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PISTIS - Persuasion in social touch interactions

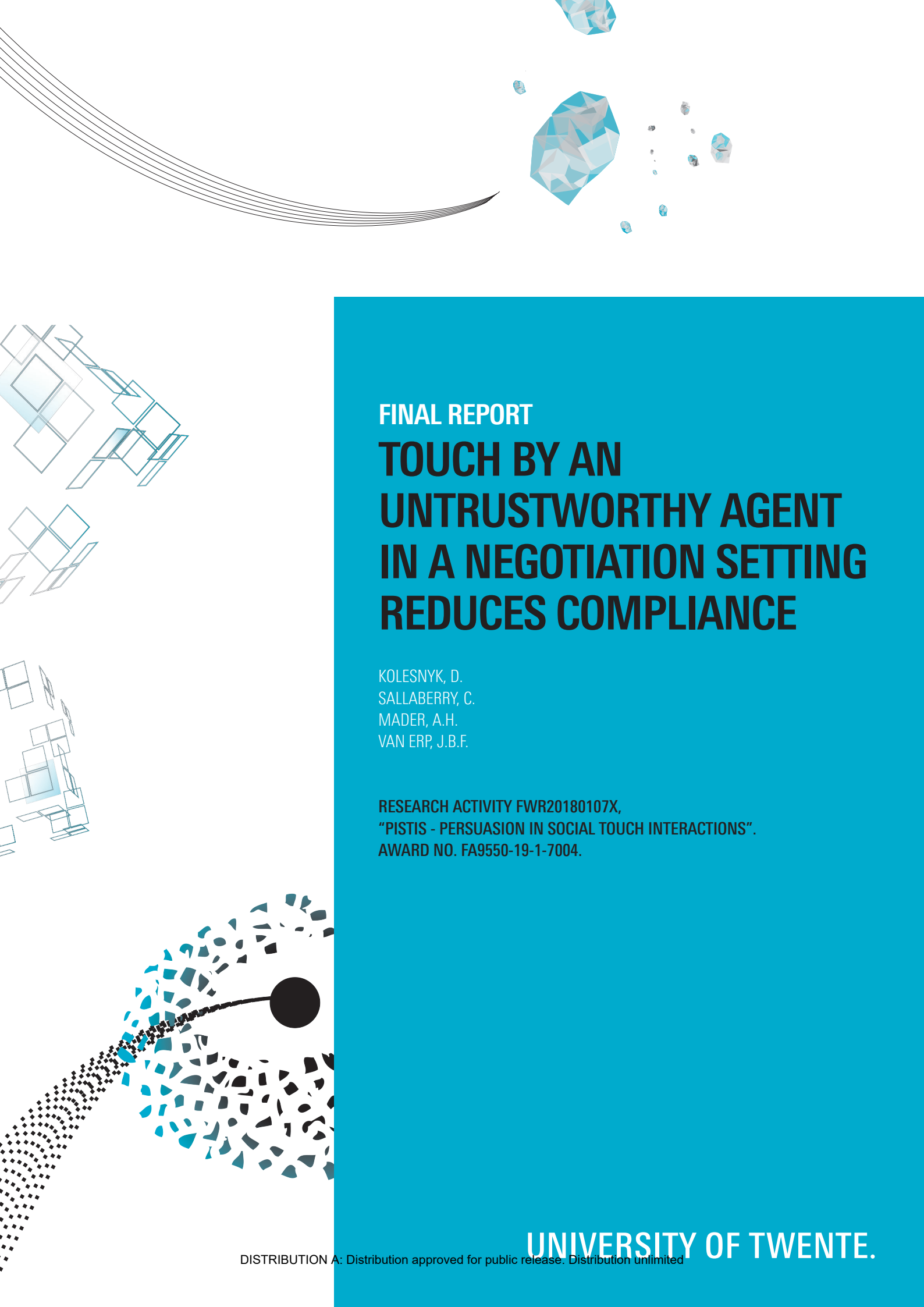
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FINAL REPORT

TOUCH BY AN UNTRUSTWORTHY AGENT IN A NEGOTIATION SETTING REDUCES COMPLIANCE

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ABSTRACT

A social touch between two people or a user and a Virtual Agent (VA) can increase compliance in neutral and collaborative settings. In this study, we look at the effects of a social touch by a VA in a negotiation setting and the role of trust in the VA as moderating variable. In Experiment 1, 63 participants were randomly assigned to a touch or a no-touch group and negotiated prices with a virtual, female bar owner on behalf of their student society. We found that touch had a negative effect on compliance for people who perceive the VA to be untrustworthy, and had no effect for people who perceived the VA to be moderately or highly trustworthy. In Experiment 2, we manipulated the trustworthiness of the VA through her face expression and the written introduction to the experiment. Ninety six participants were randomly assigned to a touch or a no-touch group and completed the same negotiation scenario. We found that touch by the untrustworthy VA resulted in lower compliance than touch by a neutral VA, confirming the results of Experiment 1. These results show that a positive effect of a social touch on compliance may be absent in a competitive settings, and may even be negative if the touching 'opponent' is perceived as untrustworthy. Our study adds to our knowledge on the boundary conditions for VAs and robots with social touch capabilities.

