

Exploring the Behavioural Effects of Location-Aware Computing While Rendezvousing

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ABSTRACT

This paper presents an exploratory field study investigating the behavioral effects of mobile location-aware computing on rendezvousing. We introduce a study where participants took part in one of three mobile device conditions (a mobile phone, a location-aware handheld or both a mobile phone and a location-aware handheld) and completed three different rendezvousing scenarios. We discuss the difference in communication patterns focusing on phatic communication and socially established protocols for initiating a conversation. Secondly, we discuss the role of contextual and state information and how each influences rendezvousing behavior.

Author Keywords

Rendezvousing, location-aware computing, mobile devices, CSCW, verbal communication

ACM Classification Keywords

H.5.3 User/Machine Systems: Collaborative Computing.

INTRODUCTION

Mobile phones have transformed our social interactions and behaviours. They provide a rich verbal communication channel that enables us to exchange contextual information. However, some context, such as location, is difficult to accurately convey through dialogue. The exchange of locations, instructions and descriptions verbally between people can be ambiguous, misinterpreted, or misunderstood. Location-aware computing avoids these complications by providing visual cues and references.

The main goal of our research was to investigate how location-aware technology impacts rendezvousing behaviour (people coming together at an agreed upon time

and location). It is obvious that location information is beneficial for rendezvousing; however, it is unclear how this information will impact social behaviours. Location-awareness is fundamentally different than active verbal communication over a phone, and as such may significantly alter people's choices and actions while rendezvousing.

This paper presents a field study that explored how location-aware devices could be used to facilitate rendezvousing. Participants carried out three rendezvousing scenarios, mimicking typical real-life situations. They were part of one of three different device conditions: a mobile phone, a location-aware handheld or both a mobile phone and a location-aware handheld. Results of this work provide important insights into the subtle differences between mobile phone and location-aware device usage and how they impact users' behaviours.

We first present related work in the area of rendezvousing and discuss previous applications of location-aware systems. We then present the methodology for our field study including a description of our Wizard-of-Oz approach to providing location-awareness. The results of this work are presented in a narrative form with discussion of the observed rendezvous outcomes for each scenario. Finally, we reflect on these results and discuss how this information should inform future considerations for location-aware mobile devices.

RELATED LITERATURE

Rendezvousing

Rendezvousing is the social activity of people meeting at a predetermined location and time. Group behaviours related to rendezvousing have been explored extensively by Colbert [4, 5] through detailed diary studies. This work illustrates common rendezvousing behaviours and various challenges that frequently arise when two people attempt to rendezvous. A follow-up investigation of technology to support rendezvousing (mobile phones, text messaging, email, and voicemail) demonstrated that mobile phones are the current preferred method of communication [4]. Other work by Ito and Okabe [13] investigated how mobile communication can alter rendezvousing behaviour. For example, rather than agreeing on a landmark and specific

time to meet, mobile users can initially agree upon a general time and place and exchange several messages to further refine the rendezvous location and time, finally terminating in an eventual meeting [13].

Location-awareness

Location-aware mobile devices have been explored by a number of researchers for a variety of activities including gaming [1-3, 9], support for communication and collaboration among distributed groups [11, 17], and support for awareness and collaboration among proximal groups [12].

Location aware devices can provide absolute or relative information. The Hummingbird system [12] is an example of technology that provides users with relative location-awareness information about other devices. For example, when one Hummingbird comes within the vicinity of another, it “hums” indicating another Hummingbird is nearby. While beneficial in some situations, as shown in this work, relative location-awareness can sometimes be insufficient to allow people to find one another.

Several projects that have explored absolute location awareness include ActiveCampus [11] and Pousman’s location-aware event planner [17]. These systems provide their users with visual location-awareness of both themselves and other group members. In addition, the devices also provide an active communication channel (i.e. text messaging, voice).

ActiveCampus and Pousman’s location-aware event planner application has been field tested in situations that are reminiscent of rendezvousing. The combination of location-awareness and communication channels provides the ability to actively initiate a rendezvous with a partner (they describe an example of seeing a friend nearby and then suggesting they go for lunch) [11]. Although applicable to rendezvousing, the focus of this research was on the design [8] and iteration [11] of the technology.

Ambient Virtual co-presence and Hyper-Coordination

Introducing a new technology that is meant to support or augment a social activity is not without effect. The term *hyper-coordination* has been coined to refer to expressive use of mobile phones for emotional and social communication [15]. Hyper-coordination has arguably augmented our social interactions [13, 15]. Ambient virtual co-presence has been identified with mobile phone users sending text messages [13]. The ability to text message allows users to maintain a continuous awareness of the people they are messaging back and forth with [13].

