Towards Empathic Touch by Relational Agents

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1. INTRODUCTION

Empathy—the process of attending to, understanding, and responding to another person's expressions of emotion—is a pre-requisite for providing emotional support which, in turn, is a key element for establishing most kinds of meaningful social relationships between people. Within healthcare, for example, provider empathy for the patient has been widely acknowledged as being an important prerequisite for the establishment of a therapeutic alliance relationship, which is associated with improved health outcomes [13]. Empathy alone can also be important: in physician-patient interactions, physician empathy for a patient plays a significant role in prescription compliance, and a physician's *lack* of empathy for a patient is the single most frequent source of complaints [10].

An essential element of empathic interaction is that the empathizer must clearly communicate their understanding of their partner's emotional state [17]. An important channel for communicating empathic understanding of distress is through physical touch as an acknowledgment of the distress and a message of comfort and caring.

We are developing a conversational agent that has the ability to touch the user at appropriate points in dialogue for the same reasons that people use this modality—to comfort, emphasize, or display or establish social bonds. One embodiment of such a "touchbot" would be a device that hospital patients can hold in their hospital beds, capable of sensing touch (squeezing, stroking, etc.) by the patient and able to use these same communicative signals in conjunction with a speech-based dialogue system for comforting, counseling, and educating the patient.

The importance of physical touch between a health provider and client in face-to-face interaction has been widely documented. For example, hospital patients who are touched by providers have been found to be more satisfied with their experience overall compared to non-touched patients [9]. Touch has also been found to be effective for providing comfort for terminally ill older adults [4] and effective in improving pain and mood in patients with advanced cancer [14]. Health providers— nurses in particular— have been found to frequently use comforting touch with patients. One study of 30 critical care nurse-patient dyads in a hospital setting found that caring touch was used by the nurses twice per hour on average (with a range of 0-17) [18].

Additional therapeutic forms of touch, such as massage, have also been widely used within healthcare to effectively reduce pain, anxiety, depression and fatigue across many conditions ranging from labor pain during childbirth to pre-debridement anxiety for burn patients [7]. Although many such kinds of touch within the healthcare context have been identified (e.g., [2]), we have been primarily concerned with "affective" and "simple" touch that is used by a provider to intentionally deliver a message of comforting to a patient in pain or distress.

2. RELATED WORK

A few researchers have developed systems that use touch as a mediated form of communication between users, relaying hugs [15], strokes [6], or touch dynamics [3] between users. A few have also explored autonomous systems that touch users for affective or therapeutic purposes, such as therapeutic massage [19]. However, we are aware of no prior work that attempts to simulate conversational touch, that is, touch employed as part of an interaction with an embodied conversational agent or conversational robot.

3. THE "TOUCHBOT" AGENT

Based on observational studies of where nurses touch patients, as well as studies of where people are comfortable being touched by strangers [16], we decided to construct an agent that would touch users on their hands. We also wanted to ensure that the touch felt comfortable and organic, so our initial design for the haptic output

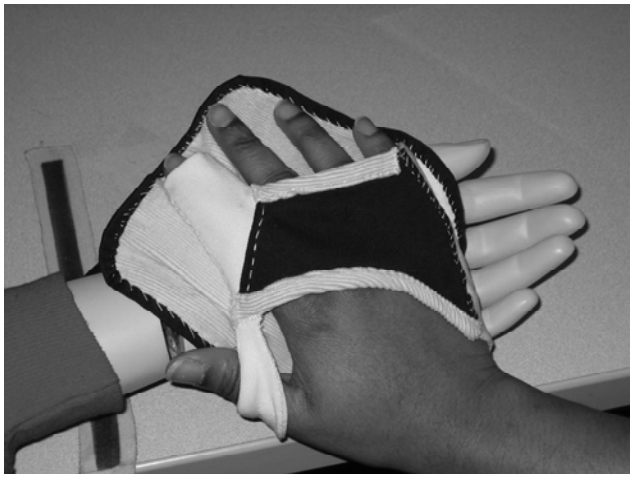

Figure 1. Pneumatic Haptic Glove

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device uses a glove with an air bladder sewn into the palm (Figure 1). The bladder is inflated or deflated via two valves, one connected to a 25 psi compressed air tank and the other venting to the atmosphere. The valves are controlled by a GadgetMaster II controller board, and our embodied conversational agent dialogue engine [1] was extended with primitives that allow the valves to be controlled within dialogue scripts and synchronized to word boundaries during an agent utterance.