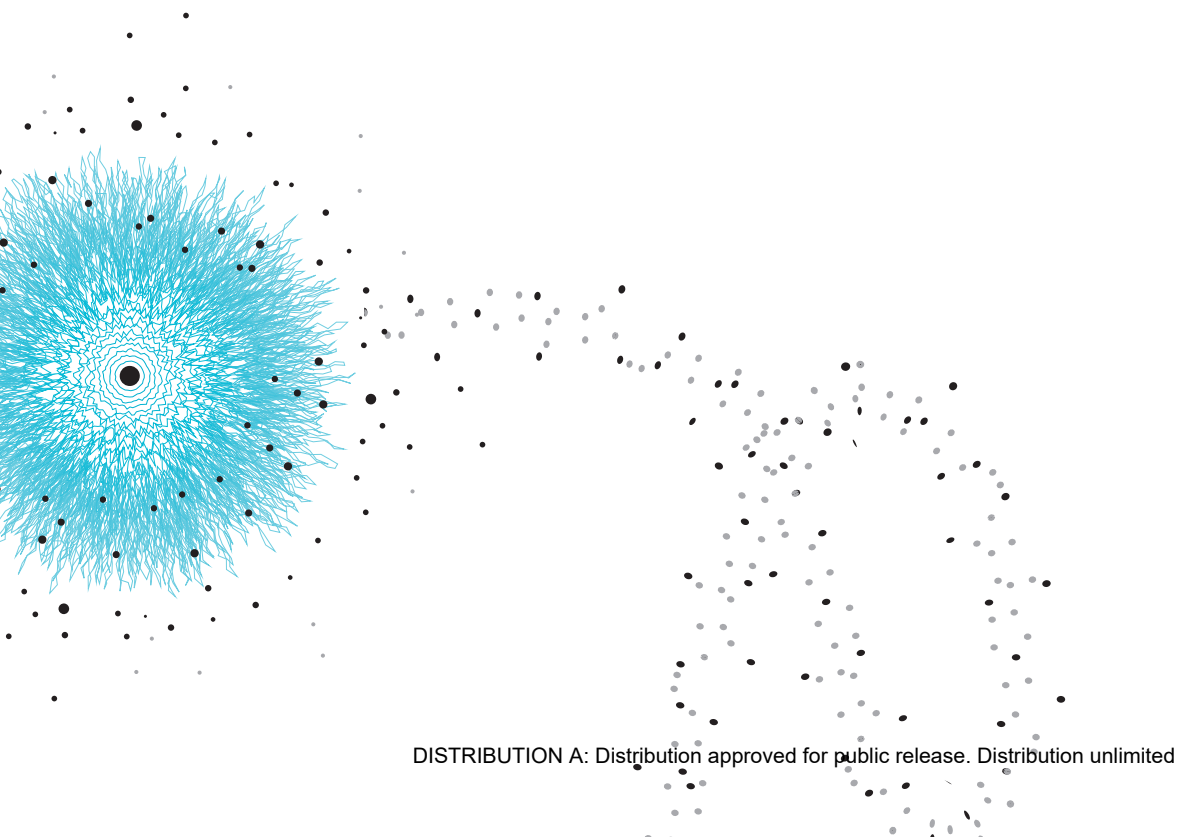
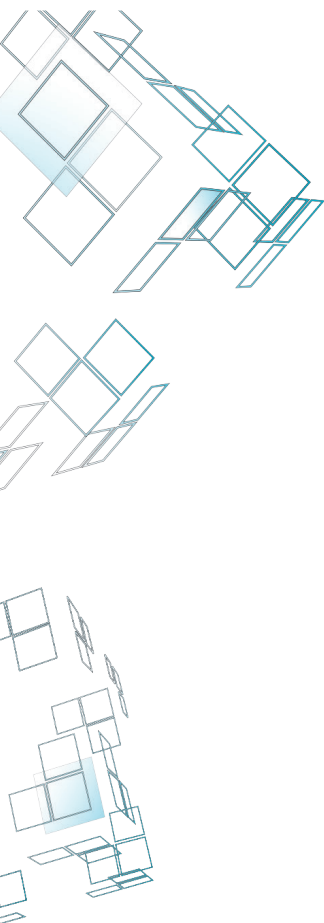


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INTRODUCTION

Virtual reality (VR) is becoming increasingly important for a large variety of training and coaching applications in military, healthcare and education (de Ribaupierre et al., 2014; Freina & Ott, 2015). Such applications recently began to exploit multisensory properties of virtual environments, which include not only visual and auditory stimuli, but also sensations of temperature, air flow, humidity, haptic sensations, and so on (for instance, Lawson et al., 2019; Serino et al., 2018). At the same time, VR applications experiment with incorporating Virtual Agents (VA) expressing complex social cues, such as facial expression, body posture, gaze, prosody, and touch in the interactions with the user. According to Cascioa, Moore and McGlone (2019), social touch includes all interpersonal touch between people as long as there is a communicative intent, behavioral outcome, or learned association. Advances in technologies related to haptic sensation in VR on the one hand, and the emphasis placed on the importance of “naturalness” of social interaction in VR on the other hand, lead to development of social touch technology (Huisman, 2017). Social touch technology is a broad category of devices that allow conveying social touch without direct physical contact. The availability of social touch technology in turn leads to the question: how do people experience touching and being touched by the VAs, what are the effects on the user’s emotions and behaviour, and what are the boundary conditions for VAs to use touch (Van Erp & Toet, 2013)?

