Are You Sleeping? Sharing Portrayed Sleeping Status within a Social Network

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ABSTRACT
Within a group of peers, it is often useful or interesting to know whether someone in the group has gone to bed or whether they have awakened in the morning. This information, naturally integrated as a peripheral augmentation of an alarm clock, allows people to know whether it is appropriate to make a call or feel more connected with someone living remotely. In this paper, we present the design and evaluation of such an alarm clock, the BuddyClock, and describe how it enables users in a small social network to automatically share information about their sleeping behaviors with one another. Through 3-6 week deployment studies of this technology with five different social networks, we found that the alarm clock affected participant behaviors and allowed them to feel more connected to those with whom they shared their sleeping behaviors.

Author Keywords
HCI, Communication, Contextual information, Design, Sleep, Sleeping behavior, Social computing, Persuasive Technology

ACM Classification Keywords
H.5.3. Group and Organization Interfaces

INTRODUCTION
Being aware of someone's presence on an everyday basis can help with maintaining intimacy. Therefore, it is commonplace for people in a close relationship, such as family members or trusted friends, to share information regarding their daily lives. For example, family members try to stay aware of the everyday activities of their households [16] or friends may share their weekend schedules to make plans. However, these informal interchanges become much more difficult for remote relationships. Thus, this work explores one simple way to share an interesting piece of information about friends or loved ones, that is, their sleeping status.

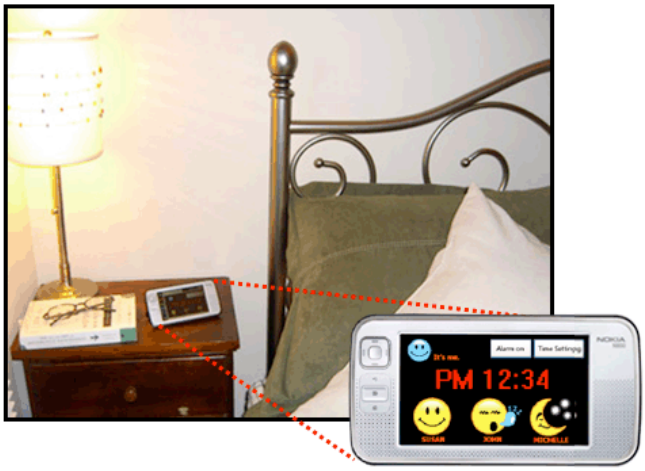

Figure 1. BuddyClock sitting on a bedside table.

By sleeping status, we refer to whether a person has gone to bed at night or awakened in the morning. This information could be a catalyst for facilitating effective social interaction as it is basic contextual information reflecting a person's physical status and condition. Knowledge of the sleeping status of others can facilitate socially-appropriate behaviors within a group. For example, if a friend is asleep, one would not want to disturb her unless it is important. Sharing otherwise hidden information about deviations from normal sleeping patterns can also offer subtle cues that friends can use to enhance their relationships [2]. Lastly, sharing sleeping status may also prompt users to reflect upon and change their own sleeping patterns.

We believe that sharing sleeping status implicitly through simple and natural means can have an impact on individuals. Thus, we developed a network-enabled alarm clock, called BuddyClock (see Figure 1), which can share alarm status with alarm clocks within a social group. We predict that this simple, natural information exchange can impact everyday bedtime activities and believe it may add a better sense of intimacy. This exploration attempts to answer several research questions, including:

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- How does knowing the sleeping status of others in a social network increase the sense of intimacy?
- How does it influence one's own sleeping behavior?
- How does sharing sleeping status impact privacy?
- To whom and when might BuddyClock be useful?

In this paper, we first motivate our choice of sleeping status as shared activity. We then provide a review of related work in promoting remote awareness and affecting behavioral change. Next, we describe the design and implementation details of BuddyClock. Then, we describe two deployment studies testing feasibility and longer term impacts over a variety of different social network types. We present both quantitative and qualitative results from both studies and conclude by discussing the key implications this work has on relevant research areas.

MOTIVATION

The initial idea for BuddyClock was to augment a simple device we use every day as a communication medium for better intimacy. Researchers have explored various activities to share with others in order to promote connectedness and intimacy in less formal settings using more lightweight media. Dey *et. al* created a series of peripheral awareness displays of online presence of close friends or family in a lightweight manner [5]. Bentley & Metcalf showed how displaying whether people are traveling or not based on cell phone data impacted their sense of connectedness [1]. Picture frames, a drawer, and a candy dispenser have also been designed to fulfill such needs [9, 20, 23, 14]. Instead of creating a specialized object to share activities, we explored how an everyday object in the home could be augmented to promote awareness and help others determine times when interruptions might be appropriate [15].

Sleep is a good index for others to presume one's physical condition. Not only does it reflect one's daily routine, but it also reflects physical state and can provide an overall sense of wellness. Moreover, an alarm clock is a widely used device assisting one's sleeping pattern. Therefore, we chose sleep as an activity to share via an alarm clock. Similarly, others found sleep patterns to be an activity that can be unobtrusively recorded, as the user remains relatively still, and provide a fixed context of a user [13].

