CoupleVIBE: Mobile Implicit Communication to Improve Awareness for (Long-Distance) Couples

Elizabeth Bales[1], Kevin A. Li[2], William Griswold[1]
[1]University of California, San Diego
{ebales,wgg}@cs.ucsd.edu
[2]AT&T Labs - Research
kevinli@research.att.com

ABSTRACT
Long-distance couples face considerable communication challenges in their relationships. Unlike collocated couples, long-distance couples lack awareness cues associated with physical proximity and must use technologies such as SMS or telephony to stay in sync. We posit that long-distance couples have needs that are not met by prevailing communication technologies, which require *explicit* action from the sender as well as the receiver. We built CoupleVIBE to explore the properties of an *implicit* messaging channel and observe how couples would use such a technology.

CoupleVIBE is a mobile application that automatically pushes a user's location-information to her partner's mobile phone via vibrotactile cues. We present qualitative results of a four-week user study, studying how seven couples used CoupleVIBE. A key result is that CoupleVIBE's implicit communication modality operated as a foundation that helps keep couples in sync, with other modalities being brought into play when further interaction was needed.

ACM Classification: H5.2 [Information interfaces and presentation]: User Interfaces, Haptic I/O; B 4.2 Input Output devices

Keywords: couples, awareness, mobile communication, implicit messaging

General Terms: Human Factors

INTRODUCTION AND MOTIVATION
Implicit cues are an important means of communication between the partners of a couple. When a partner gets up in the morning, the other feels and hears the change in her partner's life because it intersects in time and space with her own. Such cues help partners stay effortlessly in sync [16]. Long-distance couples lack these cues, causing substantial challenges in their relationships [18]. Consider the following scenario, inspired by interviews we conducted.

Krista and Jason are long-distance partners who both work outside the home. Krista commutes by bicycle to reduce save money. Jason is proud of her, but worries for her safety because she bikes on busy roads during her commute.

The increasing adoption of mobile computers and smart phones is allowing couples like Krista and Jason to e-mail, call, or message each other via instant messaging (IM), text messaging (SMS), or a social network like Twitter or Facebook. Harper and Hodges have noted that each such communication channel has unique affordances, explaining why new technologies coexist with old ones, rather than supplant them [14].

Krista and Jason have agreed that Krista will send an SMS message or call when she arrives home. Only a few days into their new routine, Krista is preoccupied with a deadline and forgets to send a message upon arriving home. Jason doesn't want to call her for fear of distracting her while on a busy stretch of road. Jason finally calls her, anxious and distraught. Krista is sorry and redoubles her efforts, but only a week later Krista forgets again.

We all know the feeling of dread when a loved one doesn't arrive home or contact us when expected. SMS and telephony allow Krista to share status information provided she *remembers* to send the message or place the call. Indeed, all of the prevailing technologies, even new ones like Loopt [2], require some form of *explicit action* by one or both partners to successfully convey status information, a barrier for busy couples.

We posit that an *implicit messaging channel* has unique properties that could better address some communication needs of long-distance couples. To explore these properties and the usage habits that result from them, we built an implicit mobile messaging application called CoupleVIBE.

CoupleVIBE *automatically* sends touch cues between partners' mobile phones to share location information. Specifically, as a user moves between locations in her day, her partner receives specialized vibrations, allowing both to keep updated without either party ever having to take their phone out. The combination of coarse location sharing and vibrotactile cues results in a privacy-friendly, unobtrusive communication channel with unique properties.

In this paper we make three contributions:

- We present the design of CoupleVIBE, a mobile implicit messaging application that automatically pushes awareness information to couples.
- We report qualitative results of a 4-week study of *how* couples used this type of awareness application.
- We discuss the properties of an *implicit* messaging channel that make it both unique and powerful for couples, examine how it meshes with existing communication practices, and propose design guidelines for future implicit communication applications.

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A key finding is that CoupleVIBE operated as a foundation that helped participants stay in sync with their partner's daily activities, supplanting some explicit communications while better coordinating others. Surprisingly, collocated couples also found CoupleVIBE to be useful. Importantly, a combination of application design and user practices sidestepped the potential annoyances of end-to-end automated push communication. Also, automated push eliminated the impulse for reciprocation, keeping communications lightweight.

RELATED WORK

As an example of the prevalence of long-distance couples, Stafford and Reske hypothesize that a third of college relationships are long distance [26]. These couples face significant challenges because they lack traditional intimacy-building interactions, such as touching, non-verbal communications, and presence [18]. Long-distance couples are creative in using existing technologies to facilitate communication, but they often fall short of expectations. Bhandari and Bardzell found this in their interviews with long distance partners, being told by one participant "the use of cell phone in long distance relationship [sic] is akin to talking to the electric waves as opposed to his girlfriend" and saying about another "that talking on the phone makes him feel he is talking to a slightly different person…a certain personality of his partner and not her in totality" [4]. Time zone differences exacerbate the problem [8].

One line of research has focused on increasing intimacy between partners with small "thinking of you" actions. Early work used interaction with a tangible object like a picture frame, releasing a lingering scent to the partner [22, 27]. Other designs have supported two-way interaction through computer-linked haptic shakers or rollers [5, 27]. More recently, Lottridge et al. proposed sharing music and background sounds with MissU [21]. Kaye employed a virtual approach, whereby separated partners click a small dot on their computer screen to cause the dot on their partner's computer to change from blue to red, thus conveying "just thinking of you" [17]. Similar to reciprocity effects observed with SMS [1], Kaye observed that even when a tiny amount of effort is expended by the sender, the receiver often feels an obligation to reciprocate.

