Pressages: Augmenting Phone Calls With Non-Verbal Messages

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ABSTRACT

ForcePhone is a mobile synchronous haptic communication system. During phone calls, users can squeeze the side of the device and the pressure level is mapped to vibrations on the recipient's device. The pressure/vibrotactile messages supported by ForcePhone are called *pressages*. Using a lab-based study and a small field study, this paper addresses the following questions: how can haptic interpersonal communication be integrated into a standard mobile device? What is the most appropriate feedback design for pressages? What types of non-verbal cues can be represented by pressages? Do users make use of pressages during their conversations? The results of this research indicate that such a system has value as a communication channel in real-world settings with users expressing greetings, presence and emotions through pressages.

Author Keywords

Pressure input; haptic feedback; mobile interpersonal communication; squeeze interaction.

ACM Classification Keywords

H.5.2 [Information Interfaces and Presentation]: User Interfaces – Input devices and strategies, Interaction styles Haptic I/O.

INTRODUCTION

Enhancing interpersonal communication is an increasingly important consideration in mobile interaction research as more and more of our everyday communication is conducted remotely via instant messaging, email and phone calls as opposed to face-to-face. Traditional methods of face-to-face communication rely heavily on the sense of touch [1]. In face-to-face interaction, touch is often used to express diverse, private and subtle nonverbal cues [2]. For example, handshakes, holding and squeezing hands, kissing, or pats on the back are all common in everyday communication.

Communication technologies such as mobile devices currently allow people to stay in contact with each other via speech, text and video. Although there have been many developments in this field, these devices make use of touch far less than audio and visual feedback thus perhaps reducing the sense of a physical connection between callers and restricting interaction. Furthermore, mobile users can be in a variety of different situations and contexts during phone calls making certain conversation topics inappropriate at times where tactile communication could still be effective.

Previous research has suggested that using haptic input and output is a good communication channel when used between two people [3]. These techniques, until now, have not been implemented on mobile devices or used during live phone calls. Therefore, this paper focuses on the integration of a haptic interpersonal communication system with a mobile device to establish whether such a system has value as a communication channel in real-world settings.

The prototype developed in this research, ForcePhone, is an augmented, commercially available mobile device with pressure input and vibrotactile output. During phone calls, users can squeeze the side of the device and the pressure level is mapped to vibrations on the receiving phone. The pressure/vibrotactile messages supported by ForcePhone are called *pressages*. This paper discusses the iterative design of ForcePhone from an input, output and field study perspective. Throughout the research, we were interested in answering the following questions: how can haptic interpersonal communication be integrated into a standard mobile device? What is the most appropriate feedback design for pressages? What types of non-verbal cues can be represented by pressages? Lastly, and perhaps most importantly, we wanted to investigate whether users make use of pressages during their normal phone conversations and whether this usage remains constant over time.

RELATED WORK

Multimodal feedback is often used to reduce the visual load on mobile device users. There has been a large body of research into mobile interaction with results of experiments using tactile feedback [4] [5] showing that high recognition rates can be achieved with a small amount of training.

Recent research has investigated pressure as an input technique on mobile touchscreen devices [6]. The results have shown that users can distinguish and apply up to ten

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pressure levels with high accuracy when navigating through a standard menu. Another interesting use of pressure can be seen in haptic conviction widgets [7]. The widgets allow users to map conviction to force e.g. emptying the trashcan requires a large amount of pressure. This paper takes the area a step further by examining squeezing as an interpersonal communication technique for mobile devices. We use squeezing in many everyday activities, for example squeezing a loved one's hand.

Interpersonal Communication

There has been a variety of previous research into using alternative modalities in interpersonal communication devices [3] [8 - 11]. Hemmert *et al.* [12] designed a prototype device using tightness actuation with the idea that users can squeeze their device to communicate through hand grasp. The receiving device includes a widening loop positioned around the user's hand that can be extended and contracted. However, this device does not provide any local feedback to the user who squeezes the device and there were no field studies conducted.

