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Keep in Touch: Channel, Expectation and Experience

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ABSTRACT

This paper investigates whether and how digitally mediated social touch (remote touch) may influence the sense of connectedness toward a speaker and the emotional experience of what is being communicated. We employ an ‘augmented’ storytelling methodology where we manipulate the modality of an ‘emotive’ channel that accompanies the speech, and the contextual expectation of the listener. Comparing a remote upper-arm touch against a similarly timed flashing light, we explore the importance of the touch modality in affect conveyance. Our second manipulation involves two cover stories where the listener is told that the touch or flashing light is triggered either by the storyteller expressively squeezing a touch input device while speaking, or by measured ‘high points’ in the mental state of the storyteller. Our results show that the story accompanied by communicative touch resulted in a significant increase in the sense of connectedness with the storyteller over the speech-only condition, and a trend toward greater affective conveyance.

Author Keywords

Remote Touch; Connectedness; Empathy; Affect; Emotional Experience; Multimodality; Haptics; Computer Mediated Communication

ACM Classification Keywords

H.5.2 Information Interfaces and Presentation: Miscellaneous—Optional sub-category

General Terms

Experimentation, Human Factors

INTRODUCTION

Human communication is not just about conveying information streams. Facial expression, gesture, ‘body language’, physical touch and voice prosody all function with speech to convey aspects of communication that strings of symbols alone cannot carry. In our current political season, for example, a politician’s speech is often judged by how well he or she has ‘connected’ with the electorate. The voters want to sense that somehow the speaker empathizes with their situation, and the speaker wants to induce in the listener a sense of empathy with his or her viewpoint. This paper investigates how remote touch in conjunction with speech may influence this sense of connectedness or empathy toward the speaker and the emotional experience of what is being communicated.

Digital communication has expanded to incorporate a number of non-verbal channels such as video to convey gestures and facial expressions, high fidelity sound to capture prosody, and accompanying textual interaction. Touch, however, has not received equivalent attention, and hence is less studied. This is problematic since touch plays a significant role in natural human interaction to convey affect, intimacy, and to increase connectedness and empathy.

Most of previous pioneering work in remote touch have focused on the design and prototype of remote touch systems. However there has been little exploration of whether and how remote touch can influence the affective components in human communication. Notable exceptions include: Haans [12, 11] and [24]. Wang [24] prototyped an armband using shape memory alloy which can produce a squeeze sensation on the user’s upper arm. The in-between study recruited two groups of participants to listen to a sad story that had a happy ending with or without remote touch channel. The result shows that participants with the augmented remote touch channel experience a significant reduction in sadness and a trend toward increased joviality. This study suggests that remote touch channel can influence people’s emotional experience.

This raises two research questions that we hope to answer in this paper. First, is the specific modality important to the conveyance of affect? Perhaps the results of altered affect comes from altering the listener’s attention, causing her to focus on the affective components of the story conveyed in speech? Can the same effect be achieved by any channel other than touch? In other words, is there anything special about the remote touch channel other than as a signaling mechanism? Second, how does the context of the communication affect one’s perception of connectedness or affect? We manipulated the expectation of communicative intent in our study to ad-
dress this question. Does it matter if the recipient think that the touch and speech were co-generated by the speaker in the process of speaking or if she believes that the touch is the result of some unintended measurement of the speaker’s affective state?

We present a similar upper-arm touch device that is paired with a pressure-sensitive casing for a cellular phone. The idea is to enable experience of touch communication in conjunction with speech. We designed a study to investigate the importance of the touch modality and the impact of the context or expectation of the recipient of the dual-channel communication. In the subsequent sections, we shall outline the relevant related work (covering both the role of touch in human communication and the design and testing of remote touch systems); describe our interactive speech/touch system; discuss the design and results of our study; and present our discussion and conclusions.

