Full length article

**Persuaded by the machine: The effect of virtual nonverbal cues and individual differences on compliance in economic bargaining**

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**ABSTRACT**

Receiving a touch or smile increases compliance in natural face-to-face settings. It has been unclear, however, whether a virtual agent's touch and smile also promote compliance or whether there are individual differences in proneness to nonverbal persuasion. Utilizing a multimodal virtual reality, we investigated whether touch and smile promotion contributed to compliance of a virtual agent's requests and whether receiver's personality moderated the effects. Compliance was measured using the ultimatum game, in which participants were asked to either reject or accept an agent's monetary offers. Decision-making data were accompanied by ear-related cardiac responses, both of which were analyzed as a function of expression (anger, neutral, and happiness), touch (visuo-tactile, visual, no touch), and three personality traits: behavioral inhibition/activation system sensitivity (BIS/BAS) and justice sensitivity. People accepted unfair offers more often if the agents smiled or touched them. The effect of touch was more enhanced in those with low justice sensitivity and BAS, whereas facial expressions amplified the effect of those with high BIS the most. Unfair offers amplified the cardiac response, but this effect was not dependent on nonverbal cues. Together, the results suggest that virtual nonverbal behaviors of virtual agents increase compliance and that there is substantial interindividual variation in proneness to persuasion.

1. Introduction

Facial expressions and body gestures convey valuable information about another's feelings and intentions (Ames & Johar, 2009, Van Kleef, De Dreu, & Mandzaad, 2010). While our tendency to rely on nonverbal behaviors is important in successfully navigating social life, this dependency can also be exploited (e.g., Fisher, Rytting, & Heslin, 1976; Vrugt, 2007). That is, sometimes a warm smile does not reflect the sender's feelings toward the receiver but is used deliberately to gain compliance. As an example of the persuasive influence of facial cues, Vrugt (2007) showed that people entering a shopping area were more likely to sign a petition promoting animal welfare if the request was accompanied by a reciprocal smile. The persuasive power is not limited to faces, however, but is also apparent in physical contact (Gallace & Wetzel, 1984) found that waiters who touched their customers during the service got larger tips than those who did not make physical contact.

Touch and smile promote compliance because they establish interpersonal connectedness and liking (Montagu & Matson, 1979). However, recent studies have shown that the persuasiveness of such affective behaviors even occurs in online settings (Haans, de Bruijn, & Jsselsteijn, 2014; Mussel, Göritz, & Hewig, 2013). For instance, replacing physical contact with computer-mediated electromechanical vibrations still evokes the Midas touch effect, as demonstrated in a recent study by Spapé, Hoggan, Jacucci, and Ravaja (2015). Spapé and colleagues had individuals play repeated rounds of the ultimatum game (Güth, Schmittberger, & Schwarze, 1982) with non-collocated opponents and showed that participants were more prone to being generous and accepting unfairness after receiving a vibrotactile touch from their co-player. Similarly, but with regard to facial expressions, Mussel et al. (2013) found that people were more likely to agree to financial proposals from another human if the offers were mediated by a smiling virtual character.

The power of nonverbal persuasion may thus extend to computer-mediated communication, but what happens to the effect of nonverbal cues when humans encounter an embodied virtual agent that is not guided by a human but by an algorithm? According to the emotions as
social information model (Van Kleef et al., 2010), nonverbal behaviors in
unce our decisions because they convey valuable information re-
arding the other person’s mental state and intentions. Therefore, if an
agent is known to have no intentions, beliefs, or mental states, one
should assume little or no persuasive in unce due to the expressions.
However, the empirical evidence suggests a different conclusion (e.g.,
Ravaja, Bente, Katsyri, Salminen, & Takala, 2016; de Melo, Carnevale,
& Gratch, 2011). As an example, in a study by Ravaja et al. (2016),
participants played the economic bargaining game called the prisoner's
dilemma with two algorithm-guided virtual agents. Before each deci-
sion, the agent showed an emotional facial expression. People were
found to collaborate less with agents showing angry facial expressions
than those expressing sadness, joy, or neutrality.

People thus seem to apply the social heuristics of natural, inter-
personal interaction to machines that mimic social features (e.g., facial
expressions) (see also Reeves & Nass, 1996). This does not, however,
mean that our emotional reactions to humanlike machines and humans
are exactly the same. While people cooperate more with virtual agents
that display cooperative facial expressions (e.g., smile after cooper-
ation) than those that do not, this effect is much stronger if the agent is
thought to be controlled by another human (de Melo, Gratch,
& Carnevale, 2015). Therefore, the social in unce is strongly dependent
on the level of agency attributed to the agent (de Melo et al., 2015).
According to Blascovich et al. (2002), a multitude of social cues, such as
the agent’s appearance, movements, emotional expressions, and sense
of presence, contribute to the agent’s in unce on a user’s social be-
havior. For this reason, Blascovich et al. (2002) saw VR as a particularly
useful methodological tool for investigating social in unce because it
allows a mundane visual experience and a high sense of presence in the
projected environment.