The second objective of BuddyClock was to create a persuasive device for a social network to encourage healthier sleep behaviors. This was inspired by previous work in persuasive computing where social groups have been used to encourage healthy behaviors such as physical activity [4], better eating habits [21], or adherence to a medical regimen for diabetes [12]. In the medical domain, researchers have explored the relationship of sleep and health, and found out a strong tie between sleep and health [18]. However, little prior work has been conducted on sharing sleep patterns among social groups.

RELATED WORK

Pervasive communication technologies, such as e-mails and mobile phones, make people less dependent on physical co-location for connectedness [25]. Although such technologies are an effective medium to share verbalized information, they are less effective for conveying implicit activity information. Kaye *et al.* explored the effect of simple information sharing among users and found that even a one-bit communication device is seen by users as a valuable and rich channel for communicating intimacy, despite the availability of wider channels of communication [10]. We are interested in how these simple, shared bits of information, shared sleeping status in particular, can affect a person's sense of intimacy with others.

Since the early 1990s, media spaces, enabling people to create real-time visual and acoustic environments that span physically-separated work groups, have been studied to see how they support remote awareness [3]. Early remote awareness applications were usually in the context of the workplace or health care, with different social goals from our home-based work. For example, Portholes [7] shared image information from several distributed workgroup sites, whereas Smith & Hudson created an audio processing technique to support awareness of conversations coworkers were not directly involved in [22]. In addition, Hindus *et al*. investigated how the concept of media spaces could be applied to households and family life [8].

Other researchers have used alarm clocks as output devices for displaying information not related to sharing sleeping status or connectedness. Landry *et al.* adopted an alarm clock as a daily routine decision-support system for a single user [11]. This focused on personal decision-making without regard to social networks, whereas in our work we aim to use others' behaviors to influence bedtime and wake time choices. Ozenc *et al.* designed the Reverse Alarm Clock [17] as a tool for using a display of sleep times for improving children's sleeping behavior. Although similar in spirit, our work differs in that we aim to utilize an alarm clock as a communication medium.

Related to sharing sleeping status within a social network, Schmidt [19] designed a Network Alarm Clock to use others' presence information and social network status as a source for setting the alarm time. Dodge [6] designed a bed environment to act as an intermediate tangible medium for bridging the distance between remotely located individuals. Our design differs from these previous projects in that we focus on sharing the alarm time setting among people in a close social network with the alarm clock itself being an information transmitter and receiver. Moreover, both Schmidt and Dodge only presented a concept design, whereas we implemented a fully functioning prototype and conducted a long-term deployment study with several groups of users in natural environments.

SYSTEM DESIGN AND IMPLEMENTATION

We designed BuddyClock as a basic, bedside alarm clock, with the time display, alarm setting, and snooze features. The prototype is implemented using Python on a touch-screen Nokia N800 Internet Tablet™ (see Figure 2). Each BuddyClock is connected to the others in its social network via wireless connection to a remote buddy server so that they share real-time alarm status with others. The BuddyClock server is implemented in Python on a standard desktop PC.

Figure 2. BuddyClock's user interface on the Nokia N800. Users interact with BuddyClock using a touch screen display.

The BuddyClock screen shows alarm status information for up to three other connected clocks. When the user changes the local alarm status (*e.g.,* alarm on, snooze, alarm off), an icon on the display of the other BuddyClocks in the network is changed simultaneously to the corresponding status icon (see Table 1). Changes in a remote user status are also signaled by a quiet audio tone. When the user touches the icons, the clock displays detailed text information next to the name. When an icon representing the "asleep" status is displayed, the display shows the time that a user's wake-up alarm is set. When the "awake" status is shown, the clock displays the time that a user turned off the alarm. A single blue icon at the top left corner indicates a user's own sleeping status graphically so users can see how their own status is shown to others.

Icon		Meaning
Others	Mine	
		User is assumed awake. Alarm has buzzed, is turned off, and is yet not set for the next day.
		User is in a "snoozing" state. Alarm has buzzed, but "snooze" button was used and user has not yet turned off the alarm.
		User is assumed asleep. Alarm has been set and has not yet gone off.

Table 1. Icons displayed on the BuddyClock and their meanings. A set of yellow icons represents others' status while a blue set represents the users' own status.

Assumptions

BuddyClock makes several important assumptions about its user. It assumes the user turns on the alarm clock each night right before going to bed, uses the snooze feature while struggling to wake up, and turns off the alarm upon getting up each day. Because of this, a person's sleeping status icon shown on the BuddyClock could be incorrect, as the time the user sets an alarm on and the time he actually goes to bed may be different. Because of this, we considered using weight sensors to determine if the user was actually in bed. However, we wanted a way for users to control their own sleeping status to mitigate any privacy concerns and allow for plausible deniability. Thus, the information transmitted from BuddyClock is not actual sleeping status, but sleeping status as portrayed by the user.

USER STUDY

To test BuddyClock in the context of real situations, we designed an exploratory deployment study. Our initial design of the user study was a three-week period, which was divided into a one-week control session and a two-week experimental session. After conducting the three-week study, we were able to discover some interesting results regarding the use of BuddyClock. However, we also found that a two-week period for Phase 2 was too short to identify meaningful changes in behavior. As we solely rely on daily activities which naturally happen only twice per day, two weeks was not enough time to observe the longer term effects of social interactions. We conducted a second study in which we doubled the duration, resulting in a two-week control session coupled with a four-week experimental session. From here on, we refer to the initial three-week study as the pilot study and the later six-week study as the primary study.