Another line of research has involved helping distant couples by digitally linking everyday objects that they use, typified by Lover's Cups [11], LumiTouch [9], and SyncDecor [1]. For example, when a person turns on a lamp, a lamp in the partner's home turns on as well, providing lightweight non-verbal communication and presence.

The Whereabouts Clock is a peripheral display placed in the home that family members can casually glance at to learn about the locations of fellow family members who are outside the home (tracked by carrying location-aware phones) by displaying their pictures in one of four zones – home, work, school, or elsewhere [6]. The Whereabouts Clock evinces both affective qualities (through pictures) and practical aspects (through location status).

The above object-based systems are incomplete solutions for busy couples, who are out of their homes and on the go much of the day, often at the same time. Such couples would benefit from a mobile design so that each could be aware of the other's status anywhere.

COUPLEVIBE DESIGN

We are attracted by the tangible qualities of many of the above implicit communication designs, yet their embodiment in common objects (lamps and clocks) that are bound to fixed locations (home or work) works against the ubiquity that long-distance couples need to stay in sync throughout their day. We considered using auditory cues, but their intrusiveness in public settings was a concern. Instead, we focused on the concept of *person-to-person touch*, without reference to a mediating object that would have to be carried around. Consequently, many of the day's most significant events could be communicated anywhere, at any time.

In CoupleVIBE, when a user arrives at or departs from a frequented location, her partner automatically receives a vibrotactile message on his mobile phone, communicating the specific change of status. This design is akin to location-based social-mobile media [1, 2, 3, 24], but with proactive detection, sending, delivery, and "playing" of the status (i.e. vibration of the phone, not just passive visual display). By using tactile cues, we hoped to achieve an unobtrusive solution, freeing the user from having to explicitly interact with their phone to send and receive status updates. Mobile phones were chosen as the sensing and delivery platform for their ubiquity. Within these constraints, past work has shown a considerable number of distinguishable vibrotactile patterns can be generated [6].

We expected that CoupleVIBE's design would minimize feelings of *reciprocal obligation* – an urge to respond to status messages – as there is no intentful action to acknowledge. Reciprocal obligation can be a positive force in communication. For our anticipated scenarios, however, response actions would increase effort and be a step away from implicit communication. Thus, we hoped both that there would be no feelings of reciprocity and that active reciprocation would not be required to sustain use, as seen with some lightweight messaging systems [13]. In this spirit, to further avoid incurring feelings of reciprocity, CoupleVIBE vibrates just the receiver's phone on a location change, not the sender's. Thus, a user learns through experience that her partner is not consciously aware that a message was sent, and hence a reply could not be expected.[1]

CoupleVIBE's visual interface is basic, consisting of just two screens, the status screen and the vibration assignment screen (Figure 1). A user tags a location by selecting the "new location" option when he is physically at the location. The user is asked to give a name to the location, which is stored with the phone's current location fingerprint (See

[1] In this respect, the touch messages behave more like a sound heard from down the hall, in that the "sender" is not directly aware that her activity is being sensed by someone else.

Implementation). Separately, the user's partner selects a vibrotactile message to identify the location.

Balancing Proactivity with Other Considerations

The intent with CoupleVIBE is that a user can go about his day and stay updated on how his partner's day is going, without ever having to take the phone out to interact with it. The design decisions that support this goal strike a balance among four variables with respect to proactive implicit communication: meaningfulness, control, unobtrusiveness, and reliable delivery. When faced with a tradeoff, we favored the choice that was most consistent with implicit communication, with the goal of learning more about it during the user study.

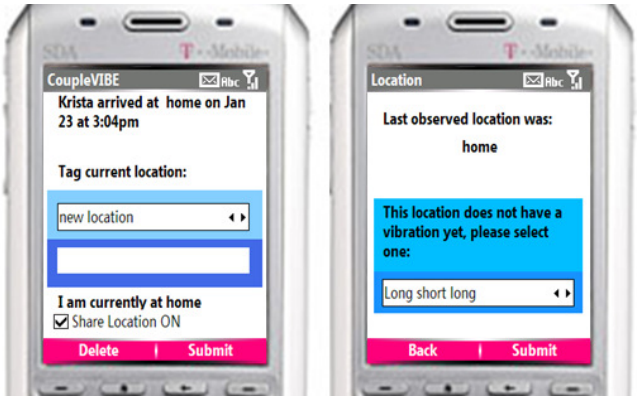

Figure 1. Left: CoupleVIBE's main screen. Right: Prompt for tagging a location with a vibrotactile cue.

Meaningfulness

To automatically capture status, the status must be inferable from ubiquitously available context. Past work in location-based reminders had found that for a single user, location can act as a proxy for availability [25]. We expected a similar result; a knowledgeable partner should be able to infer detailed status information from a partner's location.

However, not every location holds meaning for a partner, In CoupleVIBE, only predefined locations signal status changes. The intent is that the user will select locations that are meaningful to her partner – for example, frequented places that convey key aspects of her daily routine, such as home, work, gym, and grocery store. With this design choice, there is a chance that an important change in status will occur outside normal routine and will not be signaled – something to look for in the study.