Location-aware technology can provide users with hyper-coordination and ambient virtual co-presence similar to what is offered by mobile phones. Although not as socially rich and active, users can maintain constant awareness of others simply by viewing and communicating via their location-aware device.

THE RENDEZVOUS STUDY

We conducted a field experiment to explore how technology impacts rendezvous behaviour. Three different technology conditions were investigated: mobile phones; location-aware handheld computers; and both mobile phones and location-aware handheld computers.

Participants & Setting

Forty-eight participants (28 male and 20 female) took part in this study. All participants were from the Dalhousie University community and provided informed consent. Some of the participants signed up as pairs, and therefore had a previous relationship with their partner. Other participants signed up individually and were assigned a partner who, in most cases, was unknown to them.

The study took place in July 2004, within a four block radius encompassing the Spring Garden Road district in downtown Halifax, Canada. This area of the city is a busy shopping district with lots of shops, prominent landmarks, and pedestrian and vehicle traffic.

Mobile Phone

The mobile phone condition was intended to be the control group from which we could examine how location-aware technology on a handheld differed from previously identified rendezvousing behaviours (based on Colbert’s earlier work [4, 5]). In the mobile phone condition participants were provided with a mobile phone programmed with their partner’s mobile phone number. The participants were also given a laminated paper map of the area identical to the one provided on the handheld.

Location-Aware Handheld

In the location-aware handheld condition participants were provided with an HP iPAQ h4155 handheld computer. Each handheld ran custom location-awareness software that enabled participants to view a street map of the area annotated with the participants’ locations as well as the rendezvous location (see Figure 1). Each participant was represented by a coloured dot on the map. The blue dot represented the person looking at the handheld while the orange dot represented their partner. The map also showed most of the buildings in the area (without names). Approximately 1/6 of the map was visible at a time and participants panned the display to see the rest of the map.

The location-aware software also provided participants with the ability to request a rendezvous location. This involved selecting the rendezvous icon (an ‘X’) and moving it to the desired location. The participant would then select the ‘ask’ option from the rendezvous menu at the bottom of the screen. This would cause a message to pop up on their partner’s screen indicating that a rendezvous location had been requested. The partner could then view the suggested rendezvous location and respond by accepting, rejecting or ignoring the request (through the rendezvous menu). The rendezvous ‘X’ would remain red until both participants agreed on the location which would cause it to turn

green.



Figure 1. Interface for the location-aware device. Top participant dot (orange); bottom participant dot (blue); rendezvous 'X' (red).

Mobile Phone and Location-Aware Handheld Computer

In the mobile phone and location-aware handheld condition, participants were provided with both a mobile phone and an HP iPAQ h4155 running the custom location-aware software. The participants were told that they were free to use either device at any time during the study.

Wizard of Oz Approach to Location-Awareness

We initially envisioned our location-aware handheld computers being GPS-equipped and connected via a Wi-Fi/cellular network to automatically provide location-awareness information. Early on in our testing it became evident that using GPS technology to provide location-awareness information on the handhelds would be extremely challenging. The environment of the study, as well as the technology to which we had access, was not adequate to provide the location-awareness information at the level of granularity required. This is not an uncommon problem as other groups have had similar problems using GPS in a city environment [6]. Additionally, the Spring Garden Road district of Halifax does not have wide spread publicly accessible Wi-Fi hotspots. Given these limitations, we chose a Wizard of Oz approach to provide the illusion of GPS and Wi-Fi/cellular connectivity.

The wireless connectivity and location-awareness in our study was provided by two Wizards (a.k.a. undergraduate research assistants). The Wizards were equipped with Bluetooth enabled handheld-computers that also ran the custom location-aware software. Each Wizard was assigned one participant to track and walked a short distance behind that participant (see Figure 2). A Bluetooth connection was established between the participant's handheld computer and the corresponding Wizard's handheld computer. This provided the Wizards with the ability to update the participant's handheld indirectly. The two Wizards themselves were in constant contact via 2-way radios, communicating location information of the participant they were following, along with any rendezvous requests or acknowledgements. Although this approach may appear unreliable, it has been shown to be credible in previous research [1] and worked very effectively in our study.