Chang *et al.* [3] developed ComTouch, a device that augments remote voice communication. More specifically, the device converts hand pressure into vibration intensity with a single actuator. A study was conducted where pairs of friends took part in a general chatting task and desert survival problem. There were no pre-defined cues and the devices were bi-directional, meaning that users could send and receive signals simultaneously. The results of the study showed that users developed an encoding system like Morse code as well as emphasis, turn-taking and mimicry.

The outcomes of Chang's research are promising but a mobile 'real-world' version of this system was never built, which could allow researchers to investigate this extra channel of communication further. The development of a truly mobile haptic interpersonal communication system is not trivial; there are data transfer, power and feedback issues to consider. In terms of feedback, ComTouch uses a different spatial location to present local feedback to indicate the magnitude of the pressure level. Using spatial location as a design parameter requires the use of multiple vibrotactile actuators. Current mobile devices do not have multiple vibration sources and adding these features leads to an increase in size and energy consumption.

The prototype described in this paper takes a more ecological approach by integrating a haptic interpersonal communication system into a standard smartphone without any external attachments.

Shake2Talk [10] allows users to construct audio-tactile messages through simple gesture interactions, and send these messages to other people. The system was designed to send messages such as "home safely", represented by the sound and sensation of a key turning in a lock and "thinking of you" represented by a heartbeat. Each couple used the Shake2Talk phones for two weeks. Results show the pre-defined messages were used for: coordination of events, awareness and reassurance, playfulness and social touch.

Unlike Shake2Talk, the research described in this paper does not make use of pre-defined cues and synchronises the pressages with a speech conversation. This allowed us to investigate the effects of adding an additional communication channel to a voice call and to establish what types of information can be encoded in the tactile modality when users are allowed to assign their own meanings.

The aim of this research is to extend the boundaries of traditional phone calls by adding an additional channel of communication. Building on the existing research, the prototype development process and studies described here examine the use of pressure input and vibrotactile output over time during standard phone calls.

HARDWARE

The ForcePhone prototype (Figure 1) has been developed by augmenting a Nokia N900[1] with a force-sensing resistor (FSR). The tactile stimuli were presented through the standard rotational motor found within the N900.

Figure 1: The outward appearance of ForcePhone covered with a silicone case and the embedded FSR.

The implementation of the pressure sensor is based on the design proposed by Stewart *et al*. [13] and supported by the datasheet of the FSR manufacturer[2]. As shown in Figure 1, the FSR is attached to the side of the phone using double-sided tape. A 0.5mm wire is then used to connect the FSR to the main sensor board located inside the microSD card slot (visible in Figure 3). The microcontroller communicates with the phone using standard serial communication. This approach is valid for many phone models that include serial ports for debugging purposes.

The op-amp based circuit linearises the sensor output such that changes in the amount of force applied result in a similar change in output voltage across the range of pressure used (Figure 2). The output voltage from the FSR is then sampled by an 8-bit microcontroller (Atmel attiny13) at 30 Hz, and the resulting data is sent to the host system by a hardware-based serial port.

1 http://europe.nokia.com/find-products/devices/nokia-n900

2 http://www.sparkfun.com/datasheets/Sensors/Pressure/fsrguide.pdf

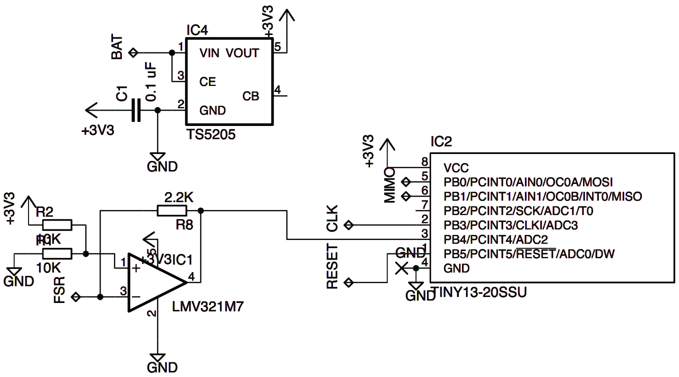

Figure 2: Schematic Diagram

One of our goals was to allow users to explore pressages without any cumbersome additional external hardware. We believe that this approach allows the user experience and subsequent feedback to more accurately reflect the interaction method, rather than the physical implementation. After several iterations, the resulting design can fit within the Micro Secure Digital (microSD) card slot (15mm by 11mm) of the Nokia N900 and has a component cost of less than US $30 (Figure 3).