Control

Although partners are generally open with each other, services that support monitoring can enable abusive or controlling behaviors. For the purposes of this study, then, we felt it was important to give users control over the information communicated to see how such a feature might be used (e.g., for privacy). Users can disable the sending of status messages from CoupleVIBE's main screen in a way that is invisible to their partner. On the other hand, we made an explicit decision to make it hard for people to turn off the *receipt* of messages. Both decisions are consistent with the way physical implicit communication works: one can make a point of being quiet, but it's harder to avoid hearing noises in your vicinity. Finally, we note that allowing each user to choose and name her locations provides an additional control for personal expression or privacy.

Unobtrusiveness

Vibrotactile messaging is designed to be relatively unobtrusive, but frequent status messages could still be distracting to the receiver. We expected that CoupleVIBE's use of predefined locations would limit the number of status messages. There is also a chance that vibrotactile messages could be insufficiently "obtrusive" to gain one's attention when desired, something we looked for in the user study.

Reliable Delivery

The reliability of delivery can be divided into three successive questions: did the sender's phone detect that it changed location, did the receiver detect the delivery of a message, and did the receiver understand the specific message?

Previous work reported that users frequently do not carry their phones on their person [23]. This could compromise both sensing and delivery. However, this study also reports that people do tend to keep their phones in an accessible location (e.g., in the house, when at home). Since our design presumes that locations can be detected through coarse positioning (See Implementation below for details), such separation is acceptable. Regarding delivery, we expected partners had already developed practices for the reliable receipt of *explicit* communications via mobile phones; we hoped to learn how those practices are carried over or extended for implicit communication.

To maximize the distinctiveness of CoupleVIBE's messages, we used an approach similar to Li et al. to vary vibration intensity [20]. We then constructed 7 user-differentiable vibration patterns (each about 2 seconds long) by varying rhythm and roughness, similar to Brown et. al [6]. Supporting more vibrations would have reduced their distinctiveness and increased the cognitive load of matching a message to its corresponding location.

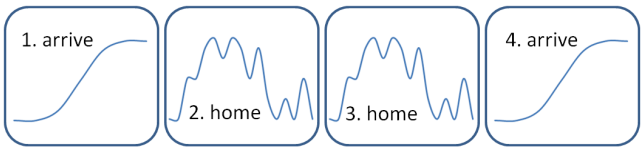

Figure 2. Four-part vibrotactile message for "arriving at home." The message for "leaving home" would look similar, with "departure" cue segments at the beginning and end.

In use, these location messages are paired with a transition message, with some repetition to increase comprehension. When a user arrives at home, for example, her partner receives a 4-part message: *arrival cue, home message, home message, arrival cue* (Figure 2). The arrival cue is a 1.2s vibration with increasing intensity, whereas the departure cue is a 1.2s vibration with decreasing intensity. There is a 1.0s pause between the arrival and home cues and a 3.0s pause between the two location cues.

We initially tried using a single arrival/departure cue at the beginning of the sequence followed by a single location cue. However, in our pilot studies, we found that participants would sometimes miss the first part of the cue. As a result, users could recognize the location information but did not know whether it was an arrival or departure cue. Pilot users also reported that they would sometimes miss part of the location cue. Repeating both the arrival/departure qualifier as well as the location pattern solved this issue, albeit at the expense of a concise cue.

With implicit communication in mind, our goal was for the vibrotactile interface to fully convey all messages, achieving an unobtrusive interaction. However, if the user misses a status message – say, because the user was otherwise occupied when it played – CoupleVIBE's main screen displays the most recent status change.

Implementation

We implemented CoupleVIBE in C# and C++ on Windows Mobile Smartphone 5.0. Location updates are sent between phones using specially formatted SMS messages. CoupleVIBE runs in the background, intercepting these messages. When a CoupleVIBE message is received, the vibrotactile message for the corresponding location plays.

Fingerprint-based GSM location algorithm

We chose to employ GSM-based positioning over GPS, given that it works indoors, is widely available, and generally has lower energy consumption. To determine location we use a tower fingerprinting method [3,19]. Our algorithm reads the cell tower IDs visible to the phone every ten seconds. To filter noise, we introduced *voting* into our fingerprinting algorithm. A vote is cast for a location when the observed fingerprint is at least 65% similar to a known location fingerprint; otherwise, a vote is cast for "unknown". A user's location is updated when one location wins a majority of the votes over a 5 minute period and it is different from the current location stored in the phone. This five-minute voting method minimizes location "jumping" when users are moving through boundary areas.

In practice, the algorithm works extremely well. We discuss real-world anomalies and their handling by users in the Discussion. To formally evaluate our algorithm, we ran a simulation on GPS-tagged GSM data collected by Chen et al. from their wardriving of the Seattle area [10].

Our algorithm recognizes a location by comparing multiple samples over time from fixed locations. Since it would be unrealistic to collect long traces at each of hundreds of locations, we simulated fixed locations using the wardrive datas and a bucketing technique. To simulate multiple samples per location, we modeled a "location" by choosing one (GPS, GSM) reading pair as a location fingerprint, and treating all the sample points that fell within a 0.05km radius of the fingerprint as a trace gathered from that location. This approach is *conservative*, as the readings for each location (~1 city block) are distributed over a larger area than one would expect from a home, or other typical location.