The topic of social touch in VR is a largely unexplored topic. Multiple studies have examined the effects of touch in human-human social communication. However, few have examined to what extent those effects hold in an interaction between a human and a VA (Van Erp & Toet, 2015; Willemse, Toet & Van Erp, 2017).

In the human-human context, social touch has multiple functions. Touch can communicate distinct basic emotions (Hertenstein et al., 2006; Hertenstein et al., 2009), as well as more complex social information, like trust or love (App et al., 2011). Further, touch can also elicit emotions (Suk et al., 2009) and positively affect one’s overall evaluation of the communication context (Fisher, Rytting & Heslin, 1976; Hornik, 1992). To add more, social touch can increase people’s willingness to tip in a restaurant (Crusco & Werzel, 1984), to give a cigarette to a stranger (Joule & Guéguen, 2007), to participate in a survey (Guéguen 2002), or adhere to medication (Guéguen, Meineri & Charles-Sire, 2010). To investigate these effects of touch on cooperation and compliance within human-VA teams the focus of the present report.

It is known that the effect of social touch on compliance in direct human – human interaction is transferable to the context of human – human technology mediated communication (For reviews, see Haans et al., 2014; Van Erp & Toet, 2015). Although the majority of the studies report a positive effect of social touch, both for direct and for mediated social interaction, many contextual factors play a role including who is delivering the touch and the intention behind the touch (Cascioa et al., 2019). For instance, social touch does not affect compliance if the task is too demanding (Gueguen et al., 2011). The effect is also sensitive to the gender composition of the dyad. Specifically, across studies that found an effect of touch, a touch performed by a woman always had an effect, while the effect of touch by a man was sometimes weaker or absent (Crusco & Werzel, 1984; Argo & Levav, 2010).

The majority of the social touch studies investigated social touch effects in a neutral or collaborative context including romantic couples, sports teams, and in casual encounters between strangers. Social touch in a more competitive settings is hardly researched. In this study we assess whether touch by a VA via social touch technology affects compliance in the context of negotiation (i.e., a competitive setting) between a user and a VA.

The main research question of this study is: *Does social touch by a VA increase people’s compliance in the context of verbal negotiation?* In this study we implement the social touch as a short (1-2 seconds long) static casual touch on a socially acceptable body part (arm). That is a touch that in many cultures is casually used between strangers or colleagues, as well as among people who are in more close ties. Such short casual social touch, also sometime referred to as Midas touch, is known to affect compliance in human social interactions in neutral and collaborative settings. If the type of setting is not modulating the effects of social touch, we can expect that people touched by the VA would be more likely to comply with the VA’s request in a negotiation compared to people who were not touched by the VA. However, Willemse and Van Erp (2019) showed that trustworthiness of the VA and compliance have a reciprocal, positive effect in a non-competitive setting. It may be that this reciprocal effect is negative in a competitive

setting. In this case, we can expect that people are less likely to comply with the VA's request. We investigate the effect of social touch in a competitive setting and the role of trustworthiness of the VA in two studies. In the first study, we explore whether perceived trustworthiness of the VA modulates the effect of touch on compliance, so that social touch would lead to increased perceived trustworthiness of the VA, and in turn would lead to increased compliance as reported by Willemse and Van Erp (2019). In the second study we manipulate the trustworthiness of the VA by changing her facial expression and the storyline participants read before the study to directly measure if the effect of social touch on compliance depends on the VA's trustworthiness. Since gender effects are not our main focus, the toucher (the VA) in both experiments is female.

STUDY 1

PARTICIPANTS

Seventy students from a European University and of various cultural backgrounds were recruited for Study 1. Six students were excluded due to poor English language comprehension or violation of the experimental procedure. After checking the data, one participant who deviated more than three standard deviations from the mean on the main outcome measure was excluded as an outlier. Thus, the final sample included 63 students (31 female): 33 in the touch group (12 females) and 30 in the no-touch (control) group (19 females). The experiment was approved by the review board of TNO, The Netherlands (reference TNO TC-nWMO 2017-031).

TASK AND APPARATUS

Participants were invited to a lab and asked to negotiate prices of four products in the bar that is hosting their student association meetings. The negotiation scenario and comprehension task were adapted from Harinck and Druckman (2017). The owner of the bar (represented by the VA) was asking for higher prices, while the participants had to negotiate the smallest possible increase, but still reach an agreement with the VA. According to the scenario, price increases for different products lead to different additional costs for the student association per month as products are consumed in different quantities.

The bar owner (the VA) was a casually dressed woman (Figure 1). Both the VA and the participant were seated at the corner of a bar, under a 90-degree angle. The VA was on the left side of the participant. The interaction with the VA followed a decision tree, controlled by the experimenter using Wizard of Oz.

