual audiences who see the display. Because people are inherently social, they view themselves in terms of how to be a competent actor in this new realm. They study how others around them are acting and imagine how they, themselves, are seen by others.

6 Conclusion

In this research, we sought to understand interaction as going beyond the user and an interface, and used a performance perspective to highlight the complex relations that figure into interaction in public spaces. Public displays are becoming increasingly prevalent, and researchers and interaction designers necessarily make assumptions about the users who encounter these displays. Thus far, researchers have largely used the concepts of the group and the audience as if they are the same, homogeneous cluster of people in a physical space. We extended the conventional notion of audiences by considering performance in terms of different audiences and different degrees of participation, and demonstrated the role that imagined audiences play in affecting the experience of a public display. By differentiating between audiences and groups, we are able to identify and speak to the specific, heterogeneous collectives *rhythIMs* mediated. We demonstrated how interpretations of *rhythIMs* were influenced by orientations to different collectives and described the ways people can participate alongside each other as part of those collectives.

We focused on the performance of looking at *rhythIMs* and what the implications were for the members of the group. In future work, we will explore the other levels of performance and interactions that *rhythIMs* mediated, such as the performance of watching a co-present audience read the display, and examine the implications between different kinds of performance.

References

1. Bateson G (1955) A theory of play and fantasy. Psychiatr Res Rep 2:39–51
2. Begole J, Tang JC, Smith RB, Yankelovich N (2002) Work rhythms: analyzing visualizations of awareness histories of distributed groups. In: Proceedings of CSCW 2002, pp 334–343
3. Benford S, Crabtree A, Reeves S, Flintham M, Drozd A, Sheridan J, Dix A (2006) The frame of the game: blurring the boundary between fiction and reality in mobile experiences. In: Proceedings of the conference on human factors in computing systems (CHI 2006), pp 427–436
4. Bly SA, Harrison SR, Irwin S (1993) Media spaces: bringing people together in a video, audio, and computing environment. Commun ACM 36(1):28–46
5. Brignull H, Rogers Y (2003) Enticing people to interact with large public displays in public spaces. In: Proceedings of the conference on human–computer interaction (INTERACT 2003), pp 17–24
6. Churchill EF, Nelson L, Denoue L, Helfman J, Murphy P (2004) Sharing multimedia content with interactive public displays: a case study. In: Proceedings of the conference on designing interactive systems (DIS 2004), pp 7–16
7. Dalsgaard P, Hansen LK (2008) Performing perception—staging aesthetics of interaction. Trans Comput Hum Interact 15(3):1–33
8. Dey AK (2001) Understanding and using context. J Pers Ubiquitous Comput 5(1):4–7
9. Ding X, Patterson DJ (2009) Status on display: a field trial of Nomatic*Viz. In: Proceedings of the European conference on computer supported cooperative work (ECSCW 2009), pp 303–322
10. Dourish P, Bly S (1992) Portholes: supporting awareness in a distributed work group. In: Proceedings of the conference on human factors in computing systems (CHI 1992), pp 541–547
11. Dourish P, Anderson K (2006) Collective information practice: exploring privacy and security as social and cultural phenomena. Hum Comput Interact 21(3):319–342
12. Erickson T, Smith DN, Kellogg WA, Laff M, Richards JT, Bradner E (1999) Socially translucent systems: social proxies, persistent conversation and the design of 'babble.' In: Proceedings of the conference on human factors in computing systems (CHI 1999), pp 72–79
13. Fisher D, Dourish P (2004) Social and temporal structures in everyday collaboration. In: Proceedings of the conference on human factors in computing systems (CHI 2004), pp 551–558
14. Foucault M (1995) Discipline and punish: the birth of the prison, 2nd edn. Vintage Books, New York
15. Ginters L (2010) On audiencing: the work of the spectator in live performance. About Perform 10:7–14
16. Goffman E (1959) The presentation of self in everyday life. Anchor, New York
17. Goffman E (1966) Behavior in public places. The Free Press, New York
18. Grasso A, Mühlenbrock M, Roulland F, Snowdon D (2003) Supporting communities of practice with large screen displays. Public and situated displays. Springer, The Netherlands, pp 261–282
19. Gross T (2013) Supporting effortless coordination: 25 years of awareness research. Comput Support Coop Work 22(4–6): 425–474
20. Huang EM, Russell DM, Sue AE (2004) IM here: public instant messaging on large, shared displays for workgroup interactions.

In: Proceedings of the SIGCHI conference on human factors in computing system (CHI 2004), pp 279–286

21. Hudson SE, Smith I (1996) Techniques for addressing fundamental privacy and disruption tradeoffs in awareness support systems. In: Proceedings of the conference on computer supported cooperative work (CSCW 1996), pp 248–257

22. Jacucci C, Jacucci G, Wagner I, Psik T (2005) A manifesto for the performative development of ubiquitous media. In: Proceedings of the 4th decennial conference on critical computing, pp 19–28

23. Lee CP, Dourish P, Mark G (2006) The human infrastructure of cyberinfrastructure. In: Proceedings of the conference on computer supported cooperative work (CSCW 2006), pp 483–492

24. Lyon D (1994) Electronic eye: the rise of surveillance society. University of Minnesota Press, Minneapolis

25. McCarthy JF, Congleton B, Harper FM (2008) The context, content & community collage: sharing personal digital media in the physical workplace. In: Proceedings of the conference on computer supported cooperative work (CSCW 2008), pp 97–106

26. McDonald DW, McCarthy JF, Soroczak S, Nguyen DH, Rashid AM (2008) Proactive displays: supporting awareness in fluid social environments. Trans Comput Hum Interact 14(4):16–31

27. McGrath JE (1984) Groups: interaction and performance. Prentice Hall, Englewood Cliffs

28. Mortensen M, Hinds P (2002) Fuzzy teams: boundary disagreement in distributed and collocated teams. Distributed work, pp 283–308

29. Nardi BA, Whittaker S, Bradner E (2002) Interaction and outeraction: instant Messaging in action. In: Proceedings of the conference on computer supported cooperative work (CSCW 2002), pp 79–88

30. Peltonen P, Kurvinen E, Salovaara A, Jacucci G, Ilmonen T, Evans J, Oulasvirta A, Saarikko P (2008) "It's Mine, Don't Touch!": interactions at a large multi-touch display in a city centre. In: Proceedings of the conference on human factors in computing systems (CHI 2008), pp 1285–1294

31. Reeves S, Benford S, O'Malley C, Fraser M (2005) Designing the spectator experience. In: Proceedings of the conference on human factors in computing systems (CHI 2005), pp 741–750

32. Robertson T (2002) The public availability of actions and artefacts. Comput Support Coop Work 11:299–316

33. Sheridan JG, Bryan-Kinns N, Bayliss A (2007) Encouraging witting participation and performance in digital live art. In: Proceedings of HCI 2007, pp 13–23

34. Troshynski E, Lee C, Dourish P (2008) Accountabilities of presence: reframing location-based systems. In: Proceedings of the conference on human factors in computing systems (CHI 2008), pp 487–496

35. Viègas FB, Golder S, Donath J (2006) Visualizing email content: portraying relationships from conversation histories. In: Proceedings of the conference on human factors in computing systems (CHI 2006), pp 979–988

36. Viègas FB, Perry E, Howe E, Donath J (2004) Artifacts of the presence era: using information visualization to create an evocative souvenir. In: Proceedings of the symposium on information visualization (InfoVis 2004), pp 105–111

37. Zerubavel E (1981) Hidden rhythms: schedules and calendars in social life. University of California Press, Berkeley