With Us or Against Us: Simulated Social Touch by Virtual Agents in a Cooperative or Competitive Setting

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Abstract. In this paper we examine how simulated social touch by a virtual agent in a cooperative or competitive augmented reality game influences the perceived trustworthiness, warmth and politeness of the agent. Before and after the game, participants interact with two agents whereby one agent touches the participant's arm. Results showed no significant difference in how agents are perceived in the cooperative and competitive situation. However, significant differences between perception of the touching and non-touching agents could be observed for warmth.

Keywords: Simulated social touch, virtual agent, Augmented reality.

1 Introduction

In the field of embodied conversational agents (ECAs), human-to-human communication is approximated through the implementation of various intelligent behaviors inspired by human communication. Verbal or linguistic intelligence in speech synthesis and prosody play a role as well as non-verbal behaviors such as facial expressions, body posture or turn-taking [7]. A modality that is understudied in interactions with ECAs is touch. Handshakes, hugs or pats on the back may occur less frequently during communication than other behaviors, such as smiling or nodding, but social touch is known to have strong effects on subsequent interactions between co-located individuals. It has been shown that co-located social touch can affect compliance to requests [10], can reduce stress [8], and can be used to communicate discrete emotions [16].

Recent studies have indicated that social touch between humans can be mediated by haptic feedback technology (i.e. mediated social touch [11]). Interesting in this regard is that mediated social touch has been found to have effects similar to co-located social touch on compliance to requests [12], perception of the communication partner [13], and the communication of affect [2], or feelings of social presence [3]. Furthermore, early work in which social touch was simulated by an agent with a physical torso and virtual head, showed that social touch by a virtual agent can influence perceptions of this agent [4]. Here, social touch is no longer applied (mediated or otherwise) by a human

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communication partner, but is simulated by a virtual agent, in sync with other modalities such as speech and gestures.

Though social touch, be it co-located, mediated, or simulated, can have effects on the interaction, such effects may strongly depend on the context in which the touch occurs. One study has found that when co-located social touch was used in a cooperative game setting, later helping behavior in a dictator game increased. However, when the same touch occurred in a competitively framed game, it had an averse effect on helping behavior [5]. In the current paper we conduct a user study to investigate whether simulated social touch by a virtual agent results in different judgements of that agent in a game setting that is either framed cooperatively or competitively.

2 Related Work

There are a number of reasons why adding social touch capabilities to an ECA may be beneficial. Social touch has been found to play a role in a wide range of interpersonal messages, such as the communication of support, appreciation, affection, and others [17]. Furthermore, social touch can positively influence compliance to requests, in a way that the one receiving the touch is more inclined to comply with the request, such as filling out bogus personality questionnaire items [19], or complying to menu item suggestions by a waiter or waitress [10]. Effects of touch that result in a behavioral change in the one receiving the touch may be dependent on the context in which the touch takes place. A study that employed a confederate that touched the participant either in a cooperative or a competitive setting, found that while touches in the collaborative setting had a positive effect on helping behavior, touches in the competitive setting had a negative effect on helping behavior in a dictator game [5].

Social touch can also be simulated by an ECA. One of the few studies investigating simulated social touch used a virtual representation of an agent's head, mounted on top of a physical mannequin [4]. The agent was able to squeeze a participant's hand. It was found that simulated social touch enhanced the perception of the relation with the agent, but only for participants that were comfortable being touched.

3 System Design

We designed a system that places two virtual agents in AR space of a tablet computer. We simulate social touch through a tactile displays worn on both upper arms by the user (see fig. 1(a)) which is actuated in sync with the touch animations of the agents (see fig. 1(b)).

Unity3D[1] with the Qualcomm Vuforia plug-in was used to develop the marker-based Augmented Reality application. As marker, we use a wall covered with printed patterns, as visible in the background of fig. 1(b). The Unity

[1] `http://unity3d.com/`

(a) (b)

Fig. 1. User wearing the vibrotactile displays and holding the tablet (a) and the Agents in AR, as seen by the user on the tablet, during a touch of the left agent (b).

Multipurpose Avatar plug-in was used to generate the two characters seen in fig. 1(b). These can be universally controlled using Unity's *Mecanim* animation system. Speech of the agents is realized with pre-recorded audio clips from speech synthesizers (Microsoft Windows 8 Hazel and Zira). Rudimentary scripts were written to implement amplitude driven lip-syncing and randomized blinking behavior of eyelids. Additional behaviors such as turning, walking, sitting, waving, and touching were implemented. In fig. 1(b), the touching animation is shown as seen by the user.