The VA was designed in UNITY, the environment (a bar) is commercially available from the UNITY store. The equipment included a VR headset with a built-in sound system (HTC Vive pro), two arm trackers (HTC Vive), a high table, a bar chair and a vibrotactile sleeve. The sleeve was handmade by one of the co-authors and consisted of stretchy fabric covering the lower part of the left forearm, four vibrotactile motors (8 mm diameter) and an Arduino (Figure 1). The sleeve was synchronized with the visual input from UNITY and vibrated when participants were touched by the VA. The touch by the VA lasted around 1.8 seconds, the VA touched participants in the touch group twice (see procedure for details).

DESIGN AND VARIABLES

Study 1 had a between-subject experimental design with two groups - touch or no touch. The extra monthly expenses (i.e. the sum of extra expenses resulting from each negotiated increase in price for all four items) was treated as the dependent variable: the higher total increase participants agreed to, the more they complied with the request of the VA. The total extra expenses for the student association over all four items could range between 0 and 400 euros per month.

We used two measures to assess trust during the interaction: the trustworthiness sub-scale from Ohanian (1990; 4 items, semantic differential, example "honest-dishonest") and the short version of the Organizational Trust Scale (OTI; Cummings & Bromiley, 1996, 12 items, Likert scale, example: "I think the VA tells the truth in the negotiation"). These measures were used to split both experimental groups in 'low', 'medium', and 'high' trust.

Finally, participants filled out a questionnaire, assessing a) whether participants felt safe during the interaction (Levav & Argo, 2010; six semantic differential items, example "safe-unsafe"), b) whether they were aware of the touch ("Has the VA touched you?") and if so whether they liked it (on a 10-point Likert scale), and c) their overall receptivity to touch (Bickmore et al., 2010; 10 items using Likert scale, example item "I like people who casually touch a lot").

PROCEDURE AND MEASUREMENT



Figure 1. The virtual reality setup. Left: A participant wearing the vibrotactile sleeve on the left forearm, holding the movement trackers and wearing the VR head setup. Right: The virtual environment (bar) with the VA that were used in the study. The VA reaching towards the user's forearm just before the touch.

Participants were invited in the lab and received by a male experimenter who welcomed the participants and walked them to a laptop with the study instructions. After reading and signing the informed consent, participants received written information on the negotiation scenario and the role they had to represent in the negotiation (see Appendix). To verify that the participants understood the scenario and conditions, they were asked to answer a 5-item comprehension test. If answers were incorrect, participants were asked to review the scenario until the correct answers were given. After passing the test, the experimenter helped participants to put on the VR headset and the vibrotactile sleeve, and participants proceeded to the negotiation with the VA. The conversation with the VA started with an introduction during which the VA touched the participants assigned to the touch group for the first time. Then negotiation proceeded for each item one by one (soda, beer, liquor, snack). If participants offered a price below the fair middle, the VA would request an increase once. The participant could offer a higher price or keep the price the same, after which the negotiation proceeded to the next item. When moving to the fourth negotiation item (snacks), the VA touched the participants in the touch condition for the second time. For the snacks item, if the participants did not offer the highest price after the second request, they were offered an opportunity to lower the price for one other item if they agreed to the highest price for snacks. Participants in the no-touch (control) group had exactly the same negotiation procedure and wore the vibro-tactile sleeve, but since they were not touched, the sleeve did not vibrate. After the negotiation, participants filled in the questionnaires on a laptop.

RESULTS

The participants agreed to spend between 20 and 210 euros per month extra, with mean at 120 euros ($SD = 45$ euros), the distribution was not significantly different from normal and all assumptions of ANOVA were met. All of the used scales had an acceptable reliability (Cronbach's Alpha above .7).

To investigate the moderating role of the trustworthiness levels, we used quantile split with two cut points to divide the sample into three groups based on perceived trustworthiness of the agent: low, medium and high trustworthiness. We then ran a 2 (touch vs no touch) $\times$ 3 (low, medium, high trustworthiness) ANOVA. The model explained 15% variance, $F(5, 57) = 1.95$, $p = .1$. The main effects were not significant for both Touch, $F(1, 57) = 1.76$, $p = .19$, and Trustworthiness

level, $F(2, 57) = 0.46$, $p = .631$. However, the interaction effect was significant, $F(2, 57) = 3.60$, $p = .034$. The means are presented in Table 1 and the simple effect tests indicate that touch had a significant negative effect on compliance only among people who gave the agent low scores on trustworthiness. There was no effect of Touch for respondents who rated the agent and moderately or highly trustworthy.

Table 1. The effect of touch on the negotiated outcome for three levels of perceived trustworthiness of the VA (quantile split).

Trustworthiness	M, touch	M, no touch	Simple effect (pairwise comparison)	Partial eta squared
Low	81.1	140.0	$F(1,57)=8.50$, $p=.005$	0.13
Medium	122.2	112.1	$F(1,57)=0.29$, $p=.594$	0.01
High	126.0	123.3	$F(1,57)=0.16$, $p=.901$	0.00

The first study revealed that touch can have a negative effect on compliance in a competitive setting, when the touching VA is perceived as untrustworthy. However, trustworthiness was not manipulated in this study, and hence no causal relation can be established. In order to establish causality, we replicate the same study protocol in Study 2, but additionally explicitly manipulate trustworthiness level of the VA.