RELATED WORK

Touch as Emotion Communication

Despite the importance of touch in different domains of social life, its role in emotion communication has received little attention compared to facial and vocal displays of emotion [23]. Based on existing research on touch and emotion communication, generally there are four claims:

First, touch is capable of communicating and eliciting the valenced emotions (i.e. either positive or negative). Wolff [28] studied the development of smiling in the early life of the infant and reported that the widely known game of ‘pat-a-cake’ becomes an effective generator of positive emotions in infants as indicated by their intense and broad smiles. Wolff inferred that tactile stimulation, and not other stimulation, resulted in infant smiling because the infants played the game without being able to see or hear the interactive adult. Touch seems to be an extraordinary powerful sensory system for communicating hedonically valenced emotions. The skin contains receptors that directly generated hedonic values, either because there are portions of the skin that are erogenous or because there are nerve endings that are nociceptive. Studies have also indicated that touch is capable of eliciting negative emotion. Brossard and Decarie [3] explored a number of stimuli varying in complexity that reinforced infants most effectively, laying a hand on the infants’ abdomens for 30s of time to reinforce infant smiling. Furthermore, infants displayed the most amount of tension when they were touched statically.

Second, touch amplifies the intensity of emotional displays from the face and voice [18]. Third, Hertenstein et al [15] indicate that touch can communicate distinct emotions in a robust fashion. 248 subjects (124 unacquainted dyads) participated in their study. The randomly designated encoder entered the lab to find the blindfolded decoder. The encoder was presented emotion words on sheets of paper and asked to communicate the specific emotion by making contact with the decoder’s body using any form of touch he/she deems appropriate. The results show that all emotions including anger, fear, happiness, sadness, disgust, love, gratitude and sympathy were decoded at greater than chance levels without significant level of confusion. Its accurate rates for emotions are comparable to the accuracy rates observed in facial and vocal studies of emotions.

Fourth, the meaning of touch is largely shaped by context. Jones and Yarbrough [16] found that there is no one-to-one correspondence between meaning and touch. Their context-based analysis study on meanings of touch shows that similar touches may have different meanings while similar meanings can lead to different touches. Context plays a critical role in shaping the meaning of touch. With context, touch can convey meanings including closeness, support, appreciation, comfort, reassurance, anger, hate etc.

These literatures in emotion communication not only show that touch can communicate different emotions but also suggests that touch conveying affect in an immediate non-symbolic manner. By “non-symbolic”, we mean no predefined meaning or code is needed for affect conveyance using touch. The sender of touch does not try to make a statement when touching others and the recipient just receive the touch without trying to decode the meaning of the touch. We also note that this does not cover certain aspects socially codified physical interaction such as a handshake that obviously has a symbolic component in its meaning [16]. This characteristics of touch is important. If the way that touch conveys affect is the same as message passing, it can be easily replaced by a speech/textual communication channel and thus the significant of research on digitally mediated touch will be very limited.

Digitally Mediated Touch to Increase Sense of Connectedness

Prior research in digitally mediated touch has focused on increasing connectedness between individuals. However, most of these work have been focused on the design of remote touch system. Very few studies are available that report on the empirical system validations beyond the level of anecdotal descriptions of user experiences [10]. On the other hand, in contrast from the results suggested from psychology and communications literature, most of the remote ‘social touch’ technology is used for message passing (an extensive review of the literature that comes to this conclusion can be found in [24]). Either by design or by user decision, users of the technology typically performed conscious encoding of symbolic messages and used the devices as signaling channels, in essence, using the remote touch device as some kind of tactile Morse Code. Following, we shall present several instances of prior research relating to remote touch devices that increase connectedness between individuals.

Brave and Dahley describe an inTouch [2] system that used a pair of linked devices with rollers that mirror each other’s movements. Users placed their hands on the rollers, and as they moved the rollers, the paired device would mirror the roll in displacement and force. Users reported that the device supported ‘playful’ interaction. Chang et al presented the ComTouch system designed to enable symbolic commu-
nitive function through a tactile interface [4] that is attached to cellphone and utilizes encoded haptic patterns in communication. They reported preliminary studies in which benefits were found with the tactile channel for 1. Redundancy between voice and haptics for emphasis, 2. Mimicry of haptic patterns to indicate attention and camaraderie, and 3. Turn taking signals. Apart from mimicry, the haptic interaction was used to transmit symbolically coded messages. Mueller et al [19] and DiSalvo et al [7] describe a ‘hug’ devices that support remote hugging. An inflatable koala bear serves as the input device. When it is squeezed, a paired inflatable vest inflates to simulate a hug. After 4 seconds, the hug ends, and a ‘kissing sound’ is sent back to the koala to express ‘appreciation’. The target use was to support intimacy between people in close relationships. A user test was not reported (the system was presented to a design workshop). The consensus was that the pumps for the vest inflation was too noisy and slow, and that the participants did not think that the system was useful in daily life.