Due to BuddyClock's reliance on users setting their alarms as an indication of sleeping status, we had two criteria for selecting participants. First, we recruited participants who used alarm clocks every day. Second, we chose participants who normally set their alarms on right before going to bed. Before the study started, we also explained to participants that the sleeping status shown on BuddyClock is the users' portrayed status as indicated by setting and turning off an alarm, and thus is not always identical to others' actual sleeping status.

Pilot Study

The pilot study was structured as a two-phase, within-subjects design. Phase 1 was a one-week control period using our prototype alarm without the shared sleeping status feature. Phase 1 allowed participants to become accustomed to using the new alarm clock and allowed us to collect baseline sleeping behavior data. Phase 2 was a two-week period using the fully featured prototype. In this phase, BuddyClock synchronously transmitted its current alarm clock status to others in the group and received the status from other devices within the group in real time.

At the beginning of the study, we visited each participant's home to set up the network connection for the device and train each participant on BuddyClock's use. We also conducted a short, pre-study interview to get an understanding of how users currently use their alarm clock to ensure we were not disrupting their sleep habits. We asked participants to use BuddyClock as an alternative to alarm clocks they were already using, or in some cases, in addition to their own device (*e.g.,* one user preferred to use a radio wake-up, which we did not implement). Whenever the user changed the alarm status, the server logged the time-stamp. This data can be used to look for differences between data gathered from two phases to look for BuddyClock's influence on the user's own sleep patterns. After the three-week study was finished, we conducted a semi-structured focus group with all participants in the same social network during which they were encouraged to share their experiences and thoughts with others. This was to determine whether our system impacted the sense of connectedness of the social network and other interesting aspects of sleep behaviors.

We conducted the pilot study with two groups of participants, whom we recruited locally through craigslist.org and via word-of-mouth. We initially recruited one participant from each group and asked each to invite two more participants in his or her social network, such as close friends, family members, or colleagues. We required that each member of the social network had to sleep in a different room or home, have similar social relationships, and have continuous wireless internet access at home. To aid in recruitment, we offered all participants a $20 gift card as compensation for their time.

Each group consisted of three participants, with six participants in total (5 females, 1 male; age ranged 27 to 36). Group 1 consisted of friends of 5 years. Two of them lived next door to one another, and the third lived 30 minutes away from the other two. All participants in Group 1 were professionals working standard 40-hour work weeks. Group 2 consisted of graduate students enrolled in the same academic program for over 1 year and shared many school activities together (*e.g.*, attending the same classes). Two were roommates with separate bedrooms and the third lived in the same apartment complex.

Primary Study

The structure of the primary study was the same as the pilot study, except the duration of both phases were doubled so that the total period was six weeks long: a two-week control phase (Phase 1) and a four-week experimental phase (Phase 2). We also included a mid-study interview session after the first two weeks of the experimental phase to probe initial feelings and experiences using BuddyClock.

We conducted the primary study with three social networks. As with the pilot study, we initially recruited a single participant and asked him/her to invite one to three more participants to the study who were in his/her social network. All initial participants we recruited were undergraduate college students taking an HCI class and were given extra credit toward their final grade in the class. All the other participants in the social groups recruited by the initial participants completed the study willingly without any compensation. We recruited a variety of social network types, as shown in Table 2.

	Group #	# in group	Type	Housing	Age Range
Pilot	G1	3	Friends	Next door	32 to 35
	G2	3	Roomates	Shared housing	26 to 30
Primary	G3	2	Significant others	Blocks away	23 to 23
	G4	3	Roomates	Shared housing	22 to 23
	G5	3	Friends	Scattered	23 to 24

Table 2. Summary of participating groups in both studies.

The make-up of the three social networks was as follows. Group 3 consisted of two participants and Groups 4 and 5 consisted of 3 participants each. Thus, the primary study had 8 participants (7 males and 1 female; age ranged 22 to 24). Group 3 consisted of a couple who had been dating each other for two years and were enrolled in the same undergraduate program. They both lived in on-campus housing, but in different buildings located several blocks from one another. Group 4 consisted of male roommates who shared a multi-story house. They had been friends for one year and recently moved to their current house and became roommates two months prior to beginning the study. Group 5 consisted of males who had known each other for three years. They met through an extracurricular college activity several years ago and became close friends with one another. They are neither sharing a house nor enrolled in the same program.

Semi-Structured Interviews

We conducted semi-structured interviews for the pre-study and the post-study interviews. For the mid-study interview in the primary study, we used the same guides and interview questions as the post-study-interview.

The purpose of the pre-study interview was to learn more about the participants' sleeping and alarm clock usage patterns, such as when they turned alarm clocks on or off, their current sleeping habits, and their relationship with the other participants in their group. As the alarm status is used to portray sleeping status in this study, we attempted to maximize the validity of sleeping status BuddyClock showed to others by confirming that the recruited participants typically set it right before going to bed. During the pre-study interview, we also asked questions about

whether they were happy with their current sleep behaviors and if there was anything they wished to change.

