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Individual differences in affective touch: Behavioral inhibition and gender define how an interpersonal touch is perceived

Harjunen, V. J.^{1,2}, Spapé, M.⁴, Ahmed, I.^{1,3}, Jacucci, G.^{1,3}, Ravaja, N.^{1,5}

1. Helsinki Institute for Information Technology, Aalto University

2. Department of Social Research, University of Helsinki

3. Department of Computer Science, University of Helsinki

4. Department of Psychology, Liverpool Hope University

5. Aalto University, School of Business

Corresponding author:

Ville J. Harjunen, email: ville.harjunen@helsinki.fi, tel: +358 504922807, address: Helsinki Institute for Information Technology, Aalto University, Otaniementie 19-21, 02150 Espoo, Finland

Individual differences in affective touch

Highlights

- Facial expressions affect touch perception and post-touch orienting response
- Behavioral inhibition moderates the effect of expressions on touch perception
- The influence of BIS on affective touch perception differs depending on gender

1 **ABSTRACT**

2 Receiving a tender caress from a caregiver or spouse reduces stress and promotes emotional well-
3 being, but receiving the same caress from a stranger makes us feel uncomfortable. According to recent
4 neurophysiological findings, we not only react differently to the invited versus uninvited touch but also
5 perceive the touch differently depending on context. A virtual reality experiment was conducted to
6 investigate whether individual differences regarding behavioral inhibition system (BIS) and gender
7 contribute to this affective touch perception. Touch perception was measured directly using self-reports
8 and indirectly using the touch-related orienting response. The results showed that touch perception
9 depended on the emotional expression of the virtual agents. High-arousal approach-related (happiness,
10 anger) and avoidance-related (fear) expressions increased self-reported touch intensity, while happiness
11 reduced the orienting response to touch. Moreover, interpersonal differences in behavioral inhibition and
12 gender played distinct roles: BIS sensitivity in males was associated with stronger affective touch
13 perception, particularly with high-arousal emotions whereas in females BIS sensitivity did not affect
14 touch perception. The results suggest that individual differences that are related to preferences regarding
15 tactile communication also determine how touch is perceived.

16 *Keywords:* interpersonal touch, touch perception, orienting response, facial expressions, BIS

17 1. INTRODUCTION

18 Decades of social-psychological research demonstrate the remedial power of human touch: being
19 touched reduces stress (Ditzen et al., 2007), promotes relationship satisfaction (Gulledge, Gulledge, &
20 Stahmann, 2003) and enhances prosocial behavior (Gueguen & Fischer-Lokou, 2003; Crusco & Wiesel,
21 1984). However, not every touch is considered pleasing or calming. Uninvited physical contact is rarely
22 reciprocated with acts of kindness, but rather experienced as an offensive breach of one's personal space
23 (Sussman & Rosenfeld, 1978). One of the critical differences between touch and communication in the
24 visual or auditory modalities is that it requires a very close distance between interactants. Perhaps due to
25 this intimacy, the occurrence of tactile communication is particularly dependent on situational and
26 individual norms (Remland, Jones, & Brinkman, 1995).

27 Research on individual differences has consistently shown that characteristics related to social
28 tolerance are of particular importance when it comes to physical contact. Social anxiety, for example, is
29 marked by a tendency to avoid interpersonal proximity and by feelings of discomfort when touched by
30 others (Wilhelm, Kochar, Roth, & Gross, 2001). Moreover, our social environment creates multitudes of
31 gendered norms when it comes to physical contact. For example, in Western cultures heterosexual males
32 have been shown to avoid touch while interacting with same-sex partners (Roese, Olson, Borenstein,
33 Martin, & Shores, 1992). Violation of this norm, particularly for persons with homophobic tendencies,
34 causes aversive feelings (Floyd, 2000) and can remove the effects of touch on generosity (Dolinski,
35 2010).