As tactile display we used the *Elitac Science Suit*[2], a modular system consisting of several eccentric mass vibration motors that can be attached to elastic bands of different sizes using Velcro. The intensity of vibration of each vibration motor can be individually controlled with sixteen levels of vibration intensity. Three actuators, with approximately 10 centimeters spacing between them, were placed in a triangular position, and were attached to each upper arm of the user. An additional six actuators (two rows of three, with approximately 10 centimeter spacing between them vertically, and approximately 20 centimeter spacing between them horizontally) were placed on the participant's abdomen to give general feedback during the game.

4 Experiment Configuration and Game

To investigate the role of touch by a virtual agent in the perception of this agent, as well as the role of a cooperative or competitive context, we designed an experiment (see Section 5). For the experiment, specific scenarios that involve two female virtual agents named Anna and Belle, were scripted using the AR touching virtual agent setup. Variables of the experiment were configured in advance, including the condition (cooperative, competitive), which of the agent was the touching agent, as well as which agent started the interaction on all

[2] `http://elitac.org/products/sciencesuit.html`

occasions. We call the latter, the assertive agent. We hypothesized that the agent that started the interaction could be perceived as more assertive. Assertiveness has been found to influence participant's perceptions of a conversational agent [20]. The flow of the experiment and dialogs is shown in table 1.

As part of the experiment, participants played a game that was framed either cooperatively or competitively. During the game, players (the participant and the two agents) collected virtual coins that were arranged in a three-dimensional grid in AR space (see fourth image in table 1). To collect a coin, the participant pointed the tablet at one of the coins and touched the screen to 'shoot'. Upon hitting the coin, it flew towards the player, increasing a common score in the cooperative condition, or a personal score in the competitive condition. To make the game more interesting, a moving block occluded some of the coins. The game was designed so that it would be impossible to collect all coins during the games duration (40 seconds). The time was shown counting down at the top of the screen. After the time ran out, the participant received feedback about his or her performance compared to the agents. For all participants in both conditions, participants were told that they performed slightly better than both agents. As shown in table 1, the two agents gave different commentary during the game, depending on the condition, and the agent's assertiveness.

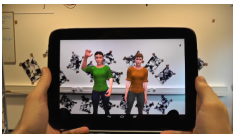
5 Experiment

Our first hypothesis was that social touch results in a more positive perception of the agent administering the touch. The second hypothesis was that, while in the cooperatively framed condition, the social touch would have positive effects on the perception of the agent, the effect would be significantly weaker or reversed (i.e. more negative judgements of the agent) in the competitive condition. Finally, we control for participants trait touch receptivity and the assertiveness of the agent. Table 1 provides an overview of the conditions.

Measures. Participants rated the agent on a list of 13 adjectives from [1]. Because of the importance of politeness in communication with ECAs, we decided to add the adjective "polite" (see also [20]), for a total of 14 adjectives. For both agents the participant indicated his or her agreement with statements like "I though Anna was likeable" on a 7-point Likert scale, ranging from "strongly disagree" to "strongly agree". The participant also completed a touch receptivity questionnaire adapted from [4], with two healthcare-specific items removed. Participants indicated their agreement to statements like "I feel uncomfortable when someone casually touches me" on a 7-point Likert scale, ranging from "strongly disagree" to "strongly agree".

Finally, a behavioral measurement was employed. After the final interaction with the participant, the agents both sat down on two of four physical chairs present in the room. The participant was asked to sit down on any of the four chairs. It was hypothesized that participants, on average, would sit next to the touching agent more than next to the non-touching agent.

Table 1. Flow of Experiment. A is the assertive, B the non-assertive agent. Touches happen on lines marked with *, if the respective agent is also the touching agent.



[START]

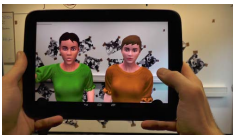
A: Hi there, I'm [Anne/Belle]. (waving)
B: And my name is [Anne/Belle], hi! (waving)

[AGENTS STEP CLOSER]

A: Here, have a look at the game instructions!

[PARTICIPANT READS GAME INSTRUCTIONS]

A: Have you read the instructions?
B: Then lets start!