In the primary study, the mid-study interview focused on initial feelings soon after participants were first exposed to others' sleeping behavioral information, while the post-study interview focused more on identifying overall physical and emotional changes. During the post-study interview, we asked questions about the impact on their behaviors, examples of social interactions caused by BuddyClock, and experiences in changes of intimacy. For each of the questions, we probed for more details based on the participant's response, and participants were encouraged to discuss and respond to others. All the interviews were audio-recorded and transcribed for further analysis.

Data Analysis

For the user study, we gathered two types of data: timestamps of sleeping and waking times on the device and transcripts from interviews. To identify effects on sleeping behaviors, the average sleeping times for each participant were analyzed using a 2-tailed T-test. Relevant, direct quotes from all the transcripts collected from the semi-structured interviews were coded and grouped according to the content. Then, we generated five categories under which all the responses fell: intimacy, influence on behavior, privacy, design factors, and other potential uses. For each category, the responses were interpreted for objective, transparent representations of user experiences.

STUDY RESULTS

In this section, we report the results we found through the logged sleeping and waking times and the post-study interviews from both the preliminary study and the primary study (including the mid-study interviews from the primary study). We also provide a discussion of how BuddyClock affected intimacy, behavior, privacy, and describe other potential uses suggested by our participants.

Intimacy

Intimacy, a close, familiar, and usually affectionate or loving personal relationship with another person or group, is touted as a crucial element of domestic life [24]. As we predicted, providing knowledge of one another's sleeping status provided opportunities for our participants to think and understand more about others in their social network. Participants reported that knowing others' sleeping behaviors often led them to think about the other person and made them wonder what they were currently doing, what they have done, or what they will do in the future. In many cases, these thoughts were just passing moments. In other cases, such thoughts extended to communication either via a phone call or a face-to-face conversation afterwards.

Group 1 consisted of people who knew each other well, and thus they already had a rough idea of others' sleeping patterns. However, all participants reported that after using BuddyClock, they were able to learn the regular sleeping patterns of others in less than one week. Some participants reported that it was the same as they had assumed, but to others, it was quite different from their previous knowledge of others' sleeping patterns. Those participants reported that it made them feel that they knew the others in the group better than before. Participants from Groups 4 and 5 described similar experiences. The two roommates from Group 2 reported not knowing when each other had previously gone to bed and awakened, even though they had been living together for more than one year in the apartment. After the study, they said that once seeing each other's sleeping patterns, they were surprised to observe that their friend's real sleeping pattern was very different from what they had previously assumed.

> "*I didn't know that she [her friend in the participant group] wakes up so early before. It was quite surprising, and this became a moment to realize that she is an early bird."* (Group 2, Participant A)[1]

In some cases, knowledge of a person's regular sleeping patterns gave the participant a chance to show care about another person. A participant noticed that someone in her group deviated from her regular sleeping cycle one day, such as being awake later than her normal time or waking up earlier. Upon noticing this, she reported thinking about her friend, would guess that she would be tired the next day, or wonder if she had something that needed to be done that night. Sometimes, such information was used as a conversation starter.

> *"One night, I knew it was time for her to sleep, but my BuddyClock showed that she was still awake. I started to wonder why she was still awake."* (Group 2, Participant B)

> *"I felt much closer to her when she asked me about my condition that day, because she knew I hadn't slept enough last night."* (Group 2, Participant A)

Some participants reported that it was fun to see if others were in bed or not late at night.

> *"I checked if my friends went to bed or not time to time. It was just fun to know that my friend was still awake at late night like me. I think this gave me more of a chance to think about my friends."* (Group 5, Participant C)

All participants agreed that they felt they became more intimate than before after having knowledge of others' sleeping patterns, saying that such information provided more opportunities to think about others. In some cases, it became an instigator for inter-personal activities later on.

> *"Sleeping is a kind of personal and private moment. The fact that I can get to know if he is asleep or not from my room made me feeling closer to him, I guess."* (Group 5, Participant B)

[1] Some of the interviews were not conducted in English, and thus some quotes are translations.

Participants reported that sometimes, following the same routine of waking up and sleeping time became a strong tie for a relationship, which helped fortify intimacy.

"One night, I set the alarm for 8 A.M. and checked the others' times. It was weird. We all had 8 o'clock alarms! Imagining all the rooms being filled with the alarming sound at the same time tomorrow morning was so funny." (Group 5, Participant A)

During the focus group, the other two participants in his group responded to his suggestion by agreeing that it was amusing to imagine the three rooms simultaneously filled with the alarm sound and all of them trying to reach the alarm clock to turn it off at the same time.

"There were a couple of times like I turned it off and got in my bed. And then, like two seconds later BuddyClock beeped twice meaning two other friends were also in a bed at that moment. It was fun. I felt like we were sleeping in the same room." (Group 4, Participant C).

One thing we discovered that was different between the primary study and the pilot study was that others' sleeping statuses easily permeated into a user's everyday life. One participant from Group 5 said during the mid-study interview that he was concerned about how others would perceive him based on his sleep schedule, but then changed his opinions about it later in the study.