Based on pilot testing and results from a study of affective touch-based communication between people [11], we settled on a simulated stroking pattern of 2 slow inflations (200ms duration), 750ms apart, to represent an empathic touch used during an agent utterance. Pilot observation studies of naturally occurring touch in human-human conversation indicated that touch typically occurs at the beginning of the utterance it is semantically related to, so in all dialogue content we have developed for evaluation, the empathic touch is aligned with the beginning of the corresponding agent utterance.

Preliminary testing of the glove used in combination with an animated head on a desktop monitor indicated that users felt that the glove was not being controlled by the agent. To enhance the feeling of connectedness, we subsequently introduced a mannequin to visually connect the glove to the talking head (Figure 2). Users sit facing the mannequin with their hand in the glove, resting on the mannequin's hand during a conversation (the glove is on the user, not the mannequin). To remove any complications arising from users using their hands for input control during an interaction, a wizard-of-oz control [5] was developed for pilot evaluation so that users could talk to the agent using speech.

4. PRELIMINARY EVALUATION

We are currently conducting an evaluation study to assess the ability of the TouchBot agent to establish a therapeutic alliance with users during a single brief counseling dialogue about cancer, comparing this functionality to the same apparatus but with the haptic modality disabled. We hypothesize that the touch modality will lead to significantly greater working alliance, and ratings of liking, trust and naturalness of the agent compared to the control condition.

4.1 Apparatus

A dialogue script was developed consisting of a greeting, introduction, several turns of social chat, a discussion about how the user feels about cancer, and a closing. A single, brief glove inflation was commanded during the greeting to simulate a handshake for all participants. Empathic feedback, including touch, is provided during the cancer discussion at appropriate points (e.g., Agent: "How do you feel about cancer?" User: "I hope I don't get it." Agent: *with empathic touch, concerned facial display* "I know, it can be very scary."). This dialogue lasts approximately two minutes. The only manipulation between the two conditions of the study (TOUCH and NOTOUCH) was that in NOTOUCH the haptic glove was not sent the commands to inflate during empathic dialogue—the treatments were identical in all other respects.

4.2 Measures

In addition to demographics, therapeutic alliance was assessed using the bond subscale of the Working Alliance Inventory, a validated 12-item self-report scale [12]. An additional six items assessed other aspects of the user's attitude towards the agent, including enjoyment, naturalness, desire to continue, etc. User introversion/extroversion was assessed using a 16-Likert-item self report scale [20]. Touch receptivity (how a user feels about being touched) was assessed using a new 10-Likert-item composite self report scale. User heart rate and galvanic skin conductivity were recorded continuously at 256 Hz, using finger-clip sensors from Thought Technology, Ltd.

Figure 2. Experimental Setup with Mannequin

4.3 Protocol

Prior to the arrival of study participants, the compressed air tank was charged to 25psi using an air compressor, and the compressor was then turned off during the study. There is sufficient capacity in the tank to inflate the glove 8-10 times, and the loud noise of the compressor would have been disruptive.

Participants were consented, then filled out the demographic, personality and touch receptivity questionnaires. Next, they were randomized into a TOUCH or NOTOUCH condition of the study, seated in front of the TouchBot, and their right hand placed in the haptic glove. They were instructed to rest their right hand on the mannequin's hand throughout the interaction, and told that while they were talking to the agent "the agent can occasionally inflate [the glove] to give you the sensation of a slight squeeze." (they were not told the intended meaning of the touch). Finger-mounted galvanic skin response and heart rate sensors were attached to their left hand, which they were then instructed to rest in their lap. Participants were then told they could talk to the agent via a microphone mounted on the desk next to them, but that it could only recognize one of the options displayed along the right side of the screen (dynamically updated during each conversational turn). At this point the experimenter left the observation room and the agent began the dialogue with the participant. Following the conversation, the experimenter re-entered the room, removed the sensors and glove from the participant, and administered the working alliance and attitudinal questionnaires. A semi-structured interview was then conducted to obtain impressions of the experiment and agent. Participants were then debriefed, paid and dismissed. The entire study session was videotaped.

4.4 Subjects

Twenty-one subjects have participated in the study to date, 40% male, age 34.3 (SD 14.8), 80% single, 52% students.

4.5 Preliminary Quantitative Results

There are few significant effects of study condition on outcome measures at this time. However, general trends are emerging on the attitudinal measures indicating a interaction between participant gender and study condition, such that women have generally more positive attitudes towards the agent in the TOUCH condition, while men have generally more negative attitudes towards the agent in the TOUCH condition. The only item in which this interaction is currently significant is for ratings of the agent's friendliness, $F(1,17)=4.75$, $p<.05$, (Figure 3).

Data from the physiological sensors is still being analyzed.