36 The context of touch—that is, who touches whom and when—may thus result in differential
37 affective outcomes, but recent neuropsychological findings suggest a touch could actually *feel* different
38 depending on the context. For instance, a recent fMRI study found that the primary somatosensory cortex
39 of heterosexual males responded differently depending on whether they believed they were being touched
40 sensually by a man or woman (Gazzola et al., 2012). Similarly, recent studies found that emotional
41 stimuli can alter somatosensory processing (Montoya et al., 2005; Sel, Forster, & Calvo-Merino, 2014;

42 Spapé, Hoggan, Jacucci, & Ravaja, 2015). Thus, the social-emotional context of a touch defines what a
43 touch is felt like, and the same touch could feel stronger or weaker depending on surrounding affective
44 cues. This modulatory effect can be labeled “affective touch perception.”

45 Most studies investigating affective touch perception (e.g., Montoya et al., 2005; Sel et al., 2014)
46 have presented the tactile and emotional stimuli originating from independent sources: a participant is
47 shown pictures meant to elicit emotion while the researcher touches his or her arm with a tactile device or
48 hand. In real interpersonal touch, however, emotional and tactile stimulation are situated in the same
49 person, who, for instance, smiles when reaching out to touch the recipient. In this case the emotional cues
50 are perceived as an inevitable part of the tactile message as both communication channels originate from
51 the same embodied source. Along with other bodily cues, facial expressions may be of particular
52 importance when it comes to touch, as they inform the recipient of the sender’s behavioral intentions
53 (Adams, Ambady, Macrae, & Kleck, 2006). An angry expression, for instance, communicates hostile
54 intentions, with a tendency to approach and harm the emotional target, while a fearful face implies a
55 withdrawal tendency to keep distance from the target (Marsh, Ambady, & Kleck, 2005). It seems likely,
56 therefore, that expressions would have a particularly pronounced effect on affective touch perception
57 given that touch is strongly tied to physical proximity. Indeed, recent study by Ellingsen et al. (2014)
58 showed that (static images of) smiling faces increased, whereas angry faces reduced, pleasantness of
59 concomitant touch.

60 Numerous lines of research on other perceptual modalities suggests also that facial expressions
61 can critically affect basic perception of a stimulus (cf. Vuilleumier, 2005). For instance, the mere
62 presence of a fearful face has been shown to potentiate attention and facilitate subsequent visual
63 perception (Phelps, Ling, & Carrasco, 2006). This affective modulation has been suggested to arise from
64 increased neural communication between visual cortical areas and emotion-related subcortical structures
65 (Vuilleumier & Pourtois, 2007). Interestingly, the peripheral organs, such as the heart, also take part in
66 enhancing the perception (Bradley, 2009). For example, presenting a threatening emotional cue results in

67 brief cardiac deceleration, also called a cardiac orienting response (OR; Bradley, Lang, & Cuthbert,
68 1993). Cardiac orienting has been related to biological processes involved in extracting information from
69 the environment and is thus used as an index of enhanced sensory intake (cf. Bradley, 2009).

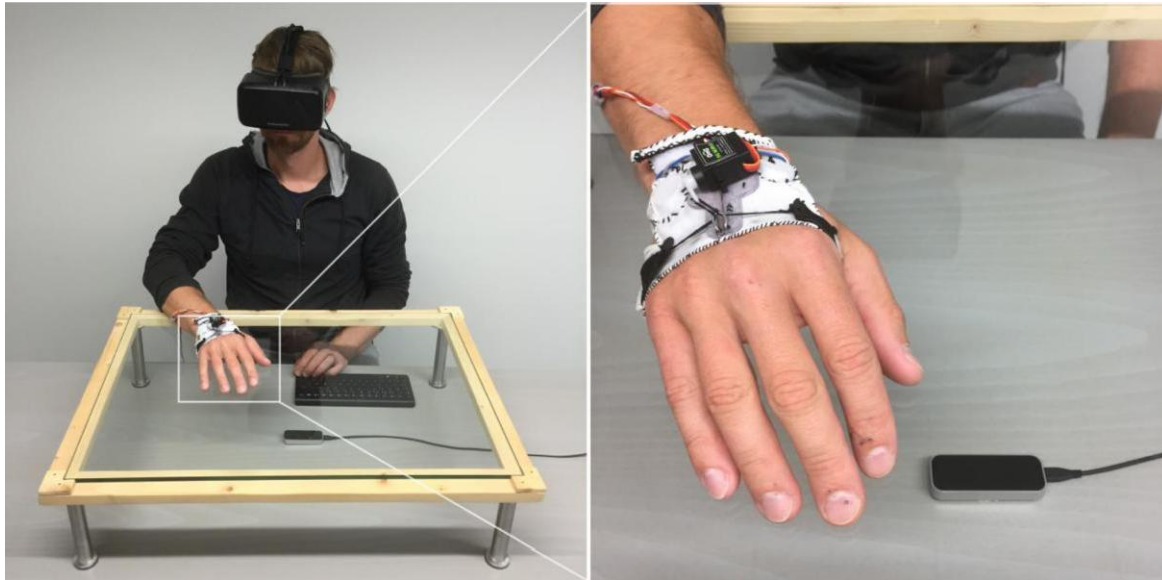
70 The degree to which affective cues affect perceptual processing has been shown to vary as a
71 function of individuals' characteristics (Smolewska, McCabe, & Woody, 2006). Traits related to negative
72 affectivity have especially been associated with facilitated sensory processing in response to emotional
73 cues (for review see Aron, Aron, & Jagiellowicz, 2012). One of these traits is behavioral inhibition
74 system (BIS) sensitivity, which reflects cross-individual variation in neurobiological systems motivating
75 avoidance of negative and painful experiences (Carver & White, 1994; Fowles, 2000). People with high
76 BIS sensitivity show heightened cardiac OR in response to negative and emotionally arousing visual
77 stimuli (Balconi, Falbo, & Conte, 2012) and perceive sad and angry expressions as more sad and hostile
78 than persons with low BIS sensitivity (Knyazev et al., 2008).