Rapid progress in VR technology has taken place since Blascovich
and colleague’s manifesto on VR-based social psychological research.
For example, recent developments in 3D graphics, head-mounted dis-
plays, and haptic technology now allow presentation of virtual agents
that not only look realistic and express emotions on their face but are
also able to touch the user via haptic devices (e.g., Ravaja, Harjunen,
Ahmed, Jacucci, & Spapé, 2017). The bene ts of such visceral face-to-
face interaction can be substantial for health care, education and ad-
vertisement as these interaction contexts typically involve persuasive
communication of some sort. Currently, conversational agents as
chatbots are becoming popular in therapy and education (Nutt, 2017;
Song, Oh, & Rice, 2017), and may soon substitute parts of other textual
interfaces (Klopfenstein, Delpriori, Malatini, & Bogliolo, 2017). Replac-
ing these simple textual interfaces with VR-based embodied virtual
agents or robots may further enforce social in unce of these systems
(e.g., see Provoost, Lau, Ruwaard, & Riper, 2017). Here, understanding
the role of a expressive nonverbal cues will be crucial.

Given that previous research on computer mediated non-verbal
persuasion builds solely on unimodal non-immersive communication
technologies, such as 2D presentations of agent expressions (e.g.,
Ravaja et al., 2016; de Melo et al., 2011), the scienti c knowledge
about the potential of non-verbal persuasion in immersive VR remains
scarc e. One aspect that remains completely unexplored is the degree to
which individual di erences determine persuasiveness of computer's
non-verbal cues. It is likely that some people are more prone to the
persuasive non-verbal in unces than others, and that individual di-
ferences in emotional reactivity play a larger role in VR-based than in
traditional communication scenarios since immersive presentation
(e.g., using stereoscopic displays) typically intensi es emotional ex-
periences (e.g., Visch, Tan, & Molenaar, 2010). As a future featuring
ubiquitous multimodal VR is gradually becoming a reality in a wide
range of social and commercial settings (e.g., conversational agents
and social VR applications), it is an urgent necessity to investigate the
potential of embodied virtual agents for non-verbal persuasion as well as
the interindividual variation in proneness to this persuasion. By ex-
amining these questions, one can provide new insight into the socio-
emotional processes and individual di erences involved in persuasive
human-computer interaction (HCI). Moreover, as human behavior and
experience in VR may be largely congruent with behavior and experi-
ences in physical settings (Bombari, Schmid, Canadas, & Bachmann,
2015), examining nonverbal persuasion in VR can provide new insight
into a active interaction in general.

1.1. Current study

The current study addresses the aforementioned knowledge gap by
investigating whether an embodied, virtual agent’s facial expressions
and touch a ect compliance. Compliance is de ned here as successful
persuasion and measured using the economic game of ultimatum. In the
game, one player (the proposer) is asked to make an o er to divide a
sum of money between themselves and another player (the receiver).
The receiver has the ultimate power to accept or reject the o er, but
rejecting means that neither player receives anything. The ultimatum
game o ers a well-de ned setting for measuring social psychological
e ects on compliance, as, contrary to the economically optimal strategy
to accept every o er, people tend to reject o ers that are unfair to them
(e.g., Bolton & Zwick, 1995). Earlier neuroimaging research has de-
monstrated that the “irrational” decision to reject an o er is largely
determined by emotional processes (Sanfey, Rilling, Aronson, Nystrom,
& Cohen, 2003). Therefore, we assume that the proposer's nonverbal
behaviors may in unce the rejection decision because they in unce
the emotional processes underlying the decision. More speci cally,
our rst hypothesis (H1) predicts that receiving a touch or perceiving a
smile results in higher compliance than no touch or a non-a ivative
facial expression, respectively.

The ultimate decision to accept or reject is itself a consequence of
complex socio-cognitive evaluations that are believed to be very fast
and sometimes outside the reach of conscious control (Osumi & Ohira,
2009). Measuring the brief delays in the cardiac cycle (i.e., cardiac
deceleration/orienting response) may provide insight into such un-
conscious processes. For example, cardiac decelerations indicate an
increased sensory intake (Bradley, 2009) and have been observed to
occur in response to perceiving unfair o ers in the ultimatum game
(Osumi & Ohira, 2009; Van der Veen & Sahibdin, 2011). Moreover,
decelerations in cardiac activity are responsive to nonverbal emotional
cues, such as touch, facial expressions (Harjunen, Spapé, Ahmed,
Jacucci, & Ravaja, 2017), and pictures of threatening situations
(Bradley, Lang, & Cuthbert, 1993). Therefore, cardiac deceleration may
rect both a e xive reaction related to the unfair o er as well as the
in unces of emotional nonverbal cues. This leads to our second hy-
thesis (H2): Unfair o ers induce stronger cardiac deceleration than
fair or generous o ers, while a proposer's touch and smile should at-
tenuate this unfairness-related deceleration.