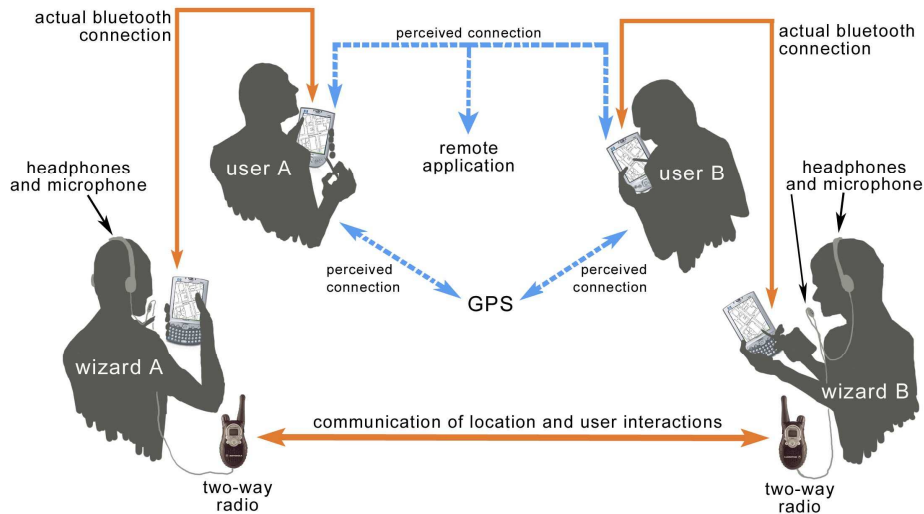


Figure 2. Wizard-of-Oz approach to providing location-awareness.

Procedure

At the beginning of each session the researchers met the participants in a small park located at the edge of the study area. Each participant was first asked to fill out a background questionnaire. Following this they were given an introduction to the technology they would be using in the study (a mobile phone, a location-aware handheld, or both). To ensure that the participants were familiar with the devices, they were asked to complete a practice rendezvous task which required one participant to request a rendezvous location across the street and the other to acknowledge the request. In the case where participants were using both the mobile phone and the location-aware handheld, they were instructed to use each device, but separately. After the rendezvous was agreed upon the participants were instructed to proceed to their rendezvous location where they would receive further instruction. Given that the area where our study took place was a high traffic area (both in terms of pedestrians and vehicles) participants were instructed not to run, and to obey all local traffic laws.

Once the trial rendezvous was complete, the participants were informed they would be taking part in three different scenarios where they must meet up with their partner after completing individual tasks. Two of the three scenarios would also have a time target in addition to a rendezvous location. The goal of all three scenarios was to successfully complete the rendezvous with their partner. For the scenarios with a time target, the participants were instructed that it was necessary to be on time as well as at the correct location for the rendezvous to count as a success. Participants were instructed that for each scenario, individual tasks would be given for the purpose of separating the participants before they could rendezvous. These tasks were assigned to the participants both verbally and on a task card that listed a business name and its civic address. Once the individual tasks were completed, the participants were required to negotiate a rendezvous location or meet up at a predefined rendezvous location.

After completion of all three scenarios the participants took part in a semi-structured interview with the researchers to gather additional information from the participants and discuss behaviours they exhibited in each scenario.

Rendezvous Scenarios

The scenarios used were based on three rendezvousing behaviours identified by Colbert [4, 5]:

- Participant-arranged rendezvous: Arranging a rendezvous while separated
- Change in plans: Negotiating a new rendezvous location when one partner is unresponsive and a previous rendezvous has already been negotiated
- Delayed: One partner is delayed while the other is waiting at the rendezvous location

The first behaviour was chosen because of its simplicity and applicability to everyday rendezvousing. The second

two behaviours were chosen because they are common behaviours that are generally more stressful and have greater variability in their outcomes. Colbert has identified stress and missed opportunity [5] as key rendezvousing outcomes. Although the tasks in our study were contrived, stress could still play a role in the rendezvous outcomes, particularly in the latter two scenarios. However, given that the participants were being compensated for their time and knew they were participating in a study, missed opportunities couldn't be accurately replicated or measured.

Based on these behaviours we constructed three rendezvous scenarios for use in our study.

Scenario 1: Let's meet here.

In this first scenario, participants were instructed that they would be given a task to complete after which they were to arrange a rendezvous location (either partner could initiate the rendezvous). After successfully negotiating the rendezvous they were instructed to proceed to the rendezvous location. The goal of this scenario was to see if two distributed people could easily arrange and carry out a rendezvous. We observed how the participants negotiated the rendezvous, how they made use of the technology provided (depending on the condition), and recorded any difficulties they encountered while completing the task.

Scenario 2: Why won't they respond?