In another device called LumiTouch [5], two picture frames on the desks of a pair of users serve as interfaces. The photograph of each user adorns the frame of the other user. When the sender squeezes the picture frame on her desk, her partner’s picture frame would glow. In a test with a random user pairs, the subjects developed interpersonal symbolic signals (the authors called this an ‘interpersonal language’) that were sent over the devices. “Users created different combinations of light intensities, colors, and pulses and agreed with each other upon private meanings to their interaction. One user used a pulsing green and blue series to communicate “Good luck” and a flashing red “Good bye, I am busy now.” Rovers and van Essen designed two related devices HIM [21] and FootIO [22]. Both devices are used within instant messaging to convey hapticons (similar as emoticons), where encoded tactile patterns represent the emotion that people in chatting deliberately send out. We note that emoticons are not immediate expressions of emotion, but are part of a symbol system to communicate para-linguistic information through a channel of symbols [20, 13], and have to be interpreted for correlation with real emotions.

Several observations from these work reviewed above include:
1. Some of the systems were designed with symbolic communication as integral components in the meaning of touch;
2. Even when symbolic communication was not specifically prescribed, users tend to use the systems to transmit deliberately encoded messages, turning a rich human touch system into a low-bit-rate signaling tool; 3. The most commonly cited ‘non-verbal’ communication resulting from these devices was ‘playful interaction’ – the promise of broader affect conveyance was not in evidence, and 4. Few user studies were reported on the affective use of the systems, making it hard to derive design principles for enabling immediate affective interaction through remote touch. We believe the lack of understanding of whether and how remote touch may facilitate the affect conveyance in tele-communication contributes to the usage of touch as a symbolic channel. In this paper we will explore whether and how remote touch may affect people’s attitude to the speaker and their emotional experience differently when it is used as a communicative or information signal channel.

**Pressure as One Dimension of Touch**

From childhood, we are exposed to many types of touch (e.g., patting, stroking, kissing, squeezing, pinching, poking, and jabbing). All these forms can be conceptualized into a number of dimensions. A few researchers have proposed analytic frameworks to describe touch. For example, Geldard [8] categorized properties of touch into mechanical (i.e. locus, intensity, duration, and frequency) and non-mechanical (i.e. thermal, chemical and electrical). Weiss [27] proposed a conceptual framework in which she considers four dimensions of touch: duration, location, action and intensity. Hertenstein [14] build a physical touch space upon Weiss’s framework including parameters (location, frequency, duration, and extent of surface area) and qualities of touch (action, intensity, velocity, abruptness and temperature). With such a huge and complex design space, itself is a big challenge to choose a reasonable starting point.

Clynes explores the pressure dimension of touch as an output modality of seven basic emotions in his book “Senticus: the touch of emotion”[6]. In that study, the subject sits in a chair with a straight back and no armrests. His/her middle finger rests on a finger rest one inch high so that other fingers are relaxed in a natural position without touching anything. The finger remains in touch with the finger rest throughout and not lifted off at any time. Researchers request each subject to produce an action for a particular emotion thirty to fifty times at varying intervals a few seconds apart. Clynes measured the force and the direction of the finger tip action. They found surprisingly that over 400 participants produced very similar dynamic forms for each of seven basic emotions (love, joy, anger, hate, grief, sex, and reverence). When they replayed the recorded dynamic profile of finger tip pressure action to another group of participants, participants can recognize these emotions clearly. Bailenson and his colleagues did a similar study in virtual environment, in which they request 1st group of participants to produce a handshake using a commercial available handshake device for a particular emotion and 2nd group of participants to recognize emotions from recorded dynamic profiles of handshake. They also find the similar results in digitally mediated touch condition [1].

Clynes and Bailenson’s work informs that pressure may be a good place to start the investigation of remote touch because pressure can provide rich emotion range for us to explore and relatively easy to implement. We will take remote pressure transmission as our start point for the similar reason.