As people di er in their responsiveness to emotional cues (Balconi,
Falbo, & Conte, 2012) and willingness to take economic risks (Ferguson,
Heckman, & Corr, 2011), we assume that some individuals are espe-
cially prone to machine persuasion as well. Furthermore, if machine
persuasion is similar to human persuasion, we should assume that
personality modulates the degree to which nonverbal cues a ect com-
pliance. Given that the literature does not currently sustain any clear
predictions, the present study explores relevant individual di erences
and the degree to which these a ect nonverbal communication in
machine persuasion.

Among the relevant personality traits, di erences in approach
(seeking of reward) and withdrawal (avoiding negative experiences)
tendencies are of particular importance when it comes to responding to
emotional cues (Balconi et al., 2012) and making economic decisions
(Ferguson et al., 2011). These two motivational tendencies are well
captured by two neurobiological regulation systems: the behavioral
activation and inhibition systems (Carver & White, 1994). Behavioral
activation system sensitivity (BAS) is associated with enhanced self-
reported positive valence and increased cardiac-orienting responses
when perceiving an appetitive emotional stimulus (Balconi, Brambilla, & Faibo, 2009). Behavioral inhibition system sensitivity (BIS), in turn, has been linked to heightened responsivity to negative facial expressions (Knyazev, Bocharov, Slobodskaya, & Ryabichenko, 2008) and touch (Harjunen et al., 2017). With regard to economic decisions, high-BAS individuals have been shown to accept monetary offers more easily than low-BAS persons in the ultimatum game and to be more likely to defect in the prisoner’s dilemma game to maximize the economic gains (Ferguson et al., 2011; Scheres & Sanfey, 2006).

BIS and BAS may be good in reflecting general motivational tendencies but fall short in capturing more context-specific features of the decision-making task. Players in the ultimatum game need to balance between economic gains and fairness, which causes people’s average rejection rate to vary according to their sensitivity to unfair treatment (Fetchenhauer & Huang, 2004). In fact, high ratings in this so-called justice sensitivity (JS) trait have been associated with higher rates of rejection and stronger activity in neural substrates that are responsive to error and pain when receiving an unfair offer (Boksem & De Cremer, 2010; Fetchenhauer & Huang, 2004). One could assume, therefore, that high justice sensitivity makes nonverbal persuasion less effective because of the person’s readiness and responsiveness to unequal deals.

As the analysis of the individual differences in nonverbal persuasion is more explorative, we make no precise predictions about how each trait relates to specific nonverbal cues, and we present two more general hypotheses based on the findings reviewed above. First (H3), we hypothesize that persons with high BAS will be more compliant and perceive touch and smile as being more persuasive than low-BAS individuals. Second (H4), we assume that persons with high JS and BIS will show lower compliance to unfair offers and be less sensitive to the persuasiveness of touch and facial expressions than those scoring low in these traits.

The present study utilized an iterative version of the ultimatum game in which both the responder (i.e., the participant receives the offer) and proposer (i.e., the participant makes the offer) trials were repeated multiple times with eight virtual agents. Proposer trials were used to make the experiment feel less repetitive and more meaningful for the participants. However, because proposer behavior is more related to generosity than compliance (Spapé et al., 2015), we limited our analyses to data obtained from responders.

2. Materials and methods

2.1. Participants

Sixty-six undergraduates from the University of Helsinki and Aalto University were recruited to take part in the study. All of the participants were healthy adults with normal or corrected-to-normal eyesight, and none had a history of neurological or psychopathological disorders (or other chronic health issues). Before signing their informed consent, participants were informed of their rights to withdraw from the study at any moment and that the default compensation for their time would be €35 but they could earn an extra amount ranging from €1 to €35 depending on their decisions in the game. Nine participants were excluded from the analysis for accepting more than 95% of the offers, and one was excluded due to a technical issue. (A more precise description of the exclusion criteria can be found in Appendix A.1.) The sample consisted of 32 females and 24 males, both having a similar age range (females: M = 24.28, SD = 5.22; males: M = 25.65, SD = 4.67).

The study was conducted following the guidelines of the National Advisory Body on Research Ethics in Finland and approved by the Research Ethics Committee of Aalto University. The obtained research data are made available on Open Science Framework repository (Harjunen, Spape, Ahmed, Jacucci, & Ravaja, 2018).