In the second scenario, participants were asked to complete individual tasks and then rendezvous at a pre-determined location. After completing their individual task, one participant was told that the rendezvous location was changed and that they would need to notify their partner where the new rendezvous location was. The other partner was also made aware of the rendezvous location change, however, they were not able to communicate with or respond to their partner. If the cell phone was used, the call was automatically forwarded to voice mail. If the location-aware handheld was used, no acknowledgement was sent. The goal of this scenario was to observe what the requesting partner would do when their partner was unresponsive and a previous rendezvous had already been negotiated. We observed the behaviours of the requesting participant, how they made use of the technology provided, where they chose to go to meet their partner, and recorded any difficulties they encountered while completing the task.

Scenario 3: Why are they late?

In the final scenario, participants were again asked to complete an individual task and then rendezvous at a pre-determined location. After completing their individual task, one participant was told that they needed to complete an additional task before proceeding to the rendezvous location. The goal of this scenario was to force one partner to be late for the rendezvous and observe what the waiting partner would do. We observed the behaviours of both the waiting participant and the delayed participant, how they

made use of the technology provided (depending on the condition), whether or not the waiting participant chose to stay at the rendezvous location, and recorded any difficulties encountered.

Data Collection & Analysis

Data was collected via a number of methods; field notes, audio recordings, data logging on the handheld computers, questionnaires, and a semi-structured interview.

Field notes. Experimenters following the study participants made observation notes recording participants' actions and verbal comments. These notes were coded to provide a linear narrative of actions occurring during the rendezvous'.

Audio recording. Each participant was given a voice recorder to create a digital record of all comments and conversations. The recordings were transcribed and pertinent comments and conversations were added to the linear narrative of the rendezvous.

Data logging. All actions performed using the location-aware handhelds were recorded. The logging allowed for a more concise analysis of selected rendezvous locations and user interactions that were missed in field notes.

Questionnaires. A demographics questionnaire was administered to gather background information on participants. Following each rendezvous scenario a simple questionnaire was administered to determine users' perceptions pertaining to the rendezvous just completed.

Interviews. A post study interview was conducted to further probe the participants' rendezvousing experience. Questions were designed to identify participant's choices in given situations and how the available technology affected their actions.

Aggregation of all pertinent data from these sources enabled us to understand how participants proceeded with the rendezvous scenarios given their device condition.

RENDEZVOUS OUTCOMES

Despite the fact that participants' individual differences shaped their rendezvous behaviours, common patterns were evident. The rich behavioural data collected in this study provides important insights into people's rendezvous behaviour with cell phones and location-aware devices and provides an initial basis for comparison. This section will characterize the common trends observed for each rendezvous scenario in each of the three experimental conditions through narratives and associated discussion. All of the narratives represent real participant data collected during the study.

Scenario 1 – Let's meet here.

In this scenario participants were each given an individual task to perform and asked to arrange a rendezvous with their partner after they had completed their task.

Condition 1: Mobile Phones

Amanda and Jason each went off to perform their individual tasks. Amanda arrived first at her task location and picked up the mobile phone to call Jason.

A: "Hey, how are you doing?"

J: "Hello, how are you?"

A: "Good, good. Where are you?"

J: "I am at John Allan's Cigar Emporium."

A: "Alright."

J: "Where are you?"

A: "I am down at Clyde and Dresden."

J: "You're down at Clyde and Dresden?"

A: "Hair Design Centre."

J: "What are you beside?"

A: "Across from the liquor store."

J: "Ok, I can be there. Do you want me to meet you?"

A: "I can meet you at Shoppers. Is that better?"

J: "Shoppers is fine."

A: "Ok, I'll meet you at Shoppers then."

J: "Shoppers, I can be there. Wait for me there."

A: "Ok. Bye."

J: "Ok. Bye."

Amanda and Jason headed to Shoppers Drug Mart and rendezvoused successfully.

Although the actual words exchanged between individual pairs in our study differed, all of the conversations were similar to Amanda and Jason's, which we define as being phatic in nature. Phatic communication involves the exchange of "small talk" in order to establish a rapport with one another when initiating and ending a speaking relationship [14, 16]. Although phatic communication can be used to enrich a conversation and give it a more personal feel (i.e. "Hey, how are you doing?"), it relies heavily on clichés and superfluous conversation exchanges. This tends to lead to longer, more drawn out, conversations.

Before arranging the rendezvous location all pairs either explicitly asked their partner where they were located or offered their location without being prompted. This exchange of location information often led to further dialog to clarify the person's location. For example, here is an excerpt from Andrew and Tina's rendezvous conversation:

A: "Where are you?"

T: "I'm on Dresden and Clyde. Just behind the Shoppers on Spring Garden, which is the corner of ... Dresden and Spring Garden."

A: "What? So you are at the Shoppers?"

T: "No, I'm about half a block away."