79 Also, the gender of the receiver is of particular importance when it comes to affective touch
80 perception. As already noted, gender has a strong effect on the preferences regarding interpersonal touch.
81 However, it has also been shown to influence the way a person extracts information from facial
82 expressions (Montagne, Kessels, Frigerio, de Haan, & Perrett, 2005). A meta-analytic review by McClure
83 (2000) showed that females are overall more sensitive to perceive emotional facial cues. Therefore, it can
84 be concluded that the perceiver's gender as well as motivational tendencies can be considered as relevant
85 individual-level factors involved in affective touch perception.

86 **1.1 Present study**

87 The purpose of the current study was to investigate whether individual characteristics and
88 emotional expressions influence the perception of interpersonal affective touch. We utilized an immersive
89 virtual reality (VR) paradigm to measure affective touch perception in the context of an emotionally
90 expressive virtual character (VC). Haptic technology was used in order to provide the illusion that,

91 following a facial emotional expression, the VC touched the participant. This novel methodological
92 approach allowed us to control for visual (reaching gestures, facial dynamics) and haptic (tactile location,
93 intensity) aspects without compromising the ecological validity of the touch experience (Blascovich,



94 Loomis, Beall, Swinth, Hoyt, & Bailenson, 2002).

95 **Figure 1. Experimental setup.** A head-mounted display presented visual stimuli. A hand-
96 tracking device underneath a glass table allowed participants to move their virtual hand in synchrony with
97 their real hand. The tactile glove, presented at right, delivered vibrotactile and mechanical stimuli.

98 Supporting the notion of affective touch perception, we expected that emotional expressions
99 would change how touch was experienced in terms of its intensity and pleasantness as well as cardiac OR.
100 More specifically, we expected that a touch preceded by a VC's angry facial expression would be rated as
101 less pleasant and more intense compared to other facial expressions. Furthermore, we investigated
102 whether individual differences contributed to the affective touch perception. Taking into account the fact
103 that high-BIS persons perceive angry faces as more hostile compared to low-BIS persons (Knyazev et al.,

104 2008), we expected that high-BIS persons would rate touch preceded by angry expression as less pleasant
105 and more intense and show more enhanced touch-related OR compared to low-BIS persons. Finally,
106 given that males show usually more aversion of same-sex touch (Roese, et al., 1992) we assumed males to
107 rate male VC's touch as less pleasant and more intense especially when accompanied by negative
108 expressions.