**REMOTE TOUCH DEVICE**

Our previous prototype with Shape Memory Alloy (SMA) is lightweight, very quite in operation, and was able to activate quickly (able to produce a squeeze in 300 milliseconds). However, because SMA typically only contracts 3~5% in length, the pulling force is quite limited. Users comment that the force provided by armband is much softer compared to a normal human squeeze. This low force level also makes user’s sensation of squeeze sensitive to rise-time of the SMA.
Users can only feel the squeeze when the SMA is activated quickly. We achieved this speed by over-driving the SMA in our first prototype for our study reported in [24]. This reduced the life of the SMA considerably.

For the current study, we designed a new remote touch device prototype [25] shown in Figure 1. This prototype is composed of two main parts: the output armband , and a squeeze input device.

Figure 1(a) and 1(b) show our output armband design. It employs a servo motor as the mechanical actuator that retracts a fabric layer in the armband worn by the touch recipient. The armband is designed to wrap around the upper arm of the user and has a width of about 7cm approximating the width of an adult’s palm, and can provide maximum pulling force off around 120N in 0.2s.

Figure 1(c) and 1(d) show the touch input part of our prototype. It comprises force sensors embedded in an acrylic case designed to house a Google Nexus One smart phone, and the control electronics. The case is made of acrylic pieces and is precisely cut into the required shape using a 2D laser cutter. Two Flexi-Force sensors are mounted along one side of the case (see Figure 1(c)). The control circuit (Figure 1(c)) includes a Bluetooth module and a micro-controller PIC-16F76. After initial calibration, this input part can detect soft/medium/hard levels of squeeze force on the phone. It is also able to distinguish such squeezes from the normal force by which one would hold the phone. Once a squeeze is detected, the control circuit will send a signal to the phone via Bluetooth.

When a paired phone case is paired with an output armband, the armband will deliver a squeeze with a force that corresponds to the pressure detected in the phone case. Our perception study with 22 subjects shows that 100% of users agree or strongly agree that they can easily feel the squeezes they are assigned to experience. 86.4% of users report that the squeeze is similar to human touch, although they can feel a difference [25].

EXPERIMENT
Since we are interested to explore how the touch modality and context modulate people’s emotional experience, we decide to use stories as emotion elicitation. We use the same story and a similar study protocol as was used in Wang and Quek [24]. We invite participants to listen to the emotive story recording told by a professional actress. We are interested to examine the closeness they feel to the storyteller, the emotion they experience in hearing the story.

Recall that our previous study in [24] found a significant decrease in sadness and a trend towards increased joviality when one listens to the story with remote touch as opposed to without. Our current study design is discern if the second channel effect is unique to touch or if some other arbitrary similarly synchronized channel would suffice. We also want to know if the contextual expectation that the touch received is expressively generated by the speaker is a significant factor in the experience.

Table 1. Cover stories for the Communicative and Measurement conditions

| Cover Story For Communicative Condition: “A female storyteller is going to tell you a story. Her mental state is monitored in real time by a device. Every time her mental state reaches a high point, the remote pressure transmission device will be in action and you will feel a squeeze on your arm (or, you will see a flashing light on your monitor). Now enjoy the story.” |
| Cover Story For Measurement Condition: “A female storyteller is going to tell you a story. In additional to audio, she is allowed to use a soft object in her hand to express her mental state. Every time she squeezed the soft object, the remote pressure transmission device will be in action and you will feel a squeeze on your arm (or, you will see a flashing light on your monitor). Now enjoy the story.” |

Figure 2 illustrates our study design. At the highest level, our study compares the Speech+Additional Channel (where Additional Channel may be touch or a flashing light) against the base Speech Only condition. For Additional Channel conditions, we manipulate two factors: Type of channel (Remote Touch vs Flashing Light) and Expectation of the participants (Communicative vs Measurement). The Remote Touch vs Flashing Light manipulation is designed to ferret out the importance of modality. In both conditions the signal is ‘on/off’, of the same duration (1 second in this study), and synchronizes with some emotionally laden portion of the verbal story stream. Hence, any difference in effect between these conditions must be related to modality. The Communicative vs Measurement manipulation is designed to determine the influence of context on affective and connectedness experience. The two conditions differ only in the cover story communicated to the participant. In the Communicative condition, the participant understands that the touch or flash they receive is triggered by the expressive intent of the storyteller as she squeezes an object for expressive effect as she tells the story. In the Measurement condition, the participant is told that the touch or flash they receive is the outcome of an ‘emotion measurement device’ that monitors emotional high points in the storyteller. Table 1 contains the respective cover stories. We denote these different conditions CT and CL for communicative touch and light, and MT and ML for measurement touch and light respectively.