We performed four measurements. Figure 3a shows how voting amplifies the accuracy of basic fingerprinting, for every given fingerprinted location in the dataset. The question, however, is how this maps to user experience – how quick is the algorithm at recognizing arrival at a location, and how unlikely is it to falsely report a departure once there. Arrival was detected within 5min for 66% of locations, and within 10min for 92% of locations. On average, 83% of locations would not send a false departure cue for at least 36 hours. Lastly, if two tagged locations are close to each other, the algorithm might falsely report an arrival at one location when at the other. Figure 3b shows the rate of false positives at various distances from a given location. Locations at least 0.3km apart were less than a 0.4% likely to falsely report an arrival.

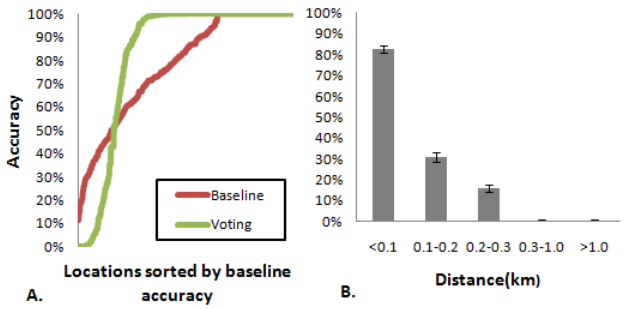

Figure 3. (a) 5-minute voting substantially increases accuracy over baseline; (b) Probability of reporting a false arrival cue from various distances from a location (error bars show 95% confidence intervals).

These levels of (conservatively measured) accuracy are compatible with our intended usage scenarios, where the information is nice to know, and the tagged locations are few and likely far apart.

USER STUDY

We ran a 4-week exploratory, qualitative field study to learn how couples would incorporate CoupleVIBE's implicit communications into their lives, as well as identify salient design issues for implicit mobile communication. We studied 3 long-distance couples and 4 couples who lived together. We used Facebook advertisements as our primary recruiting tool, but not from our own networks.

Methodology

The CoupleVIBE system was used for weeks 2-3 of the study, with one week of data collection both before and after the deployment to capture existing practices and observe the transition back.

During the study several different methods of information gathering techniques were used. Nightly online-journal entries were used for the entire length of the study. Communication logging was also used every week of the study, except for the second week when logging was suspended to reduce participant fatigue. Figure 4 illustrates how long each method was deployed, as well as when the CoupleVIBE technology was used by the participants. The two-week deployment of the technology, though brief, helped

us identify and address important issues, which can be integrated into later experiments.

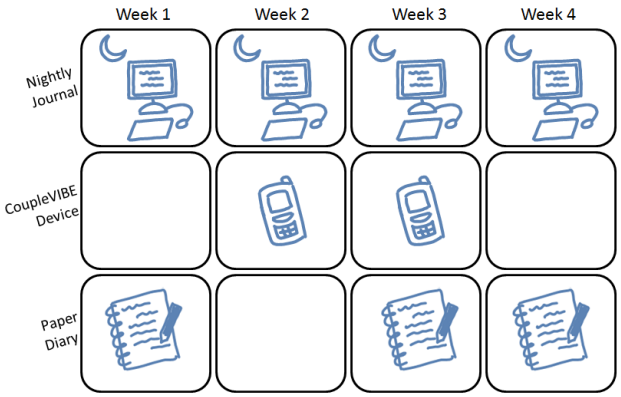

Figure 4. Forms of media used for collecting communication during the study. We collected data before and after CoupleVIBE usage to observe changes in behavior.

At the end of the study, participants were interviewed both together as a couple and individually in private. Collocated couples were interviewed in-person, while long-distance interviews were conducted using video chat.

We considered using the experience sampling method (ESM) to gain in-the-moment insight on usage [12]. However, interrupting users would have been counter to our unobtrusive design goal, so we decided against it. Consequently, we focused on gathering data in the form of message event counts, end-of-day journals, and interviews.

Participants

We recruited 7 couples, four living together in shared households and three living apart.[2] The latter three had been apart for six months or more and were separated by at least 400 miles. We originally recruited four long-distance couples but one dropped from the study due to time commitments. The couples recruited were between 21–32, and did not have children. The study therefore reflects CoupleVIBE usage for this typical demographic, which comprises the majority of, but not all, long-distance couples. All couples had been together for at least 2 years.

Close #1. 23 year old Abigail and 28 year old Adam have been together for over two years. They live in the same house located near Abigail's barista job and the bus route that Adam takes to school. When Abigail is at home, they communicate frequently over IM. Her employer does not allow her to use any communication devices while she is at work. Recently, Abigail got upset with Adam when he went to a friend's house for the evening without notifying her or answering his phone. She worried about his safety for several hours.

Close #2. Brenda and Bob are 28 and 32 and have been together for over 4 years. Brenda is looking for work while Bob supports them with his postdoc position. To coordinate their days, Brenda and Bob use shared online calendars. Bob is a bicycle commuter and Brenda worries when he forgets to call before he sets out on the road.

Close #3. Cheryl and Chris are a 28 and 30 year old secretary and student, together for 8 years. Often at their computers, they use IM as a primary means of communication. Chris is a bicycle commuter and has flexible hours. This often causes Cheryl to worry when Chris doesn't call or IM to let her know when he is heading home.

Close #4. Deborah and Dale are 25 and 30 year old graduate students at the same school, together for 3 years. They work about a mile apart on campus. They primarily call to coordinate things like when to eat or go home. They are also avid IM users since they are often at their computers.