STUDY 2

PROCEDURE AND MEASUREMENT

Study 2 used the same procedure and scenario as in Study 1, but we manipulated the trustworthiness of the virtual agent, resulting in a 2 (touch vs. no touch) by 2 (low vs. neutral trustworthiness) design. The trustworthiness of the virtual agent was manipulated as in Schul et al. (2004): in the scenario description, which participants read before the start of the negotiation, we added a picture of the virtual agent (bar owner) either with trustworthy round eyes or with untrustworthy narrow eyes (Figure 2). We additionally augmented the scenario description either with “During the first negotiation meeting, you did not reach an agreement, because you did not have enough time to review the new menu together”, or with “During the first negotiation meeting, you did not reach an agreement, because the owner was not transparent about the new menu”.



Figure 2. The manipulation of the trustworthiness of the virtual agent - trustworthy (left) and nontrustworthy (right).

After the negotiation we used the same measures of safety, trustworthiness, and a shorter version of the receptivity to touch using only 5 highest loading items from Bickmore et al., 2010). We replaced the organizational trust scale by general trust scale items (3 highest loading items from Yamagishi & Yamagishi, 1994; “Most people are basically honest/trustworthy/basically good and kind”) and general distrust scale (Yamagishi & Yamagishi, 1988; 8 items with Likert-scale items, example: “In dealing with strangers, one is better off to be cautious until they have provided evidence that they are trustworthy.”).

RESULTS

Ninety six participants were recruited for this study¹. Twelve had to be excluded due to not following the procedure, or due to technical failures. One outlier was excluded due to very high score on the main outcome measure (more than 3 SD above the mean). The final sample, thus, consisted of 82 participants (56 male). The participants agreed to spend between 10 and 280 euros per month extra, with mean at 129 euros (SD = 59 euros), similar to Study 1. All of the used scales had an acceptable reliability (Cronbach’s Alpha above .7).

Confirming the previously found interaction, an ANOVA (R squared = .06) with Touch (*present, absent*) and Trustworthiness (*low, neutral*) on the negotiation outcome (quantified as extra expenses per month agreed upon) revealed a significant touch-trustworthiness interaction effect, $F(1, 78) = 4.29, p = .042, \eta^2 = .05$. In the neutral trustworthiness condition, the average extra expenses per month were non-significantly higher for the touched participants – $M_{\text{touch}} = 152.4$ and $M_{\text{no touch}} = 120.9, F(1, 78) = 2.87, p = .094, \eta^2 = .04$, but in the low trustworthiness conditions this pattern was opposite – $M_{\text{touch}} = 113$ and $M_{\text{no touch}} = 135, F(1, 78) = 1.50, p = .224, \eta^2 = .02$. That is, the interaction effect from study 1 was replicated, suggesting that under low trustworthiness, touch might have negative effect on compliance.

The main effects of Touch, $F(1, 78) = 0.14, p = .71$ ($M_{\text{touch}} = 132.6, M_{\text{no touch}} = 127.9, \eta^2 = .00$), and Trustworthiness, $F(1, 78) = 0.95, p = .33$, ($M_{\text{low}} = 124, M_{\text{neutral}} = 136.6, \eta^2 = .01$), were again not significant.

To test the robustness of the effect, we ran five additional ANOVAs, which in addition to the main effects and interaction, each controlled for one of the covariates – safety, perceived trustworthiness, touch receptivity, general trust and general distrust. The interaction effect remained significant in all the five models.

GENERAL DISCUSSION

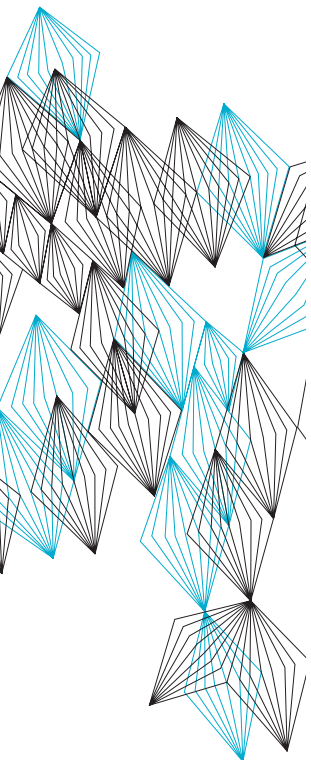
The present study looked at the effect of social touch in a negotiation setting between a human and a VA. Previous research in human to human communication and human – virtual entity communication suggested that touch by a VA can make people more compliant to the requests of the toucher (Gallace & Spence, 2010; Levav & Argo, 2010; Willemse & van Erp, 2019). However, it remained a question whether this effect would hold in a human – VA interaction in a negotiation setting.

Contrary to previous studies, we found no evidence of touch increasing compliance in the negotiation with a VA. Moreover, we found that people who perceive the VA to be untrustworthy were less compliant, as they insisted on more favourable negotiation outcomes for themselves when they were being touched.