In this instance Tina was attempting to explain her location using a landmark (the Shoppers Drug Mart on Spring Garden Road). Andrew however, misunderstood Tina's description of her location and thought she was at the Shoppers Drug Mart. This type of ambiguity was common between our participants and demonstrates the difficulty participants had articulating their physical location.

Although awareness of their partner's location appeared to be important for this scenario, only two of the groups actually used the paper map to visually reference their partner's location. This suggests that the remainder of the pairs either felt they had an adequate understanding of where their partner was located or they didn't actually care (and merely asked the question out of courtesy).

All groups appeared to choose a rendezvous location that was either a familiar place to both partners or a well established landmark close to the main road. The reliance on landmarks is not surprising and is consistent with previous literature that has shown that people typically use landmarks to navigate if they are new to an area [7, 10]. Additionally, research has shown that people are more able to recall and accurately relocate locations/landmarks if they are proximate to well known and important road intersections [7]. For the pairs in our study, once the location was agreed upon, they had no difficulty completing the rendezvous.

Condition 2: Location-Aware Handheld

Renee and Todd both arrived at their task locations at similar times. Todd decided to initiate the rendezvous with Renee. He looked at the handheld screen and noticed that Renee was just two blocks away on Dresden Row. Todd selected the top-left corner of the intersection of Spring Garden Rd. and Dresden Row for the rendezvous location. This point was midway between Renee's and Todd's locations. In the meantime, Renee looked at the screen on her handheld computer in preparation for requesting a rendezvous. A message appeared on Renee's screen indicating that Todd had suggested a rendezvous location. This looked fine to her so she acknowledged, accepting Todd's request.

All of the pairs, like Renee and Todd, relied heavily on the location-awareness information during the rendezvous negotiation process and all felt that they picked mutually beneficial locations for the rendezvous. The usefulness of the location information was explicitly noted by seven of the eight pairs during post-session interviews:

"It was useful to see where your partner was."

"It was nice to see she was here and I was there ... I just picked a middle point."

The one person who indicated that he didn't use the location information commented that he "just chose a location then looked to see where [his] partner's location was". He then remarked that he "probably should have done that first".

Only one pair selected a physical landmark on the map (a building midway on the main road) as the rendezvous location. The remaining pairs selected a street corner on the main street between the partners' locations (which was relatively equidistant to both). This suggests that the

participants felt comfortable using the icon representing the rendezvous location on the map as a point of reference (or 'virtual' landmark) to facilitate the navigation process. The results also suggest that this information was easily interpreted given that none of the pairs had any difficulty rendezvousing with their partner.

Condition 3: Mobile Phone and Location-Aware Handheld

Despite being given both devices, six of the eight pairs only used the location-aware handheld to negotiate the rendezvous. These pairs exhibited similar behaviours to those in the handheld only condition. One pair used only the mobile phone to negotiate the rendezvous. The final pair used both devices – the mobile phone to first negotiate the rendezvous followed by the handheld to confirm the location.

The pairs that chose to use the handheld computer commented that they felt it would be easier and more convenient. The pair that chose to use the mobile phone commented that they wanted to ensure an exact location was chosen. The pair that chose to use both devices used the mobile phone initially because they felt it would be easier to converse and wanted to check and see if their partner needed anything. They did not comment on why they felt it was necessary to re-confirm the rendezvous using the handheld. Regardless of the approach, all of the pairs easily met up at the rendezvous location.

Scenario 2 – Why won't they respond?

In this scenario the participants were told that the Fireside Restaurant had cancelled their reservation because they were overbooked, but a new reservation had been made at Deco. One of the partners was told that they needed to communicate this change to their partner. However, in all of the conditions, the partners never acknowledged that they received the information (although they did in fact receive the message).

Condition 1: Mobile Phone

Nathan picked up the mobile phone to call Robin and let her know about the change in plans. The call was not answered and was forwarded to a voice mail box. Nathan left a message for Robin:

N: "Hey. Fireside cancelled. We're going to have to go to Deco which is on the south side of Spring Garden, just beside Rockport. I will be hanging around out there. I will try to get a hold of you again. Cheers."

Nathan walked to Deco but continued to try to get a hold of Robin on the mobile phone (6 times). He didn't stop calling until he was close enough to Deco and could see Robin standing in front of the Restaurant.

All of the participants tried to initiate communication with their partner multiple times. Four of the pairs called 2-3 times while the remaining four pairs called continuously until they met up with their partner.