Long Distance #1. Martha and Mark are 21 year old undergraduate students who attend schools 2,400 miles and three time zones apart. They are high school sweethearts and have been together for over 4 years. Throughout the day they communicate through text messaging, which they use to keep up to date with each other's activities and to coordinate their evening phone call.

Long Distance #2. Nancy, 24 and Nick, 26 have been together for 6 and a half years. Nick has a software job but Nancy is still a student and lives three time zones and 1,900 miles away. They chat on the phone during Nick's commutes, and while at work they often keep a chat window open to communicate throughout the day. Sometimes they leave a video chat window open with the sound turned off so that they can see each other as they work.

Long Distance #3. Olivia, 30 and Orlando, 31 have been together for 9 years and living apart for 8 years. Olivia is an engineer and Orlando works as a researcher for a company located 400 miles away. Olivia's work prohibits the use of phone and instant messaging, so most of their communication occurs on the phone when Olivia is commuting, and in the evening when they have their nightly phone call. Orlando is also an occasional bicycle commuter and Olivia appreciates when he lets her know when he chooses to bike.

DATA ON LOCATION SELECTION AND MESSAGING

All participants tagged their home, as well as work or school, as appropriate (Figure 5). Other popular places to tag included the gym, restaurants, shops, and friends' houses. All 14 participants said that they selected places that are part of their regular routine. Three participants also volunteered that they chose places that they thought would be of interest to their partners. Olivia volunteered that, "There were the ones that were, you know, standard, home and work" and Chris said, "I just chose the most frequent locations I'm at and the ones I thought Cheryl would care about." A few locations were selected to elicit a particular response from the partner, notably places that are favorites of the remote partner from previous visits.

Overall, the number of locations tagged per user ranged from 2 to 9 with an average of 4.6. Users were limited to 7 unique vibrations, but they could define more locations,

[2] Names are pseudonyms. Those starting with A through D are local couples. Those starting with M, N, O are long-distance.

mapping some to the same vibration. Two users defined more than 7 locations because they spent time in multiple cities during the study. They knew that their partners would be aware of which city they were in, so they could unambiguously assign locations like home and work in one city to the same vibrations as chosen in the other.

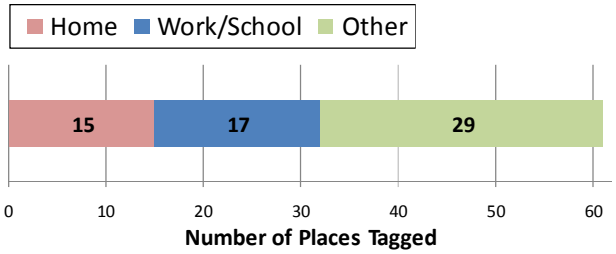

Figure 5. Number of places tagged by users, aggregated across all users. Tagged places are categorized by type.

Thirty-seven out of the 65 (58%) were tagged within the first two days. By the end of the first week 57 (88%) locations had been tagged. On average, 3.0 messages were sent per user per day (std. dev. 2.4). Users reported not using the application when spending the day together, such as weekends. This and related factors moderated the average.

USES OF COUPLEVIBE

Past work has found that when introducing new technologies to improve awareness in families [7] or between couples [21], coordination, connectedness, and reassurance are common uses. CoupleVIBE compliments the findings of these studies by reporting the unique properties of mobile- symmetric-implicit communication.

Coordination: Location as a Proxy of Availability

Participants frequently used the information they gleaned from CoupleVIBE to help them coordinate a future activity with their partner. Eleven out of 14 participants volunteered examples of using CoupleVIBE for coordination activities.

Not surprisingly, coordination between long-distance partners centered on determining when to call or text the other person. As Abigail noted in her journal, "*I needed to ask Adam a question today and knew that he was at lunch because I had received a vibration. I was alerted that he had returned to his office and could then call him to ask him the question without interrupting his lunch.*" Her partner Adam related a similar experience in his journal saying that the "*application was useful for knowing when to call...I knew when she left work and was able to call then.*" Thus, like users in the *Place-its* [25], and *Connecto* studies [3], location was used as a proxy for availability. In a couple-based application, this extends to communication coordination.

Sometimes coordination extended to making a more informed safety decision. Mark recorded in his journal, "*I knew Martha left her house to work out at the gym. This was helpful, I knew I shouldn't text her if she is driving.*"

Collocated couples used CoupleVIBE for coordinating face-to-face interactions, such as unlocking doors, tidying the apartment, or putting away the PlayStation when one feels his partner arriving home. They also coordinated communications, like the long-distance couples.

Increased Feeling of Connectedness Between Partners

Eleven participants noted that vibrations often elicited feelings of connectedness. Martha was typical, saying, "It put a smile on my face, just knowing something about him." Participant Olivia reflected on how she enjoyed receiving her partner's location changes, saying "*I was able to follow Orlando through his day, activities like ultimate frisbee and going to Jamba Juice.*" Interestingly, feelings of connectedness were not only generated by receiving location updates, but also by sharing one's own location status. Olivia continued, "*It was nice to go to local places and have him know where I was without having to tell him.*"

Three participants also volunteered that they appreciated how CoupleVIBE's lightweight messaging helped them stay connected without detracting from other social experiences. Martha observed, "*I liked getting the vibrations when I was busy with friends, it was easy to feel connected and I didn't have to stop what I was doing to talk to him.*"