2.2. Procedure and design

The participants were seated at a desk equipped with a glass table and motion-tracking sensors. Following the instructions, the participants were instructed to put on a head-mounted display (HMD) and a tactile glove (Fig. 1, panel A). Through the HMD, the participants could see the word “Respond” or “Propose” cueing the participant’s role in the upcoming trial. A virtual reality was then presented, in which the participants could see their right hand resting on a table and moving based on their own hand. Moving the hand over the crosshair launched a random delay lasting 0–200 ms, after which a 1700 ms animation of a facial emotional expression was displayed. In visual and visuo-tactile touch trials, the facial expression was accompanied by a reaching gesture starting at 0–200 ms (randomized) after the expression’s onset. In the visual and visuo-tactile touch conditions, the agent moved its right hand toward the participant’s hand, which took 1000 ms. Upon contact, the glove sent 500 ms of tactile feedback if a visuo-tactile condition was presented. However, no feedback was sent in case of visual touch or in
the no-touch condition, and no reaching gesture was shown in the no-touch condition. The VR environment was then replaced by a black screen with a fixation crosshair shown in the middle, after which the beginning screen of the ultimatum game part started. In the role of receiver, participants rst saw the agent's proposal presented as two numbers within a grey frame. The proposal was then replaced by a response cue indicating that the participant could accept the o er by pressing the left arrow key and reject it by pressing the right arrow key. The next trial was presented after a blank intertrial interval. Fig. 1 (panel C) presents the complete structure of the response trials and the exact timing of each step.

Each participant went through 594 trials organized in nine blocks. The rst block consisted of 18 orientation trials with extensive instructions and feedback, whereas the following eight blocks had 72 trials each and more concise feedback. Apart from the orientation, each block consisted of four series of 18 proposer trials and responder trials. Touch type (no touch, visual, visuo-tactile), facial expression (angry, neutral, happy), and, in case a responder trial was shown, o er type (very unfair: €2-€6 for the participant; €18-€14 for oneself, somewhat unfair: €7-€8; €12-€13, fair: €10; €10, generous: €11-€15; €5-€9) were randomly presented within each block. In each responder trial, participants received an o er from the agent that was selected by a simple selection algorithm. The algorithm was based on approach used by (Boksem & De Cremer, 2010), in which the probability of making fair o ers was higher than that of making unfair ones. A detailed description of the algorithm can be found in Appendix B.1 (Fig. B1).

After completing a block, participants could have a self-timed break. During the break, they received feedback on how much money they had earned so far. The average duration of the experiment was 150 min, including preparation.

2.3. Stimuli and apparatus

2.3.1. Emotional expressions

Agents’ facial emotional expressions were created with Unity 3D software (Unity Technologies, San Francisco, CA). The face contained action units that could be dynamically manipulated to create expressions of six basic emotions, according to Ekman and Friesen (1976). In the beginning, we created a set of 42 expression animations—six for each of the seven emotion categories (happiness, anger, fear, disgust, surprise, sadness, and neutral). The animations were then validated by a separate sample of 13 participants. Only the neutral, happy, and angry expressions were used in the present study, since the other expressions were considered less suitable for the current context. The pilot study revealed average recognition accuracies of 70% for anger, 98% for happiness, and 100% for neutral expression.

2.3.2. Tactile stimuli

The participants were instructed to place their right hand on top of a glass table while a Leap Motion (www.leapmotion.com) controller, placed 16 cm below the hand, tracked the participant's movements and re ected them into VR (see Fig. 1, panel A). Dynamic presentation of the participant’s hand movements created a sense of agency over the participant’s virtual body. The sensation of touch was enabled upon skin contact in VR using a tactile glove developed by Ahmed et al. (2016). The glove works by creating mechanical pressure over users’ metacarpal bones. The pressure is applied by a servomotor stretching two elastic tapes over the volar of the hand. Recent studies on mediated multimodal communication have found that this sort of pressure feedback better approximates real human touch than more commonly used vibrotactile stimuli (Ahmed et al., 2016). The maximum intensity of the pressure was reached when the lever of the motor rotated 180° (see Fig. 1, panel A, right hand side). Each touch stimulus lasted for 0.5 s and had the maximum level of intensity. Finally, a masking sound was played throughout the experiment to prevent biases due to auditory cues.

2.3.3. Virtual reality

Agents and the environment were presented via an Oculus Rift head-mounted display (Developer Kit 2, 960 × 1080 pixels per eye; 75 Hz refresh rate; 100° nominal eld of view). The Rift enabled an immersive visual experience utilizing a combination of positional tracking and stereoscopic and parallax cues. The agents were manually morphed from male and female Genesis 2 characters from Daz Studio (Daz3D, Salt Lake City, UT). In order to increase the diversity in the virtual agents’ appearance, four pairs of male and female agents were created, with each pair possessing features related to four ethnic backgrounds (Caucasian, African, East Asian, and South Asian; see Appendix C.1, g. C1). Objects like the virtual table and cues were created using Unity3D software (Unity Technologies, San Francisco, CA). The user's virtual hand was the default hand model of Leap Motion’s Unity3D package. After de ning all of the static properties, both the agents and objects were transferred to the Unity 3D software, which was used to model the agent’s touch gestures and the surrounding environment. Custom-made software was then designed with Unity 3D to control the stimulus presentation, record decision behaviors, and send triggers to the ECG ampli er. The presentation software ran on an Intel-based desktop PC equipped with Windows 7 operating system. Ravaja et al. (2017) previously used the aforementioned VR setup.