Emotional High Points and Story Narration
A suitable story used in this experiment should be: 1) emotive so it has the power to influence the listener’s emotional state; 2) not widely known. If some subjects have heard about the story before it might reduce the reliability of our experimental results; 3) be attractive to a wide range of people with different backgrounds. We decide to avoid stories dealing with sensitive topics such as religion and politics. We chose and edited a story named Story of Stevie. This story is emotion-laden and has a happy ending.

The story is about a boy with Down’s Syndrome who found purpose bussing tables in a truck stop cafe. He is diagnosed with a heart problem that forced him to stop working. The story continues that this boy’s absence was noticed by truck drivers who then spread the word. Every time a truck driver stopped at the cafe, he would leave money and mark a napkin
Figure 1. Remote Touch System: (a) Armband, (b) Armband Attachment, (c) Force Sensor, (d) Squeezable Case and Phone

Figure 2. Experiment Design

"for Stevie". The story ends happily with enough money collected for Stevie's operation that returns him to health and his favorite activity, bussing tables at the cafe.

We employed the same ‘emotional high points’ used by [24] to determine where the touch or flashing light would be administered in the story audio stream. These high points were obtained by proposing 29 possible touch points in the story to 6 participants who evaluated these points in response to the question “Is this an emotional high point in this story?” in 1-5 scale. Fourteen touch signals are chosen which got highest scores.

We provided the story and ‘touch’ points to a professional actress. She was asked to narrate the story in a conversational style. She was also asked to hold a soft object in hand to help her keep her vocal narration congruent with touch activities. The recording of her narration serves as the audio stimulus in this study.

Participants
Twenty female and twenty male participants are recruited from on-campus listservs and a participant recruiting system maintained by Psychology Department at Virginia Tech. The participants include undergraduate/graduate students and university staff members. Participants from Psychology Department are compensated with 1 course credit for participation and participants from other sources are compensated with 5 dollars for their participation. Their age range is from 18 to 44 with an average of 23.13.

Procedure
Participants are gender balanced and randomly assigned into one of five experiment conditions. At the start of the study, participants are asked to fill a background information form. At this point, the participants are told their respective cover stories from Table 1. For familiarization with the study setup (room, audio equipment, and their assigned study condition), the participants were given a story practice session in which they will listen to a story about a distinguish alumnus of their institution. This familiarization story is accompanied with touches or light flashes in the same fashion as our stimulus story (the touch or flash points were identified in the same way as for our stimulus story). For participants in with-additional-channel condition, the experimenter ensured that participants can feel touch sensation clearly or see the flashing light on the monitor clearly, and are comfortable with the signal.

We use pre- and post-Positive Affective Negative Affective Schedules (pre- and post-PANAS) to measure the changes in subjects’ current feelings and emotions. This form is adopted from Positive Affective Negative Affective Schedules Expanded form (PANAS-X) [26]. After the practice session, the participants are asked to fill a pre-PANAS form, after which the study stimulus (‘Story of Stevie’ with respective touch or flash signals) is administered. After the storytelling session, participants are asked to fill a post-PANAS form and a 10-question quiz about the content of the story. A semi-structured interview follows, which include questions:

1. How close do you feel to the storyteller? Please use the liker scale 1 (not at all) to 7 (extremely) to indicate
2. Why do you feel connected this way?
3. What is in your mind when you get squeezed or see the flashing light?
4. (Only for Touch Condition) How do you rate the sound level accompanying the remote pressure transmission device when it is in function?

The entire study takes about one hour.

Data Collection and Analysis
The pre- and post-PANAS test we use to measure emotion involves the participants responding 60 words relating to emotions on a scale of 1 (not at all) to 7 (extremely). This yields a scale that measures the instantaneous affective state of the respondent [26]. The internal consistency reliabilities (Cronbach’s coefficient alpha) are high, generally ranging from .85 to .90 for positive affect, and .85 to .90 for negative affect. Additionally, the correlation between positive affect and negative affect is generally low, ranging from -.05 to -.35, giving
quasi-independence between positive affect and negative affect [26].