Our findings could have at least three potential explanations. One explanation is that the effects of touch in human-to-human communication are not transferable to the interaction between a human and a VA. This explanation is less plausible due to previous evidence that touch by a VA might lead to increased perceived warmth of the VA (e.g., Huisman, Kolkmeier & Heylen, 2014). Thus, at least under some circumstances, touch by a VA could actually have effects similar to those induced by a human touch.

Another explanation could lie in the competitive nature of the interaction. The framing for the participants in the current experiments (they had to negotiate the best prices on behalf of their

¹ N.B.: Study 2, unlike Study 1, was conducted in the time of COVID-19 pandemic under partial lockdown and social distancing regulations.



fellow students) may have set them in a competitive mode. In such an environment, touch might still have a positive effect. For instance, Harjunen and colleagues (2018) found a positive combined effect of touch and smile on compliance in the context of ultimatum game paradigm. However, there is also research that suggests that social touch can have a negative effect in a competitive environment, possibly because touch signals dominance (Camps et al., 2013). Dominance could also explain why trustworthiness moderated the effect of touch. Dominance from an untrustworthy party can be perceived as transgression, while from a trustworthy party it could be seen as support and patronage. The effect of social touch in a competitive setting has hardly been researched: Most studies reported in the literature focus on the positive effects of social touch in a cooperative setting. Thus, the effect should be studied with more rigor, accounting for interactions with other social cues and across a variety of cooperative and competitive environments.

The third explanation reconciling our findings and those from previous studies, could be that touch does not have a one-directional effect, but rather acts as “amplifier” of the context in a given situation. In that sense, the explanation of the previous paragraph would also fit this theoretical framework. Touch might have a negative effect on compliance and cooperation when the interaction context suggests anything threatening or unpleasant – whether it is due to competitive nature of the task, or due to perceiving the communication partner as untrustworthy. In the meantime, touch might have a positive effect on compliance and cooperation, when the setting is friendly, as the communication partner is unthreatening, or even highly trustworthy. This suggestion could be tested in further studies by systematically manipulating various aspects of the context – from the aspects of the task itself, to the environment, to the characteristics of the interaction partner.

The important implication of our findings is that social touch can affect interaction and cooperation in human-VA interaction. Trustworthiness is a key factor in the effectiveness of mixed teams (Hanna & Richards, 2015; Schaefer et al., 2017). On the one hand, humans should rely sufficiently on the VA, so that the advices proposed by the VA are taken seriously. On the other hand, humans should also not over rely on technology, because mistakes can happen (Hancock et al., 2011). If touch can have both positive and negative effect on compliance, the haptic aspect of interaction in mixed teams should be treated with care when designing interactive systems. There are applications, where it might be beneficial to intentionally incorporate social touch into the interaction scripts. In the meantime, there are also applications where touch is necessary by design of the system (some training purposes, for example). Our findings highlight that the specific context in which touch occurs matters, and, should therefore be carefully tested before implementation.

This research will advance the insights into how to design VAs with social touch capabilities in order to improve collaboration with the agent, its persuasiveness, and trust in the agent’s judgments (e.g., Pinyol & Sabater-Mir, 2013). Moreover, the proposed research complements ongoing research on humans touching (embodied) virtual entities (e.g., Bailenson & Yee, 2008; Jung et al., 2017), and thus is an essential step towards bidirectional touch interactions and a closed communication loop between humans and VAs. Finally, the insights gained from this research may extend to interactions with other artificial social entities such as social robots.

Concluding, non-verbal tactile interaction with a VA can be quite nuanced and deserves special attention. As virtual environments develop, the key challenge is to understand how our knowledge about collaboration in human teams transfers to human-VA teams. Reversely, virtual environments offer an unprecedented possibility to control for all potential additional social cues (such as facial expression, voice tone, or), that cannot be controlled for in human-human studies, and thus broaden our understanding of social touch effects in human-human interactions. Our study makes the first steps towards deeper understanding of the dynamics of the haptic interaction in mixed human-VA teams, and effects of social touch on compliance and cooperation as such.