2.4. Measures

2.4.1. Compliance

Compliance was operationalized as a binary decision to either accept or reject the agent’s o er in the responder trials. The analysis was done on a trial-to-trial level.

2.4.2. Personality

The Justice Sensitivity Questionnaire by Schmitt, Gollwitzer, Maes, and Arbachi (2005) was used to measure each participant's general tolerance to unfair treatment. The measure has been proofed as a valid and reliable measure of interindividual variability in reactions to unfair situations (Schmitt, Baumnert, Gollwitzer, & Maes, 2010). The questionnaire has three subscales, of which we used only the J SVictim sub-scale of 10 items, as it measures person's proneness to experience injustice toward oneself. Items were rated using a 5-point Likert scale (1 = disagree strongly, 5 = agree strongly). The Cronbach's alpha for the 10 item scale showed acceptable internal consistency (α = 0.76). Average of the 10 items was used as the score of J SVictim. Individual di erences in behavioral activation and inhibition systems were measured using the BIS/BAS Scale developed by Carver and White (1994). The scale consists of four subscales (24 items), but only the BAS-Reward Responsiveness Scale (4 items) and BIS scale (7 items) were used. BAS-Reward Responsiveness measures a person's sensitivity to rewarding experiences and has been found to better capture individual di erences in approach motivation than the other two BAS subscales: BAS-Fun Seeking and BAS-Drive (Taubitz, Pedersen, & Larson, 2015). Participants gave their responses using a 4-point Likert scale (1 = very false for me, 4 = very true for me). The Cronbach's alpha for the BAS-Reward and BIS scales indicated acceptable internal consistency (BAS = 0.73 and BIS = 0.75). Averages of the items were used as the scores of BAS-Reward and BIS.

2.4.3. Cardiovascular responses and data cleaning

ECG was recorded using a QuickAmp (BrainProducts GmbH, Gilching, Germany) amplifier and disposable ECG electrodes (H93SG, size: 42 mm × 24 mm, Covidien/Kendall, Minneapolis, MN) placed at the upper sternum (manubrium) and the second-lowest left-hand rib. The obtained ECG signal was digitized at a 1000 Hz sample rate and reprocessed using an R-peak detection algorithm running on MATLAB, which interpolated the signal to interbeat intervals (IBI) and segmented them into 9-s epochs, with time locked to o er feedback onset. Each epoch contained 1500 ms of baseline activity that was removed from
the post-stimulus activity. Visual inspection of the baseline-corrected grand average (across conditions) IBI response suggested a cardiac deceleration occurring 1000–3000 ms after o er feedback, which is in accordance with earlier literature (Bradley, 2009). Trial-based cardiac deceleration was then calculated by averaging the baseline corrected IBI values from the post-o er stimulus interval of 1000–3000 ms.

As a result of movement artifacts, failure to detect R-peaks from the ECG signal, or unexpected issues in data recording (detected electrodes), a total of 1303 trials with erroneous IBI values were obtained. Removing these artifactual trials resulted in a 4.52% decrease in the data. Additionally, given that each participant had to go through 596 game trials, they were encouraged to respond quickly. Trials with extremely long decision times (5000 ms post-o er feedback) were taken as signs of distracted attention and were excluded from the analysis. The threshold of 5000 ms was selected as a safe cutto based on the distribution of RTs (excluding only 0.43% of the remaining data). The nal data set consisted of 56 participants and 23,438 observations.

2.5. Analysis and design

First, we investigated whether the virtual agent’s expression and touch promoted compliance in the participants (H1). Given the multilevel structure of the data (repeated measures clustered on participants), the generalized estimating equation (GEE, geepack in R; Halekoh, Højsgaard, & Yan, 2006) with the binary logistic link function was used to carry out the analyses. The GEE is used to analyze data that are clustered under more than one level (e.g., repeated measures within participants), making it a suitable method for repeated-measures designs (Liang & Zeger, 1986). In the GEE approach, one has to specify the working correlation matrix structure for the repeated measures. Here, the rst-order autoregressive structure (ar1) was selected based on the lowest quasi-likelihood under independence model criterion (QIC) value.

The model included the main e cts of o er type, expression, touch, agent gender (same vs. di erent from the participant’s own), and ethnicity (Caucasian vs. African vs. East Asian vs. South Asian). A binary factor of time (rst vs. last half of the experiment) was also included to control for habituation e cts. According to H1, the e cts of expression and touch should show up particularly with unfair o ers. Thus, the two-way interactions of expression and o er type as well as touch and o er were tested. In addition, it was possible that the e ct of touch depended on expression. Therefore, the two-way interaction of expression and touch as well as the three-way interaction of expression, touch, and o er were added. The contribution of each main and interaction e ct on model was tested with the Wald test with type III sum of squares. The e ct sizes were reported as odds ratios (ORs).