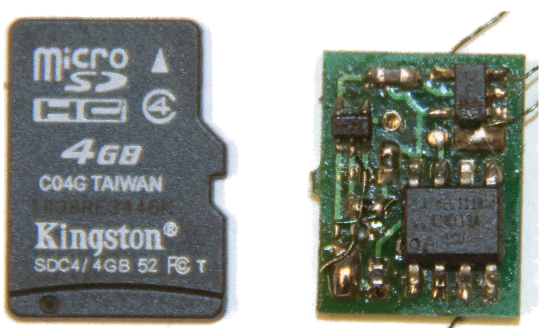

Figure 3: Completed board compared with microSD card.

PROTOTYPE DESIGN CONSIDERATIONS

The most important aspects of the prototype were centred around the touch communication design variables (as outlined by Chang *et al.* [3]): data direction, data transfer, and data content. Alongside these variables, a variety of additional issues emerged during the design stages of this research such as local and remote feedback, interaction loops and input mechanisms. Our approach to each of these variables and issues is detailed next.

Data Direction and Transfer

ForcePhone allows bi-directional transmission of data. Each user has the ability to send and receive pressages.

One of the main achievements in the development of the ForcePhone hardware and software was the synchronous data transfer feature. As far as the authors are aware, this is the first research in augmented interpersonal communication to allow real time synchronous communication via phone conversations and pressure/vibration messages on a commercially available mobile device. This feature was created using the Extensible Messaging and Presence Protocol (XMPP) so that, when the device receives a call, our program launches a Jabber client to allow information, sent as text, about pressages to be transmitted between phones. Each pressage is represented by a single number (0-3).

Data Content

In contrast to the recommendations by Chang *et al.* [3], the data content in ForcePhone is not continuous. If it was possible for users to continuously send their pressure input levels as vibration messages to the other user, it may be difficult for users to shift their attention between the two competing modalities. It has been found that our auditory sense tends to dominate over the tactile sense in certain tasks [14]. Therefore, the discrete data content is transmitted to the receiver whenever the user explicitly squeezes the phone. The threshold of pressure at which this explicit level occurred was determined to be 0.6N through testing detailed in Stewart *et al.* [15].

Local Feedback for Pressure Input

ForcePhone uses an asymmetric modality mapping where the input modality is translated into the output modality (in our case, pressure to vibrations). A key consideration when designing an interpersonal communication device is the use of local and remote feedback. In terms of our prototype, the remote feedback is the vibration presented on the recipient's phone and local feedback is presented to the sender as a result of their pressure input.

Even though our body provides us with natural feedback about the amount of pressure we apply to something through our muscles and our sense of touch in general, it has been shown that additional feedback can improve our ability to achieve specific target forces [16].

When considering the feedback modality, the combination of pressure input and vibrotactile output seems logical given that both types of stimuli are part of the haptic sense. Rekimoto *et al.* [17] implemented a 3 level pressure-based button ("not pressed", "light pressed", and "hard pressed") and provided vibrotactile feedback for each level. However, there were no user studies conducted to assess the effectiveness of the tactile feedback. Building on this related work, the following section presents an experiment investigating tactile feedback for pressure input.

Pressure Input

The range of pressure, or applied force, our hardware design can measure is approximately 0 – 6 Newton (measured in a similar approach by [13] [6]). The pressure range is separated into 4 discrete levels.

The prototype hardware used in this research allowed users to input pressure using the quick release method. This method has the benefit of allowing much faster selection times than the dwell technique used in [6]. The quick release selection method is performed by applying pressure until the target pressure level is reached and quickly removing the finger to confirm the selection.