A: Good luck in the game! *
B: Yes, good luck and have fun! *

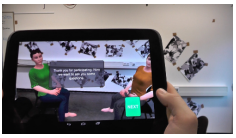
[GAME STARTS]

[COMPETITIVE]	[COOPERATIVE]
Only one of us can win	Let's work together
I was quicker than you	Good Job
That one was mine	Nice work
My accuracy is better than yours	Let's collect all the coins
These coins are mine	Well done
I will win this	We can do it

[GAME ENDS]

[RESULTS ARE DISPLAYED]

A: You did really well in the game, congrats. *
B: Yes, an impressive performance. Well done! *



A: We should do this again some time! *
B: Yes, just let us know! *

[AGENTS SIT DOWN]

[PARTICIPANT IS PROMPTED TO SIT]

[PARTICIPANT FILLS OUT QUESTIONNAIRE]

Participants. In total 42 people participated in the study. There were 29 male participants and 13 female participants. The average age was 21.5 ($SD = 2.54$). Participants were all students or employees of the University of Twente.

Procedure. After obtaining written consent, the experimenter explained the study's general procedure. Next, the vibrotactile displays were attached to the participant's body, and the participant received the tablet computer. Instructions on how to hold and use the tablet were given by the experimenter. The principle of the coin-collecting game was introduced for both conditions. Next, the working of the tactile display was tested in a trial version of the game. All further instructions were given on the tablet computer. After completing the game, the participant was asked to sit down on one of the four chairs to fill out the agent perception questionnaire, demographics, and touch receptivity questionnaire using the tablet computer. The touch receptivity questionnaire was given at the end of the session as to not to prime the participant to the agents' touches. After completing all questionnaires the participant was debriefed about the aim of the study. The total duration of the study was approximately 20 minutes.

Results

Data analysis. Data from five participants was removed because they could not correctly identify the touching agent. As it is not possible to confidently attribute these participants' ratings to either the touching or non-touching agents, only the data from the 37 remaining participants was used for all further analysis. A principal component analysis with varimax rotation and Kaiser normalization for the 14 adjectives revealed a three factor structure that explained 59.5% of the total variance. Table 2 shows the factors, items, and factor loadings. The first factor describes the trustworthiness of the agent, which consists of items such as trustworthy, and competent. The second factor, warmth, deals with more affective interpersonal aspects of the agent, such as its friendliness and likeability. Finally, the third factor describes the agent's politeness, with the items polite and modest. The touch receptivity questionnaire had an acceptable internal consistency ($\alpha = .69$). A median split procedure ($Mdn = 4.71$) was used to divide participants into 'touch receptive' ($n = 15$, $M = 5.32$, $SD = 0.38$) and 'non-touch receptive' ($n = 22$, $M = 4.18$, $SD = 0.56$) groups.

Behavioral measure. Overall, the behavioral measure that was employed showed no clear preference for sitting either next to a touching agent (18 participants) or non-touching agent (17 participants)[3]. Furthermore, participants showed no preference for siting next to an assertive (19 participants) or non-asssertive (18 participants) agent. Participants higher in touch receptivity also did not sit next to a touching agent, more than participants who were less touch receptive. These findings are similar for both cooperative and competitive settings.

[3] The remainder of the participants chose to sit on a chair occupied by one of the agents in AR.

Table 2. Principal component analysis of 14 adjectives

Factor	Item	Factor loading
Trustworthiness (α = .82)	Honest	.76
	Informed	.75
	Competent	.71
	Trustworthy	.71
	Sincere	.67
	Credible	.62
	Interesting	.48
Warmth (α = .81)	Approachable	.76
	Warm	.74
	Confident	.73
	Friendly	.65
	Likeable	.59
Politeness (α = .69)	Polite	.83
	Modest	.80

Perception of the agents. We ran a repeated measures ANOVA with Greenhouse-Geisser correction, with touch/non-touching agent as the within subjects variable, and agent assertiveness (the agent is assertive or not), touch receptivity (touch receptive and non-touch receptive), and condition (cooperative or competitive) as between subject factors. We found no significant main effects or interaction effects for the between subject factors (all p's $>$.05). However, we did find a significant main effect of touching/non-touching agent (F(3.56, 103.13) = 5.96, p <.001).

Paired-samples tests were used to further explore the within-subject effects. We first compared ratings for trustworthiness, warmth, and politeness between the touching and non-touching agents. Trustworthiness, and politeness did not show a significant difference, however, warmth was rated higher overall for touching agents (M = 4.90) compared to non-touching agents (M = 4.16)(t(36) = 4.69, p <.001).

To assess whether the agent's assertiveness influenced participants' perceptions of the agent we ran a paired-samples comparison for the three factors for assertive agents and non-assertive agents. We found a significant difference for trustworthiness between assertive (M = 4.48) and non-assertive (M = 4.23) agents (t(36) = 2.31, p <.05). We found no differences between assertive and non-assertive agents for the other two factors.