It was surprising to see that although one partner was instructed to inform the other of the location change, only half of the participants left voice messages for their partner. All of the participants proceeded to the new rendezvous location (Deco) rather than the original meeting place (Fireside). It is understandable why the participants who left a message proceeded to Deco: they had communicated their intent in a form they perceived would be accessible by their partner (voice mail). However, the participants who did not leave a voice mail message also chose to proceed to the new location, despite the fact that they had not received any confirmation from their partner. Only one of these groups exhibited any hesitation as to where to proceed. We speculate this may be attributed to the artificiality of the scenario. Given a researcher had told them to change their rendezvous location they may have felt compelled to go to the new location rather than proceed naturally.

All of the rendezvous excluding one was accomplished easily since both partners proceeded to Deco. One rendezvous was classified as difficult because the participant became increasingly agitated that his partner would not answer the mobile phone or return his messages. This was the same person who was also unsure of whether to proceed to the old or new rendezvous location.

Condition 2: Location-Aware Handhelds

Glen used the handheld to move the rendezvous point and suggest to Jill that they meet at the new location (Deco). Glen received no response from Jill so he continued to suggest the new location (using the handheld) as he walked toward Deco. He assumed that Jill would see the new location on the map and head there, even if she hadn't acknowledged his suggestion. Shortly thereafter, Glen saw Jill's location indicator moving towards Deco on the map, indicating to him that she received his message.

All of the pairs made use of the location-awareness information provided on the handhelds. This information allowed the communicative partner to observe his partner's movement and infer whether or not the request had been received. All the groups except for one chose to proceed to Deco after viewing their partner heading in that direction.

"I saw [my] partner's dot move towards the location, confirming that he was heading there."

The number of times the new rendezvous location was suggested varied between groups. Half of the groups made requests once or twice while the remaining groups made several attempts at confirming the new rendezvous location (six or more times). It appeared that most of the groups stopped suggesting the new location after they observed their partner heading to the new rendezvous location.

"I looked at where he was going and saw that he was heading towards the new rendezvous [location], so then I went there."

Given that the participants felt comfortable that their partner was heading to the new location, all of the pairs met up at Deco without any problem.

Condition 3: Mobile Phone and Location-Aware Handheld

Michael used the handheld computer to suggest the new rendezvous location to Bill. No response was received from Bill. Michael decided to call Bill on the phone. Bill didn't answer and the call was forwarded to voice mail. Michael left a message for Bill:

M: "Hi Bill. This is Michael. We are supposed to meet at 5518 Spring Garden Rd., Deco. So let me know. Bye."

Michael glanced at his handheld and noticed that Bill was now at Deco and walked there.

The participants in this condition were free to use the handheld computer, the mobile phone or both to arrange the new rendezvous location. Seven of the eight pairs chose to use both devices to arrange the new rendezvous location while the remaining pair used only the mobile phone. Just as Bill did above, six of the pairs initially used the location-aware handheld to suggest the new rendezvous location and then followed-up with the mobile phone when no acknowledgement was received. When no response was received from the phone call, several of the pairs switched back and forth between the handheld and mobile phone in an attempt to reach their partner.

"I tried the handheld, then the cell, then the handheld again, then the cell again. I then saw where her dot was and I went there." (Referring to Deco).

All of the groups used the location-awareness information provided by the handheld to their advantage when deciding how to proceed with the rendezvous and easily met up with their partner. Similar to the handheld only condition, all pairs chose to proceed to the new rendezvous location after observing their partner's location or movement. Even the pair that relied strictly on the mobile phone to arrange the new location used the location-awareness information on the handheld to monitor their partner's progress.

Scenario 3 – Why are they late?

In this scenario the participants were again sent on individual tasks and given a place to rendezvous. The pairs were also given a time target within which to complete the tasks. Once en-route, one of the participants was asked to complete a secondary task (count a bag of pennies at Curry Village) that would delay their arrival at the rendezvous point and make it difficult for them to arrive on time.

Condition 1: Mobile Phone

Laura arrived first at London Hair Design (the rendezvous location), one minute before the targeted time. Four minutes later when Vanessa still hadn't arrived, Laura took out her mobile phone and called Vanessa.

L: "Hello."
 V: "Hello."
 L: "Hi. Where are you?"
 V: "I am trying to find Curry Village. Brenton St. I can't find it. Where are you now?"
 L: "I am at South Park. London Hair Design. I'm waiting for you."
 V: "So you made it. Ok. I'll be there in about five minutes."
 L: "Ok. Goodbye."
 Laura continued to wait until Vanessa arrived three minutes later.

Like Laura, three participants chose to call and check in when their partner was late for the rendezvous. They all inquired where their partner was and why they were delayed. Two other participants chose to call their partner to let them know they were running late and wouldn't be able to make the rendezvous time.