We also use a semi-structured interview to evaluate the sense of connectedness the participants feel toward the storyteller and why, and their understanding of the additional channel and their strategy in understanding it. The interview is audio-recorded and transcribed. This yielded 90 pages of transcriptions that were analyzed using an open coding methodology.

We developed a questionnaire consisting of 10 multiple-choice questions based on facts in the story. This is to check whether the participant is involved in the experiment and to validate their data. Data from participants who scored less than 7 out of 10 in this questionnaire were removed from the study.

Results

Closeness Rating. We did one-way ANOVA to compare the closeness rating of CT, MT, CL, ML with that of the base condition. Figure 3 shows that participants in the with-additional-channel conditions all showed a trend of a higher degree of closeness to the storyteller. In particular, participants in CT reported highest closeness to the storyteller among all conditions which is significantly higher than that in the base condition \((p < 0.05)\). For each bar in the graph, the central red mark is the median, the edges of the box are the 25th and 75th percentiles, the whiskers extend to the most extreme data points not considered outliers, and outliers are plotted by red cross individually.

![Figure 3. Closeness Rating Across Conditions](image)

We divide all participants in each condition into a close group when their closeness rating is between 5 and 7 and the rest (1-4) into a not-close group. Figure 4 shows the number of participants falling in close and not-close group across all conditions. Applying a Fisher Exact Test, we found that the CT condition had significantly \((p < 0.05)\) more participants in the close group than the base group. The same test on the other conditions (MT, ML) showed a trend toward closeness though not crossing the threshold for significance. The trend was not seen for the CL condition.

![Figure 4. Close Group and Not-Close Group Across Conditions](image)

Why do you feel close this way? We coded participants’ answers to “Why do you feel close to the storyteller at this level” into five categories:

1. “The story is nice.”
2. “The way she told story,” and “The way she carries her emotion in her voice.”
3. “Own personal experience makes me feel close.”
4. “The squeeze feels like a personal physical contact and helps me visualize the activity.” (Only in CT and MT)  
5. “The flashing light makes me feel more about her feelings.” (Only in CL and ML)
6. “Not much in common”, and “I don’t like her story.”

Figure 6 shows how many participants’s comments falls into each category across conditions. Note: participants may mention multiple categories in their comments.

![Figure 6. Reasons for Feeling Close](image)

We counted positive comments (Category 1 to 5) made by each participant and compared the number across conditions. Overall participants with additional channel made more the positive comments about the their feelings to the story and storyteller than participants in base conditions. And the number of positive comments in CT is significantly higher than the base condition \((p < 0.05)\). Then we did two-way ANOVA by using channel and expectation as two variables and the
number of positive comments made by each participant as dependent variable. We again found the significant interaction effect ($p < 0.05$).

We did the same analysis for negative comments (Category 6). The number of negative comments in different conditions shows the similar trend: $CT < ML < MT < CL$. Two-way ANOVA also shows the significant interaction effect ($p < 0.05$).

These analysis results based on participants’ comments agree with what we find in their closeness ratings. It suggests strongly that communicative remote touch makes people feel more connected to the storyteller than the base condition. It also suggests that remote touch and flashing light have different characteristics in modulating people’s sense of connectedness toward others: remote touch seems work better as a communicative channel while flashing light is more congruent as a measurement/signal channel.

**Emotion Experience.** We compared participants’ emotion states before and after the story session using pre-PANAS and post-PANAS. Figure 7 shows the mood changes in negative emotions, positive emotions, sadness and joviality in different conditions. The negative emotion of participants in CT, MT and CL all showed a trend of reduction while there are not much changes in ML and Base condition. There shows an increase of positive emotion in with-Touch conditions while there shows a trend of reduction of in ML and base conditions. There is not much change in positive emotion in CL condition. For sadness emotion, there are not much change across all conditions. There shows an increase in joviality in CT, MT, CL and Base condition while there is not much difference in ML.