REFERENCES

- App, B., McIntosh, D. N., Reed, C. L., & Hertenstein, M. J. (2011). Nonverbal channel use in communication of emotion: How may depend on why. *Emotion*, 11(3), 603.
- Bailenson, J. N., & Yee, N. (2008). Virtual interpersonal touch: Haptic interaction and copresence in collaborative virtual environments. *Multimedia Tools and Applications*, 37(1), 5-14.
- Baron, R. M., & Kenny, D. A. (1986). The moderator–mediator variable distinction in social psychological research: *Conceptual, strategic, and statistical considerations*. *Journal of personality and social psychology*, 51(6), 1173.
- Bickmore, T. W., Fernando, R., Ring, L., & Schulman, D. (2010). Empathic touch by relational agents. *IEEE Transactions on Affective Computing*, 1(1), 60-71.
- Camps, J., Tuteleers, C., Stouten, J., & Nelissen, J. (2013). A situational touch: How touch affects people's decision behavior. *Social Influence*, 8(4), 237-250.
- Cascio, C. J., Moore, D. & McGlone, F. (2019). Social touch and human development. *Developmental Cognitive Neuroscience*, 35, 5-11.
- Cramer, H., Kemper, N., Amin, A., Wielinga, B., & Evers, V. (2009). 'Give me a hug': the effects of touch and autonomy on people's responses to embodied social agents. *Computer Animation and Virtual Worlds*, 20(2-3), 437-445.
- Crusco, A. H., & Wetzel, C. G. (1984). The Midas touch: The effects of interpersonal touch on restaurant tipping. *Personality and Social Psychology Bulletin*, 10(4), 512-517.
- de Ribaupierre, S., Kapralos, B., Haji, F., Stroulia, E., Dubrowski, A., & Eagleson, R. (2014). Healthcare training enhancement through virtual reality and serious games. In *Virtual, Augmented Reality and Serious Games for Healthcare 1* (pp. 9-27). Springer, Berlin, Heidelberg.
- Fisher, J. D., Rytting, M., & Heslin, R. (1976). Hands touching hands: Affective and evaluative effects of an interpersonal touch. *Sociometry*, 416-421.
- Freina, L., & Ott, M. (2015, April). A literature review on immersive virtual reality in education: state of the art and perspectives. In *The International Scientific Conference eLearning and Software for Education* (Vol. 1, No. 133, pp. 10-1007).
- Gallace, A., & Spence, C. (2010). The science of interpersonal touch: an overview. *Neuroscience & Biobehavioral Reviews*, 34(2), 246-259.
- Guéguen, N. (2002). Touch, awareness of touch, and compliance with a request. *Perceptual and motor skills*, 95(2), 355-360.
- Guéguen, N., Afifi, F., Brault, S., Charles-Sire, V., Leforestier, P. M., Morzedec, A., & Piron, E. (2011). Failure of tactile contact to increase request compliance: The case of blood donation behavior. *Journal of Articles in Support of the Null Hypothesis*, 8(1), 1-8.
- Guéguen, N., Meineri, S., & Charles-Sire, V. (2010). Improving medication adherence by using practitioner nonverbal techniques: a field experiment on the effect of touch. *Journal of behavioral medicine*, 33(6), 466-473.
- Haans, A., de Bruijn, R., & IJsselstein, W. A. (2014). A virtual midas touch? Touch, compliance, and confederate bias in mediated communication. *Journal of Nonverbal Behavior*, 38(3), 301-311.
- Hancock, P. A., Billings, D. R., Schaefer, K. E., Chen, J. Y., De Visser, E. J., & Parasuraman, R. (2011). A meta-analysis of factors affecting trust in human-robot interaction. *Human factors*, 53(5), 517-527.

- Hanna, N., & Richards, D. (2014). "Building a Bridge": communication, trust and commitment in human-intelligent virtual agent teams. In *International Workshop on Human-Agent Interaction Design and Models* (3rd: 2014) (pp. 1-13). HAIDM 2014.
- Harinck, F., & Druckman, D. (2017). Do negotiation interventions matter? Resolving conflicting interests and values. *Journal of Conflict Resolution*, 61(1), 29-55.
- Harjunen, V. J., Spape, M., Ahmed, I., Jacucci, G., & Ravaja, N. (2018). Persuaded by the machine: The effect of virtual nonverbal cues and individual differences on compliance in economic bargaining. *Computers in Human Behavior*, 87, 384-394.
- Hertenstein, M. J., Holmes, R., McCullough, M., & Keltner, D. (2009). The communication of emotion via touch. *Emotion*, 9(4), 566.
- Hertenstein, M. J., Keltner, D., App, B., Buleit, B. A., & Jaskolka, A. R. (2006). Touch communicates distinct emotions. *Emotion*, 6(3), 528.
- Hertzum, M., Andersen, H. H., Andersen, V., & Hansen, C. B. (2002). Trust in information sources: seeking information from people, documents, and virtual agents. *Interacting with computers*, 14(5), 575-599.
- Huisman, G. (2017). Social touch technology: a survey of haptic technology for social touch. *IEEE transactions on haptics*, 10(3), 391-408.
- Huisman, G., Kolkmeier, J., & Heylen, D. (2014). With us or against us: simulated social touch by virtual agents in a cooperative or competitive setting. In *International Conference on Intelligent Virtual Agents* (pp. 204-213). Springer, Cham.
- Joule, R. V., & Guéguen, N. (2007). Touch, compliance, and awareness of tactile contact. *Perceptual and motor skills*, 104(2), 581-588.
- Jung, M. M., Poel, M., Poppe, R., & Heylen, D. K. (2017). Automatic recognition of touch gestures in the corpus of social touch. *Journal on multimodal user interfaces*, 11(1), 81-96.
- Khalid, H. M., Shiung, L. W., Sheng, V. B., & Helander, M. G. (2018). Trust of Virtual Agent in Multi Actor Interactions. *Journal of Robotics, Networking and Artificial Life*, 4(4), 295-298.
- Lawson, G., Shaw, E., Roper, T., Nilsson, T., Bajorunaite, L., & Batool, A. (2019). Immersive virtual worlds: Multi-sensory virtual environments for health and safety training. *arXiv preprint arXiv:1910.04697*.
- Levav, J., & Argo, J. J. (2010). Physical contact and financial risk taking. *Psychological Science*, 21(6), 804-810.
- Ohanian, R. (1990). Construction and validation of a scale to measure celebrity endorsers' perceived expertise, trustworthiness, and attractiveness. *Journal of advertising*, 19(3), 39-52.
- Pinyol, I., & Sabater-Mir, J. (2013). Computational trust and reputation models for open multi-agent systems: a review. *Artificial Intelligence Review*, 40(1), 1-25.
- Ramchurn, S. D., Huynh, D., & Jennings, N. R. (2004). Trust in multi-agent systems. *The Knowledge Engineering Review*, 19(1), 1-25.
- Schaefer, K. E., Straub, E. R., Chen, J. Y., Putney, J., & Evans III, A. W. (2017). Communicating intent to develop shared situation awareness and engender trust in human-agent teams. *Cognitive Systems Research*, 46, 26-39.
- Schul, Y., Mayo, R., & Burnstein, E. (2004). Encoding under trust and distrust: the spontaneous activation of incongruent cognitions. *Journal of personality and social psychology*, 86(5), 668.
- Serino, A., Noel, J. P., Mange, R., Canzoneri, E., Pellencin, E., Ruiz, J. B., ... & Herbelin, B. (2018). Peripersonal space: an index of multisensory body-environment interactions in real, virtual, and