To check for the influence of touch receptivity we ran paired-samples comparisons for the three factors, for touch receptive and non-touch receptive participants. For touch receptive participants, warmth, was again rated higher for the touching agent (M = 5.29) compared to the non-touching agent (M = 4.19)(t(14) = 8.56, p <.001). For non-touch receptive individuals however, the difference for warmth between the touching (M= 4.62) and non-touching agent (M = 4.16) was only marginally significant (t(21) = 2.04, p = .054).

Differences for trustworthiness and politeness were nonsignificant ($p > .05$). Finally, a significant positive correlation ($r = .43$, $p < .01$) between ratings for the touching agent's warmth and touch receptivity, further supports the relation between touch receptivity and perceptions of warmth for the touching agent.

6 Discussion and Conclusions

Overall we found that participants rated the touching virtual agent significantly higher on warmth than the non-touching agent. This effect was more pronounced for touch receptive participants. For non-touch receptive participants the difference for warmth was only marginally significant. Aspects of the agent related to trustworthiness or politeness were not affected by the agent's touch. Our findings suggest that touch by a virtual agent can enhance perceptions of more affective attributes of this agent. Participants who are comfortable with social touch, seem to respond more strongly in this way than participants who are less comfortable with social touch.

We did not find any significant difference in the judgement of assertive or non-assertive agents for warmth or politeness. We did however find a significant difference for trustworthiness between assertive and non-assertive agents. This indicates that the assertive agent, who started the interactions, was seen as a more trustworthy, irrespective of whether the agent applied a social touch or not. However, considering that our manipulation of assertiveness was limited, this conclusion is far from definitive. These findings partially support our initial hypothesis. However, we found that the framing of the context in which the touch by the agent took place, did not affect the participants' judgement of the agent applying the touch. Based on a previous study [5] we expected that social touch by a virtual agent in a cooperative setting would result in more favorable judgements of this agent compared to an agent applying the same touch in a competitive setting. A possible explanation for this difference is that previous research was conducted with co-located social touch occurring between two humans. A reduction in helping behavior was attributed to the participants perceiving the touching confederate in the competitive setting as dominant. It is possible that due to the relatively simple facial animations, and friendly dialog, our touching agent was not perceived as dominant. Thus, no clear negative effect of the touch in the competitive setting occurred. What is more, [5] employed a behavioral measure that involved participants sharing a reward with their competitor (i.e. the confederate). We decided against a behavioral measure similar to [5] because anything valuable to the participant (e.g. a monetary reward) could not reasonably be 'shared' with the virtual agent. Potentially, the lack of a reward contributed to participants in our study not considering the context as 'high stakes', in which a touch by a competitor might be perceived as an expression of dominance. Therefore, the simulated social touch by the agent in the competitive setting did not have a clear negative effect. A stronger manipulation of the cooperativeness or competitiveness of the setting in combination with an agent's simulated social touch would be an interesting direct for future research.

In our study we did not find such an overall effect of touch receptivity on the perception of the touching agents. The lack of a more clear distinction between touch receptive and non-touch receptive participants in our study can be attributed to a number of factors. First, the touches applied in our study were more casual in nature, with the interaction less focussed on the touch per se. This might have negated any clear negative effect of the touch that non-touch receptive participants might have experienced. Second, the distinction between touch receptive and non-touch receptive participants was more pronounced in [4], compared to participants in our study. Finally, our touch receptivity measure was taken after the experiment as to not to prime participants to the agent's touches. However, the experiment itself might have primed participants to think of themselves as more touch receptive individuals.

To conclude, our study indicates that simulated social touch by a virtual agent enhances the perception of more affective aspects (i.e. warmth) of this agent. This effect occurred more strongly for individuals who were comfortable with social touch. Neither the assertiveness of the agent, nor the context in which the touch occurred had an influence on this effect in our study. Our findings suggest that touch might be a useful modality in the communication with virtual agents, specifically where the communication of affect is concerned. Simulated social touch by a virtual agent might be used in therapy settings, where the agent shows support or empathy [4]. Furthermore, touch by an ECA may be employed in settings where an ECA assists a user with a task, such as an information search task, to make the agent seem more warm irrespective of it's actual performance. Finally, a touching agent could be used in entertainment or gaming scenarios to enhance feelings of warmth between the player and a virtual character in the game. Ultimately, simulated social touch might be used to forge stronger affective bonds between agents and their human communication partners.

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