Stimuli

Our interaction design requires discrete feedback when the user moves into a new pressure level. Stewart *et al.* [13] explored the use of vibrotactile feedback, providing different feedback for each level. Our design is simpler, with a short burst (50ms) from the N900's built-in vibration motor when moving positively from one pressure level to the next. The duration of the pulse was constrained by two issues: the vibration had to be noticeable, and enable the detection of multiple pulses executed in rapid succession.

The visual feedback design (Figure 4) was based on half of a clock face, with 4 equal segments. The first pressure level was represented by a segment between 12 and 2 o'clock, with the last level, between 4 and 6 o'clock.

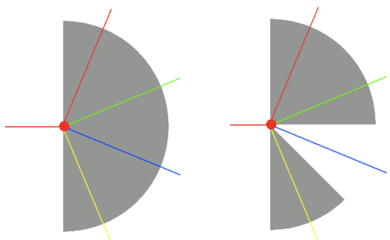

Figure 4: Experimental interface screenshot showing the selection of pressure level 3.

Delayed Interaction Loop

Our basic interaction loop implemented a naive approach without any artificial delay between the presentation of feedback for two consecutive pressure level transitions. This allowed the vibrotactile feedback to 'blur' together and individual pulses may become indistinguishable. Without being able to detect the individual pulses, users may experience difficulty in selecting the correct pressure level. Thus, a second condition, the delayed interaction loop, introduced a 100ms gap between transitions.

Methodology

We designed an experiment to investigate the effects of tactile feedback for pressure input. The experiment compared user performance with visual feedback, visual and vibrotactile feedback, and vibrotactile feedback alone whilst using a basic and delayed interaction loop. The experiment hypotheses were as follows: 1) participants will be able to reach pressure levels with the least errors and greatest speed when using combined visual and vibrotactile feedback; 2) the delayed interaction loop will lead to greater accuracy and speed for all modalities.

We used a within-subjects design with two conditions: basic interaction loop and delayed interaction loop. There were also three sub-conditions for each modality within each of the interaction loops. All conditions were counterbalanced and tested in a static lab environment.

Participants

Twelve participants took part in the experiment. All participants were aged between 18 and 34. There were 6 female and 6 male participants. 1 participant was left-handed. All participants were seated during the experiment and asked to hold the device in their non-dominant hand.

Task

A number, representing the target pressure level, appeared on the visual display and would disappear when participants applied pressure (see Figure 4). Once the level was reached, participants lifted their thumb from the sensor to register the input. The pressure level selected would then be shown, coloured green if the target level was correctly selected, or red if not. For each condition, participants received training with each target being presented 5 times consecutively.

Results - Accuracy

The average error rate (missed targets) for each modality and interaction loop is shown in Figure 5.

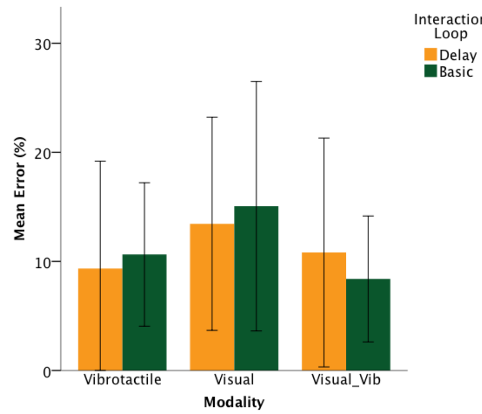

Figure 5: Average error rate for each modality and interaction loop (error bars = SD).

A repeated measures two-factor ANOVA was performed on the mean number of correct pressure levels, comparing the effects of the interaction loop (basic and delay) and feedback modality (Visual, Vibrotactile and Visual/Vibrotactile). A significant main effect for modality was found ($F(2,40) = 4.84$, $p<0.0001$). Tukey tests showed that there were significantly more errors when using visual feedback compared to vibrotactile and combined vibrotactile/visual feedback ($p=0.05$). There was no main effect for the interaction loops and no interaction between the loops and modalities. A further repeated measures two-factor ANOVA for each pressure level, comparing the effects of the interaction loop and modality showed no significant differences in the data.