"It's now 2:20 and I'll be a little bit late. I'm on my way to the location to meet you."

For the remaining three pairs, no calls were initiated by either partner. In the post-session interview with these pairs, two indicated that if the wait-time had been longer, they would have called their partner. A participant from the third pair indicated he would have called if he knew his partner was waiting at the rendezvous location.

None of the participants left the rendezvous location to find their partner. One participant continually looked down the street trying to see their partner approaching; however, they were looking down the wrong street. As a result, they were unaware of their partner approaching in the other direction.

Interestingly, in both cases where the participant called to inform their partner they would be late, it was not the partner that we intentionally delayed. These participants were running late because of navigational errors they committed. The participants who were delayed for reasons outside of their control (i.e. we asked them to count pennies) did not choose to call their partners to let them know they would be late.

Despite the delay in completing the rendezvous, all pairs were able to meet without any difficulty.

Condition 2: Location-Aware Handheld

Emma arrived first at the rendezvous location, on time. She checked her handheld computer to see where Natasha was. "Uh oh. Where is she going?" Emma looked up and down the street and frequently looked down at the handheld. Emma started making noises ("Whoa whoa whooooo") as Natasha appeared to be going the wrong way. Emma suggested a new rendezvous location on the corner of South Park St. and Brenton Place. She indicated that she wanted a quick rendezvous. She began to walk toward the new rendezvous location and saw Natasha approaching.

They met up and walked to the final rendezvous location together.

All participants who arrived first made use of the location-awareness information while waiting. Upon arrival at the rendezvous location, they immediately checked their handheld to determine the location of their partner. These participants continued to monitor the progress of their partner until they made visual contact. In four instances, like Emma in the narrative above, the person waiting at the rendezvous location chose to walk toward their partner's location. The remainder of the pairs waited at the rendezvous location for their partner to arrive.

Besides general concern over their partner being late, the location-awareness information did contribute to some uncertainty and confusion when the partner's location-indicator wasn't moving (while they were counting pennies). One participant explained that she was frustrated that her partner's location-indicator wasn't moving and she wanted to tell her to move up. Despite these concerns, all pairs easily rendezvoused with their partner.

Condition 3: Mobile Phone and Location-Aware Handheld

Jessie arrived first at the rendezvous location, right on time. She observed her partner getting closer on the handheld. The next time she looked at the handheld her partner's location-indicator was no longer moving. Jessie picked up the mobile phone and called Sandy.

J: "Hi. Are you still coming?"

S: "Hello. Hi. At some point. I have to count pennies first."

J: "Ohhh, ok. Have fun."

S: "Ok, I will."

J: "Call me if anything changes."

S: "Alright. Bye."

Jessie waited and shortly afterward Sandy arrived.

Again, all participants who arrived first utilized the location-awareness information and immediately checked their handheld computer to determine the location of their partner. Four pairs chose to additionally communicate with their partner with the mobile phone. In three cases the waiting participant placed a call to her partner to inquire where they were and why they were delayed. In the fourth case, the delayed participant used the mobile phone to call his partner to say he was running late and would arrive shortly. The remaining pairs simply monitored their partner's movements with the handheld and did not use the mobile phones to communicate with their partner.

None of the participants who were waiting left the rendezvous location to attempt to meet up with their partner sooner. In all cases, although over the target time, the rendezvous was completed easily.

DISCUSSION

Regardless of the technology provided to the participants, all of the pairs were able to complete the rendezvous tasks

without much difficulty. However, the results of this study clearly demonstrate that the participants exhibited very different behaviours depending on the technology used.

Differences in Communication Patterns

Mobile phones are a very familiar technology which most people are well accustomed to. Because of this, there are standard communication protocols that people use when communicating over phones. For example, it is well known in the literature that people engage in phatic communication when they want to establish a speaking relationship [16]. As such, arranging a rendezvous using a mobile phone naturally follows these social norms. In contrast, arranging a rendezvous with our location-aware handheld computers (which only provided location information) was not constrained by these conventions and people's behaviours were consequently different. For example, participants in our study who communicated solely with a mobile phone typically had longer information exchanges because of the necessity of phatic communication. When using just the handheld computer, these information exchanges were much faster, and streamlined. This was amplified by the fact that it was often difficult to exchange location information in the mobile phone condition. For example:

Roger needed to place a second call to David for additional information on the rendezvous location:

R: Hello

D: Hello Roger.

R: Hey David. Spring Garden Rd. and Barrington Street?

D: Yeah. Birmingham, not Barrington.

R: Oh, Birmingham Street.

D: Where are you right now Roger?