"I thought when I knew that they were going to be able to see when I was awake and when I was asleep, they will think I'm a very strange person. My sleeping schedule is not consistent. And I feel uncomfortable and weird to share it." (Group 5, Participant B)

"I know that BuddyClock will beep about ten minutes after I turned it off." (Group 5, Participant C)

Another participant mentioned that he checked if others had gone to bed already whenever he went to bed.

"Whenever I went to bed, I checked if others went to bed or not. I don't know why. I just did. I was so used to doing that. It was like checking if I turned off the bathroom light." (Group 5, Participant C)

Another interesting result was how a romantically involved couple used sleeping behavioral information differently from just a group of friends. The participants in Group 3 were a girlfriend and boyfriend. We discovered that such simple information like a person's sleeping status is not as useful for them because their intimacy was already very strong, and they already share many details of their daily activity information with one another. For example, they eat breakfast together at the cafeteria and go to classes together. They reported that BuddyClock's information was just confirmation of what they already knew about another in most cases, however, they believed it would be more helpful for a couple who are separated by a longer distance.

"He goes back to sleep quite often after I wake him up over the phone. While using BuddyClock, I knew that he actually got out of his bed when the sleepy face turned to the smiley face on BuddyClock. He was using "snooze" a lot. Really a lot!" (Group 3, Participant B)

Influence on Behavior

We logged and analyzed all sleeping-status data from each device for both phases of the study, except for weekends where many participants did not use an alarm. We did not find any statistically significant differences in the user's own sleeping pattern between the two phases. One possible reason is that the times at which participants wake up and sleep are determined by one's individual, everyday activities, such as the time when a morning class starts whether the person goes out until late at night for fun. Based on the data from Groups 2, 3 and 4, we noticed a trend that waking times became similar right after deploying the sharing feature, although such trends disappeared after a week. One possible reason for this is that participants may try to make their own patterns the same as others after realizing that one's pattern is deviated from others.

"I didn't know that I normally slept more than the other two. So, I tried to reduce my sleeping time after using the BuddyClock. But sometimes, exams and homework made me stay awake until late at night. So, I stopped trying to match my sleeping schedule with others." (Group 4, Participant A)

Overall, waking times between two participants in Group 3, the couple, suggest an interesting result. Their sleeping and waking times were fairly consistent with one another throughout the study. During Phase 1, there was a rough consistency in waking times which became almost identical a few days after Phase 2 began. This suggested some new features for BuddyClock for people in a very intimate relationship, which describe in detail later.

"Although we know about other's schedules in detail, we neither shared the exact time to go to bed nor the time to wake up. Before, the one who woke up early called the other to arouse them. After using BuddyClock, then, I checked if his alarm was on before setting mine, and set the time same to his unless there was another reason. I guess he does the same as me when I go to bed earlier." (Group 3, Participant A)

In the post-study interviews, participants confirmed that knowing others' sleeping status affected their own behavior. All participants mentioned the information affected their decision to contact others, especially late at night or early in the morning. When they noticed someone was asleep, they were careful not to disturb him. One of the two neighbors, who regularly went to bed early (around 9 P.M.) because of her 9-month old baby, said it influenced her decision on whether to call late at night. In response to this, the participant next door said that she felt like her friend cared about her.

"*I chose to send an SMS message or wait until next day instead of knocking on the door when I have something to talk to her but BuddyClock displayed she was asleep. Before, I went to her house when I had something to do with her at night, just*

guessing she was awake." (Group 1, Participant B)

In some cases, knowing friends were in bed sometimes elicited a certain behavior. One participant reported checking her alarm clock in the morning and seeing that it showed that her friend who takes the same early morning class was still asleep. Thus, she made a phone call to her friend to wake her up so she would not miss class. Another interesting reaction was that some participants tried to change their own sleeping patterns after knowing what others did. Therefore, some of them decided to go to bed later and wake up earlier than their normal sleeping pattern.

"I did not know that I sleep more than most of my friends do, which made me feel a bit ashamed and stressed. So, I decided to sleep less than before." (Group 2, Participant B)

This social influence on another's own behavior indicates that the BuddyClock could be used as a persuasive technology to help others change their negative sleep patterns (*e.g.*, if a person wants to stop sleeping in so late). We did not find statistical significance in the total number of hours that our participants slept (See Table 3). The bedtimes of the couple (Group 3), however, showed that there were many days both slept the same hours.

"I went to sleep when he slept and woke up when he woke up, even if we were not in a same room. That is, unless I have another scheduled event to do without him or work to do late at night." (Group 3, Participant B)

Meanwhile, several participants from the primary study mentioned that they started to worry about physical status or health of those in their groups after realizing inconsistent and fluctuating sleeping patterns over a long period. One participant from Group 4 said that knowledge of how long others slept became a moment for him to reflect upon his own sleeping pattern, asking to have a tracking feature for his own sleeping data.

"I saw that I had much less sleep time compared to others. Then, I thought maybe I should go to bed earlier." (Group 5, Participant A)

Others' sleeping pattern information became a calibrator for adjusting their own sleeping patterns. A participant from Group 5, who always woke up at 8:00 AM, mentioned that it made him reflect upon both his friend's and his own sleeping behaviors. The participants of this group reported that such thoughts triggered a conversation among them at the later period of the study where they discussed ways to control their sleeping patterns for better health.