A multilevel linear modeling (MLM) with restricted maximum likelihood estimation was used to test whether touch and expression in uenced responders’ post-o er cardiac decelerations (H2). The MLM was conducted using the lme4 package in R (Bates, Mächler, Bolker, & Walker, 2015). MLM assumes a linear relationship between categorical or continuous predictors and a continuous dependent variable that can be clustered and vary on two or more levels (Raudenbush & Bryk, 2002).

The MLM had cardiac deceleration as the outcome and gender, ethnicity, o er type, expression, and touch as factors. The same e cts were tested as in the GEE model described earlier. Moreover, due to the commonly demonstrated habituation e ct in cardiac deceleration (Bradley et al., 1993), a binary factor of time (the rst half of the session vs. the last half of the session) was included. Preliminary inspection revealed individual di erences in the temporal trends; thus, the factor of time was also set as a random slope, while the participant ID was assigned to a random intercept. The pseudo-R2 was used to indicate the proportion of explained variance, and the omega-squared e ct size measure was used to indicate the proportion of residual variation explained by individual predictors (2, Xu, 2003). The nal phase of the analyses was aimed at investigating whether the responder’s JS, BAS, and BIS moderated the e cts of touch and expression on compliance (H3b). The tests were carried out by building three additional GEE models, in which the previously described situational factors were accompanied by trait covariates. The trait covariates were standardized to have a mean of 0 and a standard deviation of 1. To avoid overly complex model structures and multicollinearity between the covariates, we decided to use separate models for each trait covariate. In addition to the situational factors, each of the models included the main e ct of trait (JS/BAS/BIS) as well as the two- and three-way interactions between touch, expression, o er, and trait.

3. Results

3.1. E ct of touch and facial expressions on receiver’s decisions and physiology

The participants accepted 68.30% (SD = 46.53%) of the o ers, on average. The presentation of the agent’s o er on the screen resulted in an average deceleration of 30.38 ms (SD = 54.67 ms) in cardiac cycle. As demonstrated in Table 1, the probability of accepting o ers as well as the o er-related cardiac deceleration varied as a function of the o er type.

The GEE analysis showed a signi cant main e ct of o er type, with low shares resulting in frequent rejection. As shown in Table 2 (left-hand side), signi cant main e cts of time, ethnicity, facial expressions, and touch as well as two-way interactions between o er type and touch, and between o er type and expression were found. Participants accepted fewer o ers during the rst half of the experiment (M = 0.68,
SE = 0.02) compared to during the last half of the experiment (M = 0.68, SE = 0.02, p < .01, OR = 1.13, 95% CI [1.09, 1.15]). Tukey-adjusted pairwise comparisons of ethnicity revealed that the participants were more likely to accept unfair offers presented by African (M = 0.70, SE = 0.02) versus Caucasian models (M = 0.68, SE = 0.02, p = .04, OR = 1.10, 95% CI [1.09, 1.11]).

H1 predicted that happy/neutral expressions and touch from the agent would result in higher compliance with unfair offers than the angry expression and no-touch conditions. Planned pairwise comparisons between the neutral and angry expressions and the happy and angry expressions revealed that happy and neutral expressions modulated compliance in higher than angry expression and that the effect was stronger in fair (p < .001, ORs 4.83) and generous (p < .001, ORs 4.04) offers than in somewhat unfair (p < .001, ORs 2.06) or very unfair (p < .001, ORs 1.63) offers (see Fig. 2, panel A). Moreover, the hypothesized effect of touch was also found in higher probability of accepting very unfair offers than when no touch was delivered (p = .03, OR = 1.20, 95% CI [1.16, 1.28]). No signiﬁcant differences were found between the visual and no-touch conditions (p = .29). While the persuasiveness of visuo-tactile touch (M = 70, SE = 0.02) vs. no touch (M = 68, SE = 0.01) was also present in somewhat unfair offers, it failed to reach signiﬁcance (p = .06, OR = 1.13, 95% CI [1.13, 1.16]). Moreover, no signiﬁcant two-way interaction between touch and expression (p = .08) or three-way interaction between touch, expression, and offer type was found (p = .56).

Next, we investigated whether unfairness of the offer increased post-offer cardiac deceleration and whether this fairness-related deceleration was modulated by the agent's touch and facial expressions (H2). The last two columns of Table 1 describe the average cardiac deceleration as a function of offer. As can be seen, unfair offers resulted in longer interbeat intervals than fair and generous offers. Table 2 (right hand side) shows the results of the MLM analysis. First, no xed e ect of time was found (p = .71), but the random e ect was signiﬁcant, −2(2) = 88.13, p < .001, referring to signiﬁcant individual diﬀerences in the temporal trends of cardiac deceleration. In addition, the agent's gender was found to a eect the deceleration (p = .04, −2 = 0.0001), suggesting a smaller deceleration in response to offers from opposite-sex agents (M = 29.81 ms, SE = 1.79) as compared to same-sex agents (M = 31.24 ms, SE = 1.79). Moreover, as predicted by H2, there was a signiﬁcant negative relation between offer size and cardiac deceleration, p < .001, −2 = 0.0009. Finally, and contrary to H2, neither the main e ects of expression or touch nor the interactions between offer, touch, and expression were signiﬁcant (ps > .10). As indicated by the pseudo-R^2 of 0.067, the full model was able to explain only 6.7% of the variation in cardiac deceleration. Furthermore, the intraclass correlation (ICC = 0.06) calculated based on the MLM indicated that 6% of the total variance in cardiac deceleration was accounted for by individual diﬀerences between subjects, and 94% of the variance was accounted for by within-subject e ects.