Results - Speed

Figure 6 shows the average time taken to reach each pressure level for all modalities and interaction loops. A repeated measures two-factor ANOVA on the movement time for each modality and interaction loop showed a significant main effect for modality ($F(2,40)=16.05$, $p<0.0001$). Tukey HSD tests showed that the movement time when using combined visual and vibrotactile feedback was significantly lower than the visual and the vibrotactile version ($p=0.0001$). The vibrotactile version was also significantly faster than the visual version ($p=0.05$). There was no significant main effect for the interaction loops and no interaction between factors.

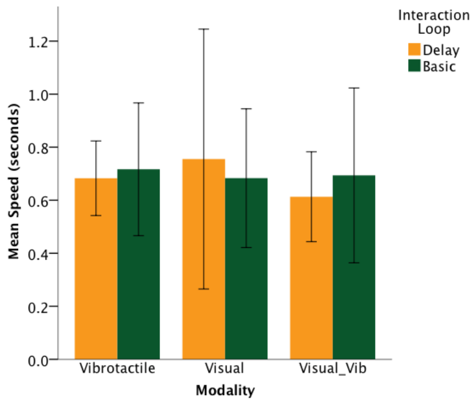

Figure 6: Average movement time for each modality and interaction loop (error bars = SD).

Further analysis of each pressure level showed a significant difference between levels for all modalities and interaction loops ($F(3,30) = 34.87$, $p<0.0001$). Tukey HSD tests showed that pressure level 1 (1.4N) was significantly faster to achieve than the others ($p<0.001$). The analysis also showed that pressure level 2 (2.5N) was significantly faster to achieve than levels 3 (4.7N) and 4 (5.8N) ($p<0.0001$). There were no significant differences between levels 3 and 4. This shows that the lighter pressure levels are quicker to reach. That being said, all of the movement times were reasonably quick (ranging from 0.16 to 1.08 seconds in the basic interaction loop and 0.17 to 1.4 seconds in the delayed interaction loop).

Discussion

Hypothesis 1 can be partially supported because the combined visual and vibrotactile version produced the fastest task times. However, as opposed to our hypothesis, the vibrotactile version of the system produced higher accuracy levels than combined visual and vibrotactile feedback. This may be due to the fact that the vibrotactile feedback allows for completely eyes-free interaction. Furthermore, the coupling of pressure input and vibrotactile feedback may be more direct and simple for users because they are both forms of the same modality. Future studies will investigate this further.

Hypothesis 2 cannot be supported. The delayed interaction loop produced high accuracy scores and low task completion times but there were no significant differences when compared to the basic interaction loop.

Given the results of this study, we chose to incorporate the vibrotactile version of pressure feedback with a delayed interaction loop into ForcePhone.

Remote Feedback for Pressure Input

The local feedback study showed that mapping pressure to vibrotactile stimuli is an effective interaction mechanism. Therefore, the vibrotactile modality was also used for remote feedback. Whenever a user squeezed the phone, a vibration was sent to the recipient's phone.

The choice of feedback for pressages did not follow the traditional guidelines for tactile information transmission. For example, the existing literature on tactons, [18] states that the most effective design parameter is rhythm, followed by spatial location and roughness. However, rhythm is not an appropriate parameter for use during speech conversations, as the durations tend to be a minimum of 500ms. This could distract users from the content of the speech conversation. It was not possible to use spatial location as the N900 only contains one vibrotactile actuator and the use of multiple actuators significantly increases the amount of power used. Lastly, the roughness parameter involves extremely harsh vibrations. Given that pressages are sent during calls when the device is placed beside the user's ear, a very rough vibration is likely to feel particularly unpleasant. Instead, we chose a similar but gentler parameter: texture. Despite the narrow design space, we took inspiration from "The rules of beeping" [19], where useful communication can occur using simple stimuli. The pressure levels were mapped to the vibrotactile textures shown in Figure 7.