"For me, bed time and wake-up time is pretty consistent. Then, I found out that [friend's name]'s sleeping pattern was inconsistent. Sometimes he went to bed around 8 P.M. and another time he hadn't slept until 5 in the morning. When I first saw that, I myself was feeling like I'm sleeping too much. But after realizing that his sleeping pattern is really inconsistent, I started to think about how bad it would be for his health." (Group 5, Participant C)

Group	User	Average # of hours slept in Phase 1	Average # of hours slept in Phase 2
1	A	9:23	9:25
	B	7:54	8:15
	C	11:01	10:49
2	A	4:46	4:45
	B	5:10	5:12
	C	6:30	6:08
3	A	6:22	6:10
	B	6:45	6:38
4	A	7:53	7:48
	B	5:20	6:22
	B	5:37	6:46
5	A	6:48	7:13
	B	5:26	5:29
	C	7:49	7:48
Total	14	6.54 (σ = 1:45)	7:03 (σ = 1:39)

Table 3: Averages and standard deviations for number of hours and minutes slept per person in both phases of our study. 2-tailed t-tests did not reveal any significant changes between the two phases.

Privacy

Although it was an early design consideration, participants did not show many privacy concerns in sharing their sleeping behaviors. BuddyClock transmits only a portrayed sleeping status rather than an exact time (minimizing embarrassment) and information that participants did not want to share could be hidden from others by simply not setting the alarm (staying in control). Thus, privacy was not an issue to all participants.

"*If I'm sleeping or not is not a secret at all, especially to my friends."* (Group 1, Participant A)

This reaction was likely due to the information only being shared with people within a self-selected, close relationship (*e.g.,* close friends, significant others, or family members). If this information were exposed to a stranger, the participants reported the possibility of feeling differently. They were concerned that it may be used maliciously, such as a signal for a burglar to break into their house.

While participants did not have serious concerns about sharing their sleeping status, they reported a desire to adjust the level of information exposure to others. For example, one participant wanted to change BuddyClock to notify others that she was asleep without sharing exact time information, such as while napping or sleeping in late in the morning. One group discussed that they would not want to share sleeping status information with someone in a competing position, such as a colleague competing for a promotion.

Design Factors

Our study also uncovered a few usability issues, most of which resulted from the device's touch-screen, as well as ideas of extra features which might improve the BuddyClock experience. Users reported the soft buttons on the display were hard to press, especially due to grogginess after just waking up. It was also problematic that the display on the original prototype for the pilot study (based on a Nokia N770) automatically blacks out after 5 minutes of idle time. The participants in the pilot study wanted to have the display lit up at all times so that they could check the current time and others' current sleeping status without touching the display. We addressed this issue for the new prototype for the primary study by using the Nokia N800, which does not black out after a period of inactivity.

When we designed the prototype, we were concerned that the ambient sound that occurs whenever another's status changed might wake the user at night. However, participants likened it to a mobile phone's SMS alert and said it was not a bother to them at all due to its infrequency. Instead, that sound acted as a useful tool for the user to know when others' statuses had changed without seeing the display. This type of behavior may indicate the need for personalized sounds for each person in the social network.

> *"I just looked at my wrist watch when BuddyClock made an ambient sound. I knew who went to bed without looking at the display, thinking 'yes, it's time for her to sleep.'"* (Group 2, Participant B)

One participant suggested having a simple note function so that they leave a message to others while they are asleep.

> *"One morning, I had a message to tell one of my roommates about paying a bill. As he was still asleep, I put a post-it on a refrigerator about that as before. By that time, I was thinking it would be sweet if I could leave a message on his sleeping face on BuddyClock."* (Group 4, Participant B)

During the design stage, we were also interested in adapting our prototype to other devices, such a mobile phone for improved mobility. Some participants had concerns that BuddyClock's sharing feature only works when the wireless network is available, which putting the device on a cell phone may address, as connectivity is more reliable. Another participant extended this idea to facilitate sleeping status information to block incoming calls at night.

Having a dating couple (Group 3) use BuddyClock revealed some interesting potential features for better usage of sleeping status information. As the couple in our study normally started the day by waking up each other in the morning, eating breakfast together, and then going to the gym to work out after breakfast, their waking time became synchronized unintentionally right after using BuddyClock for the first one week (see Figure 3). When probed about this further, they said that it would be useful if the alarm time could be automatically adjusted to the same as the other so they do not have to check when the other is scheduled to wake up next morning. Another suggestion was that one could wake the other every morning using BuddyClock if it can be set to ring from distance by another.

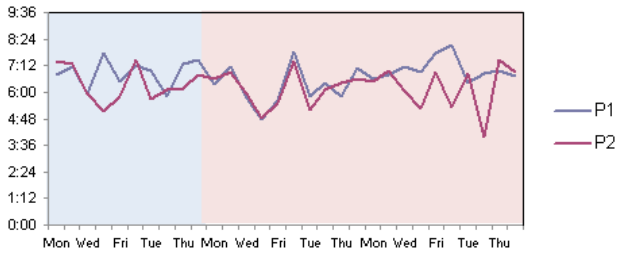

Figure 3. Plotted waking times of Group 3 from the primary study. There is no data on weekends, because the users in Group 3 did not typically set their alarms then,

Participants mentioned concern for their own sleeping behavior and the implications on their health more than we expected. Some said that recording such data overtime would be a good estimate of their health, which they would want to reflect upon overtime. However, they did not want to access to others' specific data for monitoring purposes. Instead, others' data on average sleeping hours might be used for comparison to their own sleeping behavior.