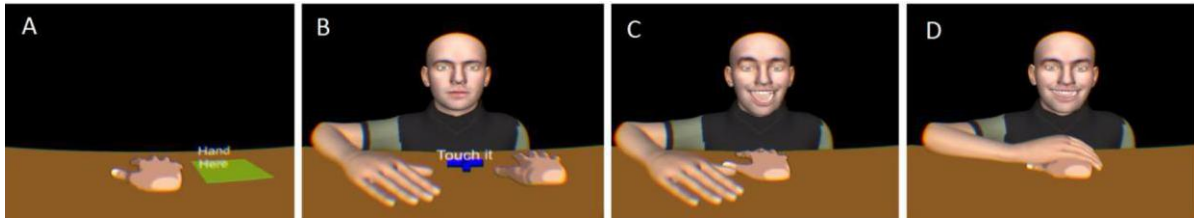
109 **2.1 Participants**

110 The sample consisted of 41 (19 female) Finnish undergraduates. They were right-handed, with no
111 history of neurological or psychopathological disorders (or other acute health issues) and had normal or
112 corrected eyesight. Before signing informed consent, participants were informed of the content and
113 purpose of the study, as well as their rights to withdraw from the study at any moment without any
114 negative consequences. At the end of the experiment, each participant received 40 € in compensation for
115 their time. Data from two participants (both females) were excluded from analysis due to technical
116 complications with the ECG recordings. The resulting gender groups had a similar age range (females:
117 25.88 ± 3.96 , and males: 24.86 ± 3.99). The study followed the guidelines of the National Advisory Body
118 on Research Ethics in Finland and was approved by the Research Ethics Committee of X University.

119 **2.2 Procedure**

120 After filling out the personality questionnaire, participants were seated at a desk equipped with a
121 glass table and assisted in putting on a head-mounted display (HDM) and tactile glove. Within VR, they
122 could see a 3-D model of their right hand resting on a table with a green area to the left of their hand (see
123 Figure 2, Panel A). As they touched the area, the VC appeared, wearing a neutral expression (B). The
124 emotional expression animation only started (C) after participants moved their hand forward to a blue cue.
125 Then, after a randomized interval of 1 to 3 s, the VC reached out and, 1 s later, touched the participant's
126 hand (D), at which time tactile stimulus was delivered. The VC remained in view for another 1 s after
127 which participants were instructed to get ready for the next trial or to answer (in the first 20 trials of each

128 block) a short questionnaire. There were 100 trials per block, and five blocks with breaks in between. The
 129 experiment took ca. 90-120 minutes.



130 **Figure 2. Experimental paradigm.** VC was shown expressing an emotion before touching
 131 participant's virtual hand.

132 2.3 Stimuli and apparatus

133 Unity 3D 4.5.4 software (Unity Technologies, San Francisco, CA), operating on a PC running
 134 Windows 7, was utilized to present stimuli and collect responses. Visual stimuli were presented via a
 135 head-mounted display (Oculus Rift Developer Kit 2, Oculus VR Inc., Irvine, CA), which uses head
 136 tracking and stereoscopic cues to provide an immersive VR experience.

137 2.2.1 Emotional expressions

138 Animations of facial expressions of six basic emotions (Ekman & Friesen, 1976) were captured
 139 by recording a professional actor's 5 s enactments using Faceshift software (Faceshift AG, Zurich,
 140 Switzerland) and a Microsoft Kinect (Microsoft Kinect for Xbox 360, Redmond, WA, USA) depth
 141 camera. The obtained depth parameters were projected onto a 3-D male model to create four unique 4 s
 142 animations (with neutral onset expression) for 7 (anger, fear, happiness, surprise, disgust, sadness, and
 143 neutral control) expressions. The resulting set of animations was prevalidated measuring recognition
 144 accuracy of 12 participants who watched and classified the animations. Expressions were overall well
 145 recognized with happy (94.64%), surprised (86.36%), neutral (80.06%), and sad (78.30%) expressions
 146 having the highest recognition rates and angry (71.43%) and disgust (55.36%) having the lowest ones.