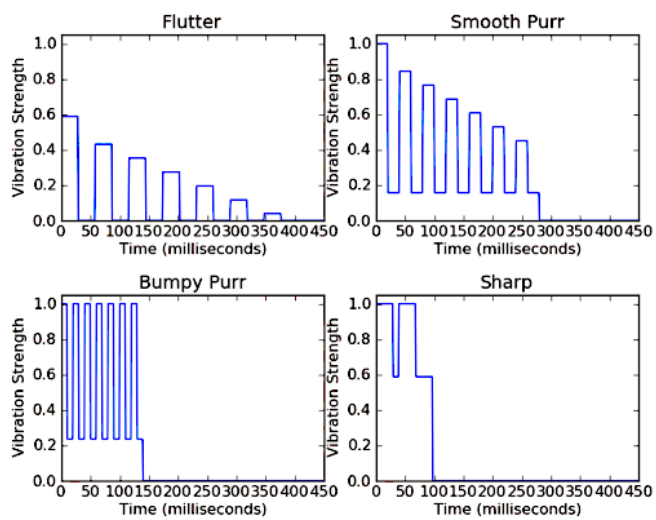

Figure 7: The vibration strengths (max strength = 1) and durations used to create each texture[3].

Based on all of these design considerations and the results of our preliminary experiment, the final version of ForcePhone incorporated bi-directional real-time data transfer, an asymmetric modality mapping (pressure to tactile), discrete data content, vibrotactile discrete local feedback with a delayed interaction loop and textured vibrotactile remote feedback to represent the pressages.

3 The vibration strength is controlled by an 8 bit number, 0 = off and 255 = full power. Pressure level 1 (1.4N) = flutter, level 2 (2.5N) = smooth purring, level 3 (4.7N) = bumpy purring, and level 4 (5.8N) = sharp pulsing.

LONGITUDINAL EVALUATION

A small longitudinal study was conducted to test ForcePhone. Although there are numerous potential use cases for the prototype devices, we decided to conduct our initial study with three couples in long-distance relationships. An introductory session was conducted in the laboratory for one hour before the participants took the devices home and completed the month long study.

The six participants in the study ranged from 24 to 32 years old, three male and three female. Each couple had been in a long-distance relationship for more than six months. The participants stated that they tend to communicate with each other through phone calls, SMS and emails on a daily basis.

Overall the longitudinal study lasted for one month. For the first week, the participants simply used the device for normal phone calls and completed a short questionnaire. This allowed us to log their normal communication behavior without any haptic additions as a baseline. After the first week, participants were asked to use the prototype device instead of their usual phones to call each other. They were informed that they could make as many calls on the prototype device as they liked throughout the study.

We did not define the meaning of the pressages so we conducted this study to answer the following research questions: what types of non-verbal cues can pressure be used to represent and also, does the combination of pressure input and tactile output provide an emotional communication channel? It may be the case that users send the pressages to indicate emotions or to mimic affectionate gestures such as hand squeezes. Then again, the pressages may also be used in a more negative manner to represent nudges or kicks or used simply to surprise the receiver.

ForcePhone logged the duration of all phone calls, the number of pressages sent and received, and the level of pressure used. We did not record any content from the conversations due to privacy concerns raised by the participants. After each phone call, the participants were asked to complete an online questionnaire and at the end of the study, the participants took part in a post-study interview on their experiences with the device.

Results

On average, the participants' phone calls lasted 4 minutes and 43 seconds with an average of 15.56 pressages sent during each call. All phone calls involved the use of pressages. Although the average number of sent pressages reduced from 14.3 to 10.6 by the end of the study, this was not a significant difference ($p > 0.05$). A log of one of the phone calls between participants is shown in Figure 8.

The mean time between received pressages was 5.8 seconds and 7.5 seconds for sent pressages. This indicates that when pressages are used, they are exchanged in rapid succession but as the log in Figure 8 shows, there can be long gaps during the call in which pressages are rarely sent. It would appear as though the participants exchanged pressages frequently at the start and end of calls but focused on the voice content in the middle.