Sleeping pattern information was regarded as a "do not disturb" indicator to many participants. When their own BuddyClock status was set as "sleeping," they expected others to not disturb them by calling or knocking on their door. In return, many commented that they felt uncomfortable or that it was inappropriate to try to contact someone when the "sleeping" status was lit, regardless of whether it reflects the actual status of others. A couple of participants asked to have an extra status setting as "do not disturb" so it would be explicit.

Other Potential Uses

During the post-interview session, participants freely discussed other potential uses of BuddyClock. Participants mentioned it would be useful where several people share a common place, such as a dormitory bathroom or a house with many females. Another potential use was between people who reside in different time zones.

> *"My mom lives where it is a 13 hour time difference from here. So, mom always calculates the time here trying not to wake me up whenever she wants to make a phone call to me. It would be great if she knew whether I would be asleep or not by watching her alarm clock." (Group 2, Participant C)*

Some participants mentioned that BuddyClock could be useful for monitoring purposes. For example, elderly parents could report their status without having to give extra information to their adult children, or a mother could monitor her young child's sleep behavior at daycare if the provider set the alarm for the child. Another suggested that BuddyClock may also be useful for people whose job

affects their sleep schedule, such as a nurse, fireman, or pilot, to share sleeping information with colleagues.

IMPLICATIONS

We believe this work has several implications for people designing for the space of sharing intimate details within a social group, technology aimed at using social networks to persuade others for healthy behaviors, and those wishing to work in the area of addressing sleep behaviors. We outline these lessons learned as guidelines below.

Support Different Settings for Different Group Types
Though our study only included a subset of the different types of social networks, we started to notice fundamental differences in sharing sleeping information amongst different types of groups. For example, those living in the same house but different rooms may want to know whether someone is up so they know if the shower is free, whereas that information would not be of concern to a couple living further apart. In addition, the needs of a dating couple differed quite a bit from the other groups, as their sleep schedules were dependent on one another. Also, there are likely different needs for individuals who do not see each other on a regular basis, such as a long distance couple. Thus, technology should support different usage cases. This is particularly relevant with respect to privacy, as different social groups have different levels of comfort in sharing sleeping status information.

Simple Shared Data Can Still Be Meaningful
When we originally planned our design of BuddyClock, we wanted to use sensors to identify actual sleeping times as opposed to using the alarm clock set time for sleep times. However, none of our participants questioned the accuracy of the sleeping data or expressed a desire for "actual" sleep time. Thus, we confirm Vetere *et al.*'s finding that sometimes simple technology can be just as effective at sharing information as complex, highly accurate technology [24].

Amount of Sleep is Another Health Concern for Technology
With the large amount of focus on technology and health, ensuring a healthy sleep schedule has been fairly neglected in terms of design. We propose that more work in this area would benefit those who wish to improve their sleep patterns. Having one's own sleep pattern exposed to others brings heightened awareness about that person's good or poor sleep habits. Thus, collaborative technology may have potential health benefits with regard to sleeping.

Reasons for Choosing Sleep and Wake Times are Complex
Since the beginning, we believed that use of BuddyClock could impact the sleeping and waking times of people within a social group. That is, the social pressure to not sleep in late or stay up too late could promote healthy sleeping habits. However, we learned that it will likely take more than just showing the sleeping status of friends to enact a change in sleeping behavior. Sleep and wake times are often chosen due to specific times a person needs to wake up, such as for work or an early class, and sleep times are often dictated by energy levels or workload (*e.g.*, one might stay up late to cram for a test or meet a work deadline). The fact that participants stated they wished to change their sleeping habits based on their friends' patterns and the thought of others viewing their sleeping habits is promising. However, there is more work needed to understand the deeper intricacies for why people choose their sleeping and waking times to build a more effective tool for enacting change.

CONCLUSIONS AND FUTURE WORK

We presented the design and evaluation of the BuddyClock, an augmented alarm clock designed for sharing sleeping behaviors with people in a close social network. Overall, we found that BuddyClock affected the behaviors of individuals who used the device and allowed them to feel more connected to those in their social network.

This research attempted to address four research questions, which we outlined in the introduction. We found that although our portrayal of sleeping status was not an accurate measure of sleep, the shared information still affected the feeling of intimacy among users. The event of a sleeping status change often elicited thoughts about that person, which participants reported helped in feeling connected, regardless of location. In addition, sleeping patterns for the previous night were a seed to conversation the next day in many cases.

Participants utilized sleeping pattern information in three distinctively different ways: a personal privacy indicator, a peephole to check others' availability, and a personal health/physical state tracker. First, the portrayed sleeping status on the BuddyClock was regarded and understood that one was not eligible to be disturbed. Participants also used this to express to others that they did not wish to be disturbed. Second, people often used BuddyClock as threshold deciding factor for whether to initiate interaction during night time. Finally, a health tracking application related to sleeping was not explicitly implemented, but was highly anticipated.