As mentioned in Location Selection, some locations were tagged in order to evoke a memory. Olivia wrote in her journal "*I put in that I was at <restaurant> and I received a text msg that he was jealous that he wasn't there. =)*"

The CoupleVIBE cues were visceral for some. Mark told us "*I can't remember how many times I've told Martha she's 'the voice in the phone, like that's who you are to me right now, you're the voice on the phone, how depressing.' And it's not until she comes and visits that she becomes physical and more real in a way. And the vibrations sort of take those abstract concepts and make it real, like it's actually physically affecting me like a real person, so maybe it sort of attaches the emotions to a more physical... And that makes us feel closer, or at least makes me feel closer.*" This attachment extended beyond the end of the study for some such as Nancy: "*It became like a habit and when I had to switch back to my iPhone I kind of missed the vibrations and I expected them but I didn't [receive any].*"

Peace of Mind: Knowing Your Partner is OK

Three of the couples had pre-existing conflicts over bicycle commuting, as prefaced by the scenario in the Introduction. These couples all commented on how using CoupleVIBE allowed for greater peace of mind since the cyclists no longer had to remember to call. Abigail wrote, "*Adam biked home from work today and I liked that I was able to know when he left work and when he got home. I worry when he rides his bike on busy streets.*" Additionally, if the cyclist stopped by any other shared location on the way home, the partner was notified and knew to expect a delay. As Brenda noted in her journal, "*It was nice knowing he stopped off in another bldg on campus rather than coming straight home, so I didn't worry that he was hit by a car.*"

Another example of comfort with the CoupleVIBE system was documented by Nick when he was concerned that his partner might have trouble using public transportation: "*I was worried about her ability to find the <local land-*

mark>, where her car was parked. The vibrations showed that she left <city> safely and arrived <at landmark> 45 minutes later. I knew all this without calling or texting." It was beneficial to both that Nick was able to observe his partner's successful journey without having to explicitly contact his partner while she engaged in an unfamiliar task.

Orlando sometimes commuted to work via a combination of bicycle and light rail train. He tagged the light rail station so Olivia would know how he was commuting to work that day – and that he had arrived safely. "*I thought the tagging of the train stations was particularly nice just for the whole bike ride thing, cause Olivia has in the past worried, if she thought I was riding and didn't hear from me.*" Olivia reflected in her nightly journal, "*I was able to get a CoupleVIBE message when Orlando arrived at the Light Rail Station. That was nice to know – I could infer from that [that] he was biking to work today instead of driving."*

DISCUSSION

With this background on how CoupleVIBE was used, we now reflect on some of the properties of implicit mobile communication that were observed during our study.

Long-distance versus Collocated Couples

Both long-distance and collocated couples benefited from CoupleVIBE's affordances, although in somewhat different ways. The long-distance couples experienced more "discovery" events, learning of a partner's activity that she otherwise would not have known about, which enhances connectedness. The collocated couples were able to use CoupleVIBE for coordinating face-to-face interactions.

Both groups used the information provided by CoupleVIBE for communication and coordination, with 9 subjects reporting they used it to determine a good time to contact their partner. Both groups also indicated that they used the location information shared to infer greater context, such as likely activity and interruptability.

As expected, there were times for collocated couples when CoupleVIBE's cues were unnecessary, especially weekends, when a lot of time was spent together. A simple fix would be to use CoupleVIBE's location detection to detect the *proximity* of partners to turn off message delivery.

Benefits of End-to-End Automation of Communication

Automation in social communication is often dismissed for being impersonal, intrusive, and error-prone. However, results from the study lead us to believe that well-designed automation can avoid these pitfalls and provide benefits missed by traditional user-initiated communications.

No (Need for) Reciprocation

In our one-on-one interviews we asked each participant whether he or she felt any obligation to reciprocate when a CoupleVIBE message was received. All of the participants reported that they felt no obligation to respond to the vibration messages. When asked to compare their experiences with CoupleVIBE to other communication technologies they used regularly, participants made observations like Abigail: "*It wasn't like if I received a text message or an IM, that's when I feel guilty like oh I gotta write back, but no, this wasn't like that at all, completely opposite.*" Or Dale: "*You're never really aware that you're buzzing the other person […] cause you're never aware of it you're never expecting a call back.*" These reports and others also convey that participants didn't want or expect their partners to actively reciprocate either, indicating overall that reciprocity was not an important dynamic. This helped maintain the effortless properties of implicit communication.

"Real" Real-time Updates

With explicit communication of status, sharing is often initiated in anticipation of an event or postponed until after the event. We found several cases of event disclosure in anticipation of an event, such as when a participant told his partner over IM that he was leaving work to come home when in actuality he didn't leave for another ten to twenty minutes. This time shifting can cause a disconnect in how partners understand each other's schedules. All of the participants reported that they share their schedules with their partners. In interviews several remarked on the differences they noticed with CoupleVIBE because now they knew in real-time when an event occurred instead of just knowing "she visits the gym around 5:00ish". The two couples separated by time-zones mentioned that these real-time updates helped them understand the time difference in a richer way.

Privacy Concerns with Sharing Location

In our one-on-one post-study interviews, we asked about concerns over one's partner knowing his or her whereabouts. Twelve of the 14 participants reported comfort with the level of sharing. CoupleVIBE was considered noninvasive *not* because of its privacy controls – no one employed them for privacy – but because of who the user was sharing with and what they already knew. Brenda was typical, saying, "*I usually tell Bob when I am going places anyway and we do have this shared calendar.*" Even the two users citing discomfort said their partners had in-depth awareness of their whereabouts; the issue was about feeling in direct control of when and how that information was shared.