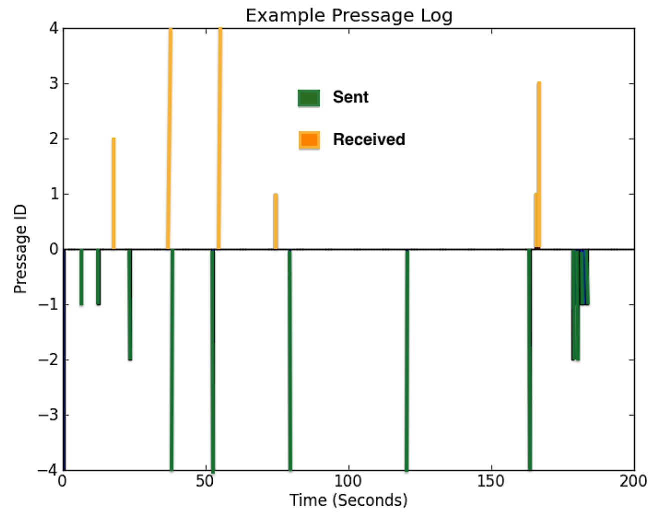

Figure 8: Sent and received pressages during a phone call between participants.

The lower half of the graph shows sent pressages and the upper half shows received pressages. Although the log shows that the participant sent a lot more pressages than he/she received, a small amount of turn-taking can be seen. Furthermore, it appears as though, if a level 4 pressage is sent, then a level 4 pressage is received i.e. the participants attempted to match each other's pressure levels.

Interviews and Questionnaires

After each call, the participants completed an 18-item rapport questionnaire (from [20]). The questionnaire responses show an increase of 5% in ratings for 'involving' and an increase of 3% in 'active' and 'positive' between week 1 with no pressages and weeks 2 – 4 with pressages.

The most interesting results came from the insights of the participants discovered in the post-study interview. The participants explained the ways in which they adapted to the extra channel of communication. All of the participants agreed that it was easy to incorporate pressages into their phone calls and that they "got used to the pressages really quickly". When asked about the specific ways in which they adapted their communication style to accommodate the tactile modality, all of the participants stated that they tended to pause briefly after sending a pressage to "make space for it in the conversation".

When asked about the non-verbal cues that could be represented by pressages, the participants highlighted three different approaches: to emphasise speech, express affection and presence, and to playfully surprise each other.

In the words of one of the participants, pressages help to "express yourself a little bit more". Pressages were found to be useful "especially in noisy situations" and to add emphasis to speech, particularly in terms of greetings: "I would send a pressage whenever I said hi".

In terms of expressing affection, the pressages were used as a mechanism to add an extra emotional element to the conversation. The participants mentioned that they found the pressages reassuring as they gave "a feeling of presence" and "they helped me to show that I was there, I was listening". In terms of positive emotions, the participants likened the pressage to stroking their partner. In one of the phone conversations, a participant received some good news and she said, "something nice happened to me and suddenly there's vibration and it was like he was stroking my arm". The pressages were also used occasionally to express anger. However, the participants found that sending a very strong vibration to their partner to indicate their anger made the receiver angry too.

Lastly, the participants reported that they often used the pressages in a playful manner and to catch attention. In many cases, the participants would send a random pressage just to play with the system and make each other laugh. One of the participants used ForcePhone to communicate privately with his girlfriend in public settings by using the pressages as "a secret message to make her laugh".

DISCUSSION

As far as the authors are aware, this is the first research prototype developed to transmit pressure and tactile data during calls. Despite the small size of our long-term user evaluation, the interview and data logs yielded a great deal of information. Throughout the development of ForcePhone, we were interested in exploring four areas: the technical issues encountered when integrating haptic interpersonal communication into a mobile device, the most appropriate feedback design for pressages, the types of non-verbal cues that can be represented by pressages, and pressage usage over time.