mixed realities. *Frontiers in ICT*, 4, 31.

Suk, H. J., Jeong, S. H., Yang, T. H., & Kwon, D. S. (2009). Tactile sensation as emotion elicitor. *Kansei Engineering International*, 8(2), 153-158.

Van Erp, J.B.F. & Toet, A. (2013). How to Touch Humans. Guidelines for Social Agents and Robots that can Touch. 2013 Humaine Association Conference on Affective Computing and Intelligent Interaction, Geneva, pp. 780-785.

Van Erp, J. B., & Toet, A. (2015). Social touch in human–computer interaction. *Frontiers in digital humanities*, 2, 2.

Willemse, C. J., & van Erp, J. B. (2019). Social touch in Human–robot interaction: Robot-initiated touches can induce positive responses without extensive prior bonding. *International journal of social robotics*, 11(2), 285-304.

Willemse, C.J.A.M., Toet, L. & Van Erp, J.B.F. (2017). Affective and Behavioral Responses to Robot-Initiated Social Touch: Towards Understanding the Opportunities and Limitations of Physical Contact in Human-Robot Interaction. *Frontiers in ICT*, 4, 12.

Yamagishi, T. (1988). The provision of a sanctioning system in the United States and Japan. *Social Psychology Quarterly*, 265-271.

Yamagishi, T., & Yamagishi, M. (1994). Trust and commitment in the United States and Japan. *Motivation and emotion*, 18(2), 129-166.



APPENDIX

DESCRIPTION OF THE SITUATION FOR NEGOTIATION PROVIDED TO PARTICIPANTS

You are asked to engage in a negotiation with a virtual agent in virtual reality. In the following negotiation you are representing a client of the cafe “Het Uitje” where your student association meets frequently.

The owner of the cafe “Het Uitje” has recently renovated the place and therefore decided to increase the prices for soft drinks, beer, liquors and snacks. As a frequent customer you are not happy with this decision. It is against your interests and you and your friends are reluctant to pay higher prices.

However, the cafe has been your favorite meeting place for years and throughout these years you have built good relationships with the owner and the staff. The location of the bar is ideal for your student association and you would like to keep using it as your meeting point. Therefore, you have agreed with the owner to meet and negotiate the special prices for your group. [Study 2 additional sentence: During the first negotiation meeting, you did not reach an agreement, because you did not have enough time to review the new menu together. Now you will meet for the second time to discuss the final prices for your student association]

You have been chosen to negotiate the prices on behalf of the whole student association. It is up to you to ensure that the prices will remain the same or increase as little as possible. You want to negotiate as well as possible since you don’t want to let down your friends.

On this page you will see the conditions which you will negotiate about.

In the table below you can see the different products for which the price increase is to be negotiated: soft drinks, beer, liquors and snacks. For every product there are two rows. In the first row (“Price increase”) you can see the proposed increases in price. As you can see the proposed increase in prices is smaller for soft drinks and beer than for liquors and snacks. In the second row (“Extra expenses”) you can see the amount that you as a group will spend extra per month, given the price increase in the first column. So, for example, if the price of beer increases by 20 cents, you as a group will spend 100 euros extra per month.

Pay attention: not every price increase results in the same amount of extra expenses. Your group consumes different quantities of each product. In your case the increase in beer price is most costly for you, while the increase in snacks price is least costly. It is your task to save as much money as possible to the group and to keep the extra expenses as low as possible.

For simplicity, please assume that only those price increases are possible.

Soft drinks					
Price increase, EUR	0.40	0.30	0.20	0.10	0
Extra expenses, EUR	80	60	40	20	0

Beer					
Price increase, EUR	0.40	0.30	0.20	0.10	0
Extra expenses, EUR	200	150	100	50	0

Liquors					
Price increase, EUR	0.80	0.60	0.40	0.20	0
Extra expenses, EUR	80	60	40	20	0

Liquors					
Price increase, EUR	2.00	1.50	1.00	0.50	0.00
Extra expenses, EUR	40	30	20	10	0