3.2. Individual diﬀerences in vulnerability to virtual agent’s persuasion

To uncover the variability in proneness to nonverbal persuasion, we investigated whether individual diﬀerences in BAS, BIS, and JS moderate the eﬀects of touch and facial expressions on compliance (H3, H4). Table 3 presents the means, standard deviations, and correlations of averaged compliance with unfair offers, averaged cardiac deceleration in unfair offers, and personality traits. As can be seen, BAS, BIS, and JS are all positively correlated with each other (ps < .01). In addition, a signiﬁcant positive relation between compliance and BAS was obtained (p = .03). However, no associations were found between the cardiac deceleration and averaged compliance (p = .39) or the trait variables and cardiac deceleration (ps > .18).

Table 4 shows the results of the GEE model. Along the predictions of H3, people with high BAS were more likely to accept any kind of offer than people with low BAS (p = .02; see M1 of Table 4). In addition, a two-way interaction between touch and BAS was obtained (p = .02), as was a three-way interaction among BAS, offer type, and touch (p = .03).

Inspection of the effect revealed that those with weak BAS (2 SD) were almost two times (OR visuo-tactile vs. no touch = 1.74, 95% CI [1.68, 1.81], OR visual vs. no touch = 1.54, 95% CI [1.50, 1.58]) more likely to accept a very unfair offer if being touched (visually or tacti1y) than if

<table>
<thead>
<tr>
<th>Variable</th>
<th>M (SD)</th>
<th>Cardiac d.</th>
<th>BS</th>
<th>BAS</th>
<th>BIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>p(accept unfair)</td>
<td>0.68</td>
<td>0.13</td>
<td>.12</td>
<td>.16</td>
<td>.29</td>
</tr>
<tr>
<td>BIS</td>
<td>2.83</td>
<td>0.49</td>
<td>.04</td>
<td>.41</td>
<td>.35</td>
</tr>
<tr>
<td>BAS</td>
<td>3.28</td>
<td>0.50</td>
<td>.14</td>
<td>.29</td>
<td></td>
</tr>
<tr>
<td>JS</td>
<td>3.32</td>
<td>0.58</td>
<td>.18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac d. (unfair)</td>
<td>32.06</td>
<td>13.81</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. N = 56 for all correlations. Cardiac deceleration, compliance, and generosity were averaged over repeated trials to obtain subject-level mean scores. p < .05, p < .01.
not being touched. Such e ect was not present in high-BAS individuals or when the o er was somewhat unfair, fair, or generous (see Fig. 3, panel A). Contrary to the assumption regarding facial expressions and BAS, no evidence was found for the interactions between BAS and expression on compliance (ps > .10).

Moreover, BAS was found to moderate the e ect of expressions (see Table M2 in Table 4). While the main e ect of BAS was not significant (p = .44), an interaction between o er type and BAS was found (p = .01). In line with H4, this e ect was further a ected by the agent's expression (p = .001). As can be seen from Fig. 3 (panel B), people with high BAS (+2 SD) showed lower compliance with very unfair o ers coming from angry agents than those coming from neutral or happy agents (OR neutral vs. angry = 2.93, 95% CI [2.76, 3.11], OR happy vs. angry = 2.42, 95% CI [2.29, 2.54]). In addition, low-BIS individuals (1 SD) showed lower compliance with fair and generous o ers made by angry agents than those made by happy and neutral agents (ORs > 3.44). Contrary to BAS, however, BAS did not moderate the e ect of touch (ps > .14).

Replacing BAS with JS (M3, see Table 4) revealed significant interaction e ects between the o er and JS (p < .001) as well as among o er, oer type, and touch (p < .001). Inspection of the three-way interaction revealed that, in line with H4, people with low JS (2 SD) were about 1.5 times (OR visual-tactile vs. no touch = 1.50, 95% CI [1.48, 1.51], OR visual vs. no touch = 1.66, 95% CI [1.64, 1.67]) more likely to accept very unfair o ers when being visually or tactiley touched by the agent than if no touch was delivered. Such an e ect was not obtained in high-JS persons or in other o er types (see Fig. 3, panel C). However, partially contrary to H4, no interaction between expression and JS was found (p = .87). Similarly, there were no significant three-way interactions among o er type, expression, and JS or among expression, touch, and JS (ps > .08).