4.6 Preliminary Qualitative Results

When asked for their overall impressions, the most frequent responses were "weird" (3 of 9 respondents) and "awkward" (2 of 9 respondents).

Most participants felt that the agent was communicating empathy, sympathy or comforting with its touch (11 of 15 respondents):

- "I saw it as an expression of sympathy or empathy"
- "Probably sympathy, compassion..."
- "I guess if it was like a real situation, I would interpret it as caring, and you know, really being in to the conversation, and not like talking to me, but talking with me."

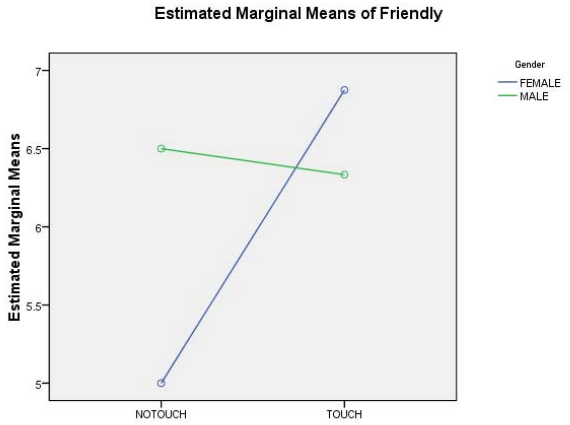

Figure 3. Interaction of Condition and Gender on Perceived Friendliness of Agent

- "Definitely felt.. like a hand squeeze... like sympathy. No, I guess not sympathy, not empathy, sort of - reassuring. Reassuring is the word."

When asked if they felt the touch was natural, respondents gave mixed reactions (roughly half said yes):

- "I thought it felt very natural, as if somebody was holding my hand while he or she was talking to me. I didn't think it was forced"
- "Felt natural towards the end I think. I think I just got more used to it".
- "The way she squeezes the hand is a little different from what normally humans do."

Most still felt that the glove was separate from the agent, even with the mannequin:

- "I thought it was weird to have the body"
- "It seems more separate, but I was trying to connect it."

Two male participants indicated that they did not feel comfortable being touched:

- "I'm more uncomfortable on the whole touching while having a conversation thing."
- "I think it's a little different for guys and girls. Being a guy, I definitely find it a bit weird. You know, if a doctor reached out and squeezed my hand as he gave me bad news, I'd you know...I would find that more strange than anything else"

Finally, several participants actually seemed to enjoy the conversational touch:

- "I found that it was amazing that a computer can actually respond to another human being's hand by squeezing it."
- "Enjoyable, very different, very comfortable"

4.7 Discussion

The interaction between gender and touch on attitudes towards the agent is not too surprising, since in American culture women are touched more than men, both as infants and adults [8], leading to greater comfort with touch. This also carries over into healthcare contexts. One study showed that in a hospital setting female

patients who were touched reported less anxiety about surgery compared to women who were not touched, but men who were touched reported more anxiety [9]. There is also a trend in our data for females to have higher touch receptivity scores compared to males.

5. FUTURE WORK

We are continuing to run study participants and manipulate elements of the protocol and apparatus to understand the best way for a conversational agent to administer empathic touch.

We have found from debriefing interviews that study participants still feel that the hand is not being controlled by the agent. For this reason, and to gain finer control over the touch dynamics (e.g., to replicate the results in [11]), we are in the process of fabricating a mechanical hand that will be covered in foam (Figure 4). We feel that by having the agent's physical hand administer user touch, users will feel more inclined to attribute the touch behavior to the agent.

We also have a study underway to understand the role of conversational touch in emphasizing important information during tutorial and counseling dialogues.

Conversational touch represents an important and unexplored modality for conversational agents, especially those deployed in the healthcare environment.

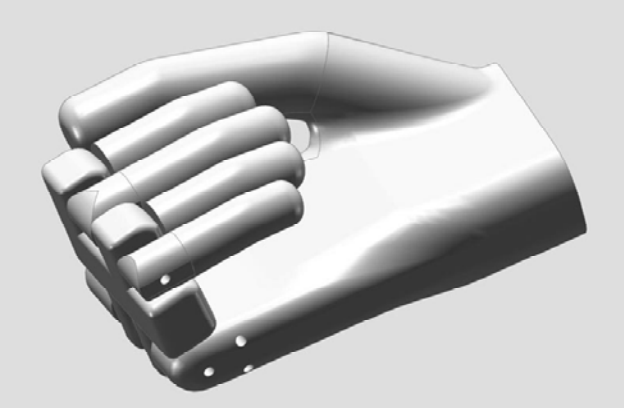

Figure 4. Mechanical Hand Design

6. ACKNOWLEDGMENTS

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