Integrating Haptic Communication With a Mobile Device

ForcePhone is a haptically augmented mobile device that allows pressure and vibrotactile data to be transmitted during phone calls. ForcePhone makes use of the built-in vibration motor and pressure sensors with a board that is small enough to be placed within the microSD card slot of a mobile device. Pressages are created using XMPP so that, when the device receives a call, a Jabber client is launched to allow information about pressages to be transmitted between phones. The robustness of the prototype was demonstrated by the fact that the participants successfully used ForcePhone as their personal mobile device for one month.

In the future we intend to investigate several technical enhancements for ForcePhone and pressages. Firstly, it may be possible to send pressages through Dual-Tone Multi-Frequency signaling (DTMF). This would make it very easy to synchronise the speech and pressages, and would allow users to send pressages when offline. However, using DTMF means that an audio beep will be sent to the receiver's phone alongside the pressage. Further studies will examine the effects of this modality combination.

All of the participants in the long-term study expressed an interest in the use of stand-alone pressages. The participants suggested that the pressage functionality should not only be used to augment phone calls but as a completely separate form of communication. The participants said that, in a meeting or in some other situation where it is not appropriate to talk on the phone or spend time typing a message, the pressages could be used to send information discretely. Short messages like 'I'm coming home' could be sent without calling or typing. Future versions of ForcePhone will include this functionality.

Pressage Feedback Design

In terms of pressage feedback, our lab-based study showed that discrete vibrotactile feedback for pressure input is as effective as visual feedback. The current version of the prototype uses a rotating vibrotactile actuator that shakes the whole device. This can lead to a reasonably strong sensation on the user's cheek and hand. This may be part of the reason why angry emotions were amplified when receiving a strong vibration. Additional vibrotactile design parameters or categories of haptic feedback could be included to allow users to choose their own feedback modality depending on the reaction they wish to generate, for example, localized vibrotactile feedback provided by piezo-electric actuators or thermal feedback.

Non-Verbal Cues Encoded in Pressages

Each set of participants used pressages to represent different types of information. Firstly, some of the messages were used as a greeting at the beginning of the conversation, then to get the attention of the person if they had been speaking for too long or if they had been silent for too long and sometimes just to surprise each other in a playful manner. Interestingly, the occasional use of a pressage during a phone call increased the users' sense of presence. Pressages were also used to emphasise speech or to express both positive and negative emotions. Larger long-term studies will help to establish the most common meanings attached to the pressages.

ForcePhone allows users to input four pressure levels and these are mapped to four vibrotactile textures on the recipient's phone. During the design stages, it was assumed that users would assign different meanings to the different pressure levels e.g. high pressure/rough vibration for important messages, low pressure/smooth vibration for short or non-urgent messages. However, according to the participants, this was not always the case. The participants did not map specific types of message to each pressure level. Nevertheless, the participants did vary their pressure levels when emphasizing their speech or conveying emotions. Furthermore, the logs show that participants attempted to match their pressure levels when sending the pressages. Similar to the findings by Chang *et al.* [3] , this suggests a form of mimicry in pressage communication. Future longer-term studies will investigate these issues further.

Usage Over Time

Conducting a longitudinal field study allowed us to examine the use of pressages over time to ensure that our findings were not dependent on any novelty effect. The usage logs show that the number of pressages sent and received throughout the study remained consistent. At the beginning of the study, the participants were informed that they could use pressages as much or as little as they wished. All of the participants chose to include pressages in every conversation with their partner.

CONCLUSIONS

To conclude, mobile devices include an increasing number of input and output techniques that are not currently used for communication. Pressure and tactile techniques have been explored in tangible interfaces for remote communication [9] [3] on dedicated devices but these techniques, until now, have not been implemented on mobile devices or used during live phone calls. Therefore, many open research questions have been addressed using ForcePhone and pressages. With the help of lab studies we document concrete design decisions. Finally a month long study helped us gather initial experiences. The results of this research indicate that an additional haptic channel of communication can be integrated into mobile phone calls using a pressure to vibrotactile mapping with local and remote feedback. The longitudinal study showed that such a system has value as a communication channel in real-world settings with users expressing greetings, presence and emotions through pressages.

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