When asked about using CoupleVIBE with people other than their partners, users said they would exercise more control over the location information. Orlando commented, "*I can imagine doing this publicly, but at a coarser grain than this.*" Nancy commented that she would "*turn off the application at certain times*" because she would not want friends and family knowing what she was doing at 1 a.m.

Three users volunteered that their levels of comfort with the system were inversely proportional to the level of detail in sharing. Location information was viewed as minimally invasive and not uncomfortable to share, while detailed task information such as whether a participant was working or playing a computer game was deemed too fine-grained, with Cheryl stating "*if it was that granularity I would feel very, very uncomfortable, even with Chris.*"

Unobtrusiveness versus Reliability of Message Cues

When we asked participants if they felt that the vibrations were sufficiently subtle, they said that the level of subtlety

depended on the placement of the phone. For participants who carried their phone in a pocket, there were no reports of others noticing the vibrations. However, two participants said they placed their phones on their desks, which amplified the vibration noise enough that their office mates could hear it. They said that even when others did notice the vibrations that they did not seem bothered. This may be due to the relative infrequency of the messages, as well as the fact that people are generally accustomed to mobile phones making occasional noises in public settings.

Interestingly, several participants actively managed the placement of their phones in order to decrease obtrusiveness or, conversely, increase reliability of delivery. For example, one participant, who didn't carry her phone at home, used noise amplification to her advantage by placing her phone on a glass coffee table in the living room. On the flip side, two participants reported not bringing the phone to functions where they felt that overheard vibrations would be inappropriate, such as a job interview.

From these stories we observe that vibration can be a powerful tangible affordance, as simply moving the phone – as opposed to navigating its interface – can dramatically change the characteristics of the application to manage an important tradeoff. The fact that users often don't carry their phones [23] can sometimes be seen as a positive feature of mobile phones as a ubiquitous computing platform.

Role of Context in Recognizing Vibrotactile Messages

Several users said they could discern the different vibration patterns after a few days, but six users reported that they never got the hang of it, beyond recognizing their partner's most frequented locations, such as home and work. Five of the six, all women, tended to keep their phones in a hand bag. Indeed, women's clothing rarely allows for carrying a mobile phone on the person. Interestingly, three of the six women reported using time as a disambiguating cue for determining their partner's status when they received a vibration. As Olivia noted, "*The vibrations distinguishing one location from another [are] difficult to recognize. It might be possible that I will "learn" them. But [I] can guess from the timing.*" Participants reported using CoupleVIBE's status screen when they couldn't identify the location from context. A few users also reported using the status screen as something to look at when they were thinking of their partner.

We attempted to design a laboratory study to learn more about the effects of placement and context issues on recognition, but found it difficult to reproduce the relevant contextual factors, such as time of day, phone placement, and sources of external vibration. Also, there were important variables that we could not control across our 14 participants, such as the number of vibrations they used during the study and the amount of experience they had with them.

Handling of Anomalies

We know from previous sections that location recognition worked well, except for a few locations that were close together. Participants adapted to these difficulties in a couple of ways. Deborah and Dale, who worked close to their home, enabled the privacy feature when home together at night, when false cues tended to occur. When Nancy incidentally drove past her gym, Nick would sometimes receive an arrival cue. However, he used situational context to disregard those cues. Thus, as we've seen throughout the Discussion, users were adept at adapting CoupleVIBE and their own practices to make the most of CoupleVIBE.

Integrating CoupleVIBE with Existing Practices

All of the couples in our study used a combination of IM, phone, or e-mail to stay in touch prior to the study. CoupleVIBE filled an important niche in their communication needs. As one example, several partners used CoupleVIBE's cues to determine which type of communication to use. A typical example is that a user would use IM when she knew her partner was at the office, but called the house phone when she felt her partner arrive home. As another example, couples would use different technologies for different purposes, according to what best suited the situation. Two couples' stories highlight this practice.

One couple would chat via IM throughout the day, messaging each other when one was about to go somewhere. During the study, they still used IM to stay in touch. However, for tracking and conveying location, they used CoupleVIBE instead. As Cheryl commented, *"[CoupleVIBE] is nice because you don't have to check the IMs, you just hear the vibrating and you're like 'oh, okay'.*"

The other couple would call each other whenever either left one place to go to another. Nancy commented "*Say Nick left his gym or workout place and the phone vibrated to let me know. I know that's a cue that he's going to call me soon because we do have that habit of calling each other when we drive. So when the vibration would go off and he wouldn't call me for a while, I would call him and be like what are you doing. Oh I'm on the phone with my parents or something had come up. It was like a cue for me for why isn't he calling me. It's unusual for him.*"

In short, the couples adopted CoupleVIBE for status that used to be exchanged over IM and phone, achieving high awareness. In essence, CoupleVIBE provided a baseline awareness for helping couples stay in sync. IM and phone calls were used for more interactive and detailed communication, often coordinated or prompted by status changes signaled by CoupleVIBE.

Improving Upon, Not Just Imitating, the Physical World

One of the design goals of CoupleVIBE was to recreate the awareness couples get through physical proximity. By mapping a user's physical location at a particular time across space, we had hoped to increase a user's awareness of her partner. This awareness is usually nice to know, but it can be disruptive if it interrupts a user's activity.