Though we did not find any statistically significant change in sleeping behavior between the two phases of our study, during interviews participants reported adjusting waking times to others during the early parts of the experimental phase. Such tendencies disappeared approximately one week after using BuddyClock. This implies that people try to adjust their own sleeping patterns upon first realization of a difference, but the urge to go back to their old patterns because of personal activities or scheduling can outweigh the desire to stay synchronized. We saw in the case of a romantic couple that sleeping patterns became identical. For a couple, BuddyClock became a window to see another's activity regarding sleeping more precisely from distance.

For most participants, sleeping status was not considered highly personal information. Rather, it was regarded as useful information to share as long as the information was shown only to people whom a user selects. This implies that sleeping status may be a socially appropriate way of tracking activity or overall health. Lastly, the different types of groups we studied all found BuddyClock to be useful in different ways. However, most were young and did not have particularly rigid schedules, so more work is needed to determine if older individuals would also find such benefits. Beyond these groups, participants reported it would be useful to share with people who are separated by greater distances or across generations.

We believe that BuddyClock is a promising, simple technique for increasing social awareness and intimacy, while acting as a tool for individuals to reflect upon their own sleeping behaviors. This work has uncovered the need for more research in the area of using technology to support improved sleeping behaviors.

REFERENCES

1. Bentley, F., C. Metcalf. Sharing Motion Information with Close Family and Friends. In *Proc. of CHI '07*. 2007.
2. Bergstrom, T., K. Karahalios. Communicating more than nothing. In *Proc. of CHI '06*. 2006.
3. Bly, S.A., S. R. Harrison, S. Irwin. Media spaces: bringing people together in a video, audio, and computing environment. *Communications of the ACM*, v.36 n.1, p.28-46, Jan. 1993.
4. Consolvo, S., K. Everitt, I. Smith, J.A. Landay. Design requirements for technologies that encourage physical activity. In *Proc. of CHI '06.* 2006.
5. Dey, A.K., E. de Guzman. From awareness to connectedness: the design and deployment of presence displays. In *Proc. of CHI'06*. 2006.
6. Dodge, C. The Bed: A Medium for Intimate Communication. In *Proc. of CHI '97*. 1997.
7. Dourish, P., S. Bly. Portholes: Supporting Awareness in a Distributed Work Group. In *Proc. of CHI '92*. 1992.
8. Hindus *et al*. Casablanca: Designing Social Communication Devices for the Home, In *Proc. of CHI '01*. 2001.
9. Ishii, H. LumiTouch: an emotional communication device. In *Ext. Abstracts of CHI '01*. 2001.
10. Kaye, J. 'J.', M. K. Levitt, J. Nevins, J. Golden, V. Schmidt, Communicating intimacy one bit at a time. In *Ext. Abstracts of CHI '05*. 2005.
11. Landry, B.M., J. S. Pierce, C. L. Isbell, Jr., Supporting routine decision-making with a next-generation alarm clock. *Personal and Ubiquitous Computing*, v.8 n.3-4, p.154-160, 2004.
12. Mamykina, L., E. Mynatt, P. Davidson, D. Greenblatt, MAHI: investigation of social scaffolding for reflective thinking in diabetes management. In *Proc. of CHI '08*. 2008.
13. Mhorain, A. *et al.* Aura: an intimate remote awareness system based on sleep patterns. In *CHI '05* Workshop on Awareness Systems. 2005.
14. Mynatt, E.D., *et al.* Digital Family Portraits: Supporting Peace of Mind for Extended Family Members, In *Proc. of CHI '01*. 2001
15. Nagel, K.S., J.M. Hudson, G.D. Abowd. May I Interrupt? Predictors of availability in home life context-mediated communication. In *Proc. of CSCW '04*. 2004.
16. Neustaedter, C., A. J. Bernheim Brush. "LINC-ing" the family: the participatory design of an inkable family calendar. In *Proc. of CHI '06*. 2006.
17. Ozenc, K.F., J. P. Brommer, B.K. Jeong, N. Shih, K. Au, and J. Zimmerman. Reverse alarm clock. In *Proc. of DPPI '07*. 2007.
18. Phyllis C., *et al*. Sleep and Health: Everywhere and in Both Directions. *Arch Intern Med.* 2006
19. Schmidt, A. Network alarm clock. *Personal and Ubiquitous Computing*. 2006.
20. Siio, I., J. Rowan, E. Mynatt. Peek-A-Drawer: Communication by Furniture. In *Ext. Abstracts of CHI '02*. 2002.
21. Smith, B.K., J. Frost, M. Albayrak, R. Sudhakar. "Facilitating narrative medical discussions with computer visualizations and photography." *Patient Education and Counseling*, 64: 313-321. 2006.
22. Smith, I., S.E. Hudson. Low disturbance audio for awareness and privacy in media space applications. In *Proc. ACM Multimedia '95*. 1995.
23. Truong, K., H. Richter, G.R Hayes, G.D. Abowd. Devices for sharing thoughts and affection at a distance. In *Proc. of CHI '04*. 2004.
24. Vetere, F., *et al.* Mediating intimacy: designing technologies to support strong-tie relationships. In. Proc. of *CHI '05*. 2005.
25. Wellman, B. "The Network Community" An Introduction to Networks in the Global Village. 1999.