We take the emotion brought out by the story in the base condition as a baseline. The results suggest that CT, MT and CL are sharing and enhancing similar emotion experience in negative emotions and joviality, that is the story about Stevie with a happy ending reduces the participants’ negative emotions and increases their joviality.

**Effects of Additional Channels.** In the semi-structured interviews, we asked participants explicitly about the effects of remote pressure transmission or flashing light in their process of listening to the story. Our open-coding process yielded seven categories from our participant responses that may be summarized by the following seven statements.

1. “It coincides with my own feelings.”
2. “I can understand why the pressure is applied or the light flashes happened most of the time.”
3. “It feels like a physical contact.” (Only for CT and MT.)
4. “It makes me more attentive.”
5. “Not much effects.” (Only showed in MT and ML)
6. “Not sure what it means/Trying to figure out”, and “I don’t understand.” (Only showed in CT and CL)
7. “It is a distraction to me.”

Figure 8 shows the number of participants from the different conditions that fall into each category. Note that because of the free-form nature of the comments, some participant responses can fall into multiple categories. There appeared to
be a subtle difference in viewpoint between participants in the measurement (MT and ML) conditions and the communicative (CT and CL) conditions. In the former, the comments appeared to take an ‘observer’s’ perspective (e.g., ‘(Additional channel) does not have much effects on me,’), while participants in the latter conditions seemed to treat the additional channels as part of the ‘communicative package’ (e.g., ‘I am not sure what it (additional channel) means). I am trying to figure out.’). This suggests that the participants accepted the cover story concerning the context of the additional channel – a measurement to interpret separately from the speech as opposed to a part of the communication to be understood.

DISCUSSION

Comparison Across Modalities
We first examine the difference between channels (remote touch vs flashing light).

CT vs CL. As is shown in Figure 8(a) and Figure 8(c), participants seem more emotionally involved in CT than in CL. In CT, three out of eight participants in CT reported that the touch coincides with their own feeling or intensifies their feeling, while none in CL reported so. For example one participant in CT reported: “It makes me feel ... jump a little bit, kind of. Cause I already feel that. The squeeze intensified it. Kind of.” And another participant stated: “I notice that it almost always squeeze when I got goose bumps. Almost always when I get goose bumps, I will get a squeeze. Or when I get a squeeze, and I get goose bumps. They are very close to each other.” Further, two participants in CT report that remote touch channel made them more attentive. One participant said that touch helped him to visualize the storyteller and her activity as a physical contact sitting across a coffee table. He stated: “The squeeze on my arm makes me feel like she sits very close to me... She is like sitting at the coffee table, squeezing my hand.”

In contrast, no such comments were made by participants in the CL condition. Some participants in the CL condition, however, reported that they had a better understanding of the storyteller’s feelings. Four participants report that although they did not feel similarly, they could understand why the storyteller may have squeezed the touch device at the particular junctures in the story.

This observation is supported by our A Fisher Exact Test results that show that CT participants felt a sense of closeness to the storyteller. CT participants also experienced a stronger trend toward reduction in negative emotions and an increase in joviality. This suggests that the CT condition invoked greater empathy toward the storyteller’s perspective. In the CL condition, the participants may have an understanding of why the storyteller may have been emotionally moved by a story although the listener did not empathize with the feeling as much.

MT vs ML. In this comparison, the expectation that the signal depicts a measurement is held constant, and the difference is only in modality (touch vs flashing light). Interestingly, more participants in the flashing light condition reported that they were more attentive than those in the touch condition (5 out of 8 in ML and 2 out of 8 in MT). We note that this is a slight reversal from the communicative context comparison. Also, more participants in the ML condition reported understanding the emotions of the storyteller than in the MT condition (4 out
of 8 in ML and 1 out of 8 in MT) – See Figure 8(b) and 8(d) for these count.

We conjecture that this effect toward greater comprehension of emotional state and attention in the flashing light condition derives from the cultural experience of the participants in associating measured values with light indicators as opposed to touch. They were thus more facile in evaluating the measured signal as a light flash than as a touch.

**Comparison Across Expectations (Context)**

We proceed to examine the difference across expectations contrasting the effects of communicative intent with passive measurement.