Two of the couples in our study lived in different time zones. In both cases, the partner living in the later time zone complained of being woken up when the other partner left home in the morning. Mark complained, "*I was asleep and she's three hours ahead and she left for the gym and it*

woke me up." As a workaround, one of the participants developed a strategy of placing his phone on the carpet before going to sleep.

It is encouraging that the couples were able to invent practices that avoided these problems. Still, being awoken by these "disruptive" cues is similar to being woken up by a collocated partner's actions. However, some argue that a new communication mechanism should improve upon, not simply imitate, real world communication [15].

Comparison to Previous Studies

Some of our results parallel those of previous studies, such as the Whereabouts Clock [7] and MissU [21], mentioned in Related Work. The CoupleVIBE study highlights many insights unique to (long-distance) couples, while providing insight on mobile, two-way, touch-based design.

It was important for couples to receive cues regardless of where they were, not just at home. The touch-based design proved similarly important, because it proactively played the status messages so partners were more in sync with the timing of each other's day.

As professional couples can have active lives outside home and work, we chose to support a larger number of locations than the Whereabouts Clock. We hadn't even supposed that some partners' travel for work would result in multiple "homes". With an average of 4.6 tagged locations, 9 max, and 47% of locations falling into the "other" category, this design decision bears out.

CoupleVIBE's mobile design led us to design for unobtrusiveness, which proved successful with a touch-based design. The small number of messages per day – even with the larger number of tagged locations – also aided unobtrusiveness. Further, we were able to observe how the couples devised practices of phone placement and use of the privacy feature to achieve the level of (un)obtrusiveness desired.

Finally, CoupleVIBE's focus on lightweight two-way communication encouraged us to design to avoid reciprocity and reflect up on its consequences.

CONCLUSIONS, OUTLOOK, AND DESIGN LESSONS

Long-distance couples have unique communication needs that are not adequately met by explicit communication modalities. The design and deployment of CoupleVIBE, a mobile application that automatically shares location information between partners with cues of touch, shows that technology-mediated implicit communication can meet some of those needs. We highlight two takeaways:

- *For couples, CoupleVIBE operated as a foundation for staying in sync with a partner's daily activities*, supplanting some explicit communications and better coordinating others, while also contributing to connectedness and peace of mind for their partner's safety. Collocated couples also used CoupleVIBE for physical coordination, such as tidying the house prior to a partner's arrival.
- *A combination of application design and user practices can sidestep the annoyances of end-to-end automated push communication.* Vibrotactile cues signaling a partners' movements between frequented locations provided the desired awareness information while still providing unobtrusiveness. Simple practices of phone placement balanced unobtrusiveness and reliability, as did inventive use of CoupleVIBE's privacy feature. Additionally, users were adept at using context to disambiguate partially sensed cues and ignore erroneous ones. Finally, automated communication eliminated the impulse for reciprocation, keeping communications lightweight.

With these observations in mind, it is possible to envision a world with a broad set of implicit communication tools that quietly keep us apprised of goings-on beyond our immediate attention, helping us to feel more connected, better coordinate activities, and increase peace of mind. Based on our results with couples, we postulate four design lessons that can apply to future mobile implicit communication systems designed for other social groupings.

Design for inattention, not just distance. Despite their frequent proximity, collocated couples found ample uses for CoupleVIBE – some involving coordination that are unavailable to long-distance couples. Seemingly, the busy life of a modern couple can create breakdowns in communication that are tantamount to physical distance. On the other hand, when a couple is truly together, a tool like CoupleVIBE needs to go into silent mode to allow proximal implicit communication to do its work.

Design for respect, not just privacy. In our couple scenarios, consideration of others played a bigger role than one's own privacy. Participants only used CoupleVIBE's privacy control as a courtesy, such as when their partner was likely sleeping, not to actually control privacy. Additionally, four participants expressed interest in being able to turn off the *receiving* of cues, such as during job interviews or when partners were together. In future designs, we would recommend including an "opt out" feature for incoming messages in addition to optional sharing. However, to support the inevitable conversations about the cues one was sent, mechanisms should be available to review suppressed cues.

Design to complement, not replace existing technologies. Harper and Hodge's observations about how a new communication modality ends up living besides old ones [14] suggests that a new modality should be designed to mesh with current ones rather than presume to replace them. By focusing on filling the existing gap in implicit communication for long-distance couples, CoupleVIBE did just that. For one, CoupleVIBE was easy to use, beneficial when already "juggling" other tools. Two, because CoupleVIBE was hosted on mobile phones, today's go-to communication device, it was a small step for couples to fashion a new practice of staying in sync – at no extra weight or cost. Recall that users often used CoupleVIBE messages to choose when (not) to call or text their partner: a CoupleVIBE vibration could cue a user to call their partner, while also confirming the phone's location. Conversely, when getting

out the phone to place a call, a glance at the CoupleVIBE screen could confirm the aptness of the timing.

Take advantage of context. We had anticipated that location would be a rich proxy for determining a partner's status. More surprisingly, context played a key role in disambiguating vibrotactile location messages. A user frequently combined an ambiguous cue, the time of day, and a general knowledge of her partner's habits to first disambiguate the cue into a location status, and then infer what her partner was doing. The take-away is that implicit communication cues need not be literal or complete to be useful, which allows for a larger design space in future applications. This is valuable, as taking advantage of context enables achieving more with less, as advocated in the previous lesson.

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