4. Discussion

The present study examined the persuasive in uences of aective nonverbal communication of embodied virtual agents and how individual differences in emotive motivations and justice sensitivity modulate proneness to agents’ persuasive impact. To uncover the sociocognitive mechanisms that underlie the persuasive in uence, we measured the receiver’s post-o er cardiac deceleration and found it to be responsive to o er fairness but not to nonverbal cues. Further investigation of the impact of motivational traits and justice sensitivity revealed a group of individuals who were particularly prone to nonverbal persuasion. In the following paragraphs, we will go through some of the unexpected findings and elaborate upon the complex state-and trait-level dynamics uncovered by the study.

With regard to the agents’ facial cues, the participants accepted the proposer’s o ers more readily if accompanied by a happy or neutral expression than when an angry expression was shown. This was in line with previous ndings by Mussel et al. (2013). However, the anger-related rejections were visible not only in unfair proposals but also in equal and generous o ers. Rejections in ultimatum games have been shown to reflect the responder’s motivation to penalize the proposer for making an unfair o er (Bolton & Zwick, 1995). Therefore, the e ect could be interpreted in terms of retaliation rather than compliance. This is, people punished proposers who expressed anger and not just complied with those who smiled.

Moreover, clear evidence of the compliance-promoting in uence of touch was found. Although small, the e ect was in line with the Midas touch e ect previously demonstrated in a human–human interaction context (Gallace & Spence, 2010). Of the controlled situational factors, gender did not predict compliance but time (1st half vs. last half) and ethnicity did. Acceptance rates were higher in the beginning than in the end, which suggests that people habituated to the o er feedback over time. Additionally, participants accepted more o ers from African than Caucasian agents, which may well be related to demand characteristics, such as a person’s deliberate attempt to be seen as unprejudiced individual (Dovidio, Kawakami, Johnson, Johnson, & Howard, 1997). Despite the signi cant e ects of ethnicity and time, it is important to note that the e ects of touch and expressions remained signi cant after controlling for the other factors.

Previous ECG studies utilizing the ultimatum game suggest that people exhibited stronger cardiac deceleration in response to unfair vs. fair/generous o ers (e.g., Osumi & Ohira, 2009). Our observations replicated this nding. However, neither touch nor expression moderated the fairness-related cardiac response. The agent’s gender had a small e ect on the post-o er deceleration but no other e ects were found.

While it is possible that nonverbal cues do not modulate unconscious o er perception, the substantial amount of unexplained variation in the deceleration of beat interval times and the non-significant e ect correlation...
between deceleration and compliance imply that cardiac deceleration does not offer an accurate picture of the unconscious offer evaluation. Indeed, using indexes of brain activity, such as feedback-related negativity (FRN) obtained from EEG, researchers have demonstrated that a smile presented before an unfair offer modulates the neural processing of unfair proposals (Mussel, Hewig, Allen, Coles, & Miltner, 2014).

Besides revealing the underlying neural processes, we aimed to increase understanding of individual differences in proneness to nonverbal persuasion of embodied virtual agents. Previous studies have shown that approach and withdrawal tendencies affect a person’s responses to nonverbal cues (e.g., Balconi et al., 2009) and economic offers (e.g., Fetchenhauer & Huang, 2004). We thus expected that high-BAS individuals would show high compliance and be easily persuaded, especially in the context of positive nonverbal cues. Although a positive relationship between behavioral activation system sensitivity (BAS) and compliance was obtained, the persuasive effect of touch was found in individuals with low rather than high BAS, and the moderating effect of BAS on expressions was completely absent. The findings suggest that
ance of unfair treatment (Sanfey, 2007). These potentials for economic gains and avoidance of unfairness are well captured by reward responsiveness and justice sensitivity. Therefore, the economic initiatives proposed later on.

Moreover, high-BIS individuals were more likely to reject very unfair offers in the ultimatum game (Fetchenhauer & Huang, 2004). We assume that high-BIS people perceive negative facial expressions as being more negative (Knyazev et al., 2008) and touch as being more threatening than low-BIS individuals do (Harjunen et al., 2017). Therefore, we hypothesized that people with high JS would be better at receiving an unfair offer in the ultimatum game results in enhanced affective cues and how they are selective.

The current study does not reveal, however, to what extent the findings are applicable-to natural human–human instead of human–computer interaction. Thus, we may expect a smaller degree of motivation to punish wrongdoers (angry and unjust agents) or nonverbal cues. This was exactly what we found. While high-JS persons showed less responsiveness and justice sensitivity, as it was also found to moderate the Midas touch effect (Sanfey et al., 2003). These regions are typically responsive to ambiguous, as they are recognized at better than chance level in all human cultures (Elfenbein & Ambady, 2002). High-BIS persons were particularly sensitive to angry vs. happy expressions but not to the social meanings of facial expressions of anger and joy are arguably less pronounced in those who are neither keen on the proposal nor worried about losing their dignity if making an unequal deal.

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