**CT vs MT.** As we described in previous session, participants in CT and MT listened to the same story recording and were touched in the exactly same point in the story. The only difference between CT and MT is their expectation of communicative intent. In the CT case, they expect the touch to be part of the communication produced by the storyteller, while in MT they believe that the touch is a signal measurement indicator. This seems to make a big difference in the reported effects of touch.

First, in CT 5 out of 8 participants report their feeling coincides with the storyteller or they can understand her feelings while no such experience of empathy found in the responses provided by participants in the MT condition. In only one case did a participant in the MT condition say that the correspondence between the touch and speech were intuitively correspondent (“it feels intuitive when the voice and touch matches”), and even in this case, the participant did not report empathy with the storyteller – only that she could understand the match.

Second, the majority of MT participants (6 out of 8) report that their feelings toward the story were not influenced by the touch, and some even said that the touch was distracting from the story. The majority of MT participants reported the touch confused or distracted them because the touch episodes did not correlate with their own emotion states or expectation. On the other hand only 3 out of 8 participants in CT reported they were trying to figure out the reason for the touches and one of them found “the touch is a little bit distracting” because of that.

One possible interpretation for the difference is in the way the multi-modal communication is experienced in a communicative context. In the CT condition, the participant believes that both speech and touch find their origin in the communicative intent of the storyteller. Hence, they interpret these as a single multimodal compound, in essence creating a single meaning from both channels. That is, they derive the meaning of the communication from both speech and touch simultaneously (i.e. *Speech + Touch = Meaning*). Hence, this single emotion-laden meaning has greater potency in inducing empathy in the recipient, and did not seem confusing, conflicting, or distracting.

In the MT condition, only the speech channel is part of the communicative package intended by the storyteller. The touch is a signal indicator that is to be reconciled to the meaning the participant experiences from the communicative stream. Using the same notation from our CT discussion, in this case *Speech = Meaning*, leaving the need to understand the measured mental state of the storyteller. Hence, the participants did not report empathy with the storyteller, and furthermore, the need to perform the added reconciliation step caused the participants to experience greater distraction and confusion.

This interpretation seems likely given our understanding of how speech and non-speech channels (like gesture, eye-gaze, and body posture) are fused in communication [9], and how the only difference between CT and MT is in the expectation of how touch is produced.

**CL vs ML.** In this axis of comparison, we see a trend where ML resulted in a stronger sense of connectedness than CL. This is surprising since in the CL condition, the participant expects that the light signal is in response to the storyteller’s communicative intent. Furthermore, participants in the ML condition reported that the light made them more attentive (5 out of 8), while none of the CL participants reported this effect.

We draw again on the notion that culturally, we are familiar with the associating of light indicators to measured signals to possibly explain this effect. Hence, the ML signal is easier to interpret than the CL situation, where the participant had to associate the flash with communicative intent.

We note, however, that all conditions with additional channels (CT, CL, MT, ML) resulted in a trend towards a greater sense of closeness to the storyteller than the base speech-only condition, although only the CT effect was significant. This may suggest that any additional signal indicating the emotional state of the speaker may influence the sense of closeness.

This result and interpretation are consistent with Chang et al’s work in [5] and Kaye’s work in [17], both of which used flashing light as an interface to increase the sense of connectedness between users.

As we found, the combination of *Speech + Communicative Touch* enhances the sense of connectedness significantly and also suggests a trend of greater emotional experience. More importantly, this is achieved when users experienced the communicative touch in an immediate “non-symbolic” way without pre-defined message coding-decoding process. We believe *Speech*, provided as a contextualizing channel for touch, plays a key role in retaining the capacity of touch in conveying sense of connectedness and affect in an immediate fashion. Without a contextualizing channel, users will tend to use the device to send messages with some kind of “tactile Morse code” in order to ‘give meaning’ to the touch interaction [5]. This may severely compromise the immediacy of touch for affect conveyance.

**CONCLUSION**

In this paper we investigate how remote touch and contextual expectation in conjunction with speech influence people’s empathy to the speaker. The results show that partic-
participants in Speech + Communicative Touch condition experienced the sense of connectedness toward the storyteller significantly higher than that in Speech Only condition though participants in all with-additional-channel conditions experienced the similar trend in varying degrees. Participants using Communicative Touch also showed a stronger trend of an increase in joviality and reduction in negative emotions.

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