R: Where am I? I am at the Hair Design Centre.

D: Ok. Where is that?

R: It's on Dresden Row.

D: Ok. Come one street over. That's Birmingham.

R: Right. Ok. Bye.

Social norms also influenced how comfortable people were making inquiries as to their partner's status. For example, in the mobile phone condition, when one partner was late for the rendezvous, the other partner always waited before calling to inquire about their state. In contrast, in the conditions involving the location-aware handhelds, upon arriving at the rendezvous location, if the person's partner was not at the location, they immediately used the device to view their partner's location. In addition, using the handheld device, the participants frequently (or constantly) monitored their partner's location. It would typically be considered rude to continue calling someone on a mobile phone to maintain a similar state of awareness. It is interesting to note that there can be a large variance in the length of time people feel is appropriate to wait before engaging in a call (or a follow-up call). This individuality was clearly observed in our study.

The location-aware handheld devices were frequently used as a background communication channel in our study. People could easily monitor their partner's location (as well as their own) without interrupting their partner. As such, when people had access to both the location-aware handheld and a mobile phone, they tended to use the handheld first to gather all relevant information and then follow-up with the mobile phone if needed. For example, when participants were confused about their partner's movements via the handheld, they called their partner to gain additional information (in the mobile phone and location-aware handheld condition).

Location-Awareness Doesn't Tell Us Everything

The results from our study clearly demonstrate that mobile phones and location-aware devices have different roles in rendezvousing behaviour. Mobile phones are an easy medium to assist people in communicating information about actions and intentions (i.e. 'what are you are doing?' or 'where are you planning to go?'). This information can be difficult to gather from sensor-based devices such as location-aware handhelds. In contrast, sensor-based devices are very good at gathering overt contextual information, such as location, in a very unobtrusive manner. However, they provide little assistance in interpreting the associated state of the person. In our study, when participants were given both devices, they easily recognized the strengths of each device and utilized each appropriately (i.e. monitoring their partner's location with the handheld and using the mobile phone to call when they were confused about what the person was doing).

The amount and type of information available to people can additionally influence their rendezvousing behaviour. This was evident from our observations of the third scenario (for all three conditions). In the mobile phone condition, when one partner was waiting for the other, none chose to leave the rendezvous location in an attempt to meet their partner. This is not surprising given that without location information they may not have known where their partner was. Even if they used the mobile phone to determine their partner's location, it would still have been difficult to infer the direction they would proceed in and subsequently be able to intercept them.

In the location-aware handheld condition, half of the participants chose to leave the rendezvous location to attempt to meet their partner. Being aware of their partner's location allowed them to easily find (and intercept) their partner. However, in the final condition when the participants had access to both a mobile phone and a location-aware handheld, none of the participants chose to leave. This suggests that the reason the participants left the rendezvous location in the location-aware handheld condition was more a result of missing contextual information (gained using the mobile phone) rather than the ease with which they could meet up with their partner.

In the location-aware handheld condition, the participants who chose to leave the rendezvous location seemed confused about their partner's actions or believed that they were lost. In contrast, in the *mobile phone and location-aware handheld* condition, the participants used the mobile phone to call their partner and gather this information. This potentially gave them a better understanding of how their partner was proceeding, allowing them to make a more informed decision as to how the rendezvous was progressing. In our study, all of the delayed partners indicated that they would be at the rendezvous location shortly so none of the participants waiting at the rendezvous location seemed to feel compelled to leave.

Before running this study, we felt that location-awareness information would always be beneficial to people attempting to rendezvous. In our third scenario, we observed instances where location-awareness information was extremely beneficial and other instances where it was detrimental. It was beneficial because participants could see their partner's location and track their progress in an unobtrusive manner. This arguably provided the waiting partner with enough information to wait contently. However, when their partner appeared to be lost or not making progress, it was very disconcerting to the waiting partner because they didn't have enough information to determine what the problem was. This uncertainty was strong enough in some cases to actually draw the waiting partner away from the rendezvous location.

CONCLUSION

The observations gathered in our study clearly demonstrate that the type of technology provided to people significantly impacts their rendezvous behaviour. One of the most compelling observations from our study was how communication patterns differed depending on the devices used by the participants. Mobile phones, although a rich method of communication, require people to use social protocols when initiating conversation; this unnecessarily lengthens and complicates the exchange of contextual information. Location-aware technology can avoid the social protocols by focusing on visual contextual exchange.

For rendezvousing behaviour, both state and context are essential pieces of information. However, location-based devices and mobile phones represent opposite ends of the spectrum. It is important to investigate additional approaches to gain contextual and state information in location-aware computing.

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