147 Five emotional expressions were then used in the present experiment (angry, fearful, sad, happy and
148 neutral).

149 2.2.2 Interpersonal touch

150 A custom-designed tactile glove was used to establish a sense of one's own hand in virtual space
151 (see Figure 1). To do this, the participant's right hand was placed on top of a glass table and tracked using
152 a Leap Motion (www.leapmotion.com) controller placed 16 cm below. Furthermore, the glove enabled
153 the tactile aspects of simulated interpersonal touch using two types of touch, vibrations and pressure.
154 Vibrations (similar to Spapé et al., 2015) were produced using two TEAX14 C02-8 audio exciters
155 (Tectonic Elements Ltd., Cambridge, United Kingdom, www.tectonicelements.com) placed dorsal to the
156 middle of the metacarpal bones of participant's right hand. The vibration was labeled as *soft* at square
157 wave frequency of 35Hz and *hard* at 100Hz. Mechanical pressure (similar to Wang, Quek, Tatar, Teh, &
158 Cheok, 2012) was produced using a servo motor stretching two elastic tapes over the volar of the hand.
159 Pressure was *soft* when a pulling lever (see Figure 1, right panel) rotated 120 degrees and *hard* when
160 rotating 180 degrees. Both touch stimuli lasted 0.5 s. Finally, a masking sound was played throughout the
161 experiment to prevent bias due to auditory cues.

162 2.3 Self-report measures

163 2.3.1 Personality

164 Individual differences in defensive motivational system were measured using the BIS/BAS scale
165 developed by Carver and White (1994). The scale consists of four subscales from which only the BIS
166 scale was used. Participants responded the items using a 4-point Likert scale (1 = *very false for me*, 4 =
167 *very true for me*). The Cronbach's alpha for the BIS scale was .80.

168 2.3.2 Questionnaires concerning visual and tactile experience

169 Three separate questionnaires were used to measure participants' tactile and visual (avatar's
170 expression) experience, and emotion recognition. The questionnaires were separated between blocks in

171 order to avoid confusion regarding the target of the items. In each block, only the first 20 trials ended with
172 a questionnaires. In the first block, items concerned pleasantness and intensity of the VC's facial
173 expression (e.g. "Was the emotional expression pleasant/intense/humanlike?"), with participants
174 indicating their agreement on continuous Likert scales (1: "not at all", 5: "very much"). In the second
175 block, participants were instructed to evaluate the tactile sensation using items concerning pleasantness,
176 intensity and naturalness of the touch (e.g. "Was the touch pleasant/intense/humanlike?"). Pleasantness
177 ratings were used to index the hedonic value of the tactile stimulus whereas intensity were used to
178 measure the stimulus magnitude. The approach to measure tactile sensation was equivalent to that used in
179 Ellingsen et al. (2014). In the last three blocks, in the end of first 20 trials, participants were instructed to
180 select the adjective that best described the avatar's emotion (angry, happy, sad, afraid or neutral). This
181 five-alternative forced-choice item was used as the measure of emotion recognition.

182 **2.4 Physiological measures**

183 Disposable ECG electrodes (H93SG, size: 42 mm × 24 mm, Covidien/Kendall, Minneapolis,
184 MN) were placed at the upper sternum (manubrium) and the second-lowest left-hand rib. ECG was
185 recorded and digitized at 1000 Hz sample rate using a QuickAmp (BrainProducts GmbH, Gilching,
186 Germany) amplifier. Preprocessing was carried out using MATLAB to detect R-peaks and interpolate
187 these to interbeat interval (IBI). Thus obtained continuous IBIs were segmented into 9 s epochs, with time
188 locked to touch onset and including 4 s of baseline activity. Temporal localization of the OR was based
189 on visual inspection of the grand average (across conditions) evoked IBI response, suggesting an average
190 latency between 1 and 3 s, in accordance with the literature (Bradley, 2009). Individual trial-based ORs
191 were then calculated by detecting the local maximum in the interval of 1-3 s following tactile stimulus
192 onset (see supporting materials for further details).

193 **2.5 Design**

194 Each of the five experimental blocks comprised five randomly ordered repetitions of each trial
195 type obtained by crossing the two touch types (vibration, mechanical pressure) x the two intensity levels

196 (low, high) x the five emotional expressions (anger, fear, sadness, happiness and neutrality). The
197 perception of VC's expression was first investigated by using four full-factorial repeated measures
198 ANOVAs with touch type, touch intensity and emotional expressions as factors and self-reported
199 expression intensity, naturalness, and pleasantness as dependent variables. The affective touch was then
200 investigated by using four repeated measures ANOVAs in which self-reported touch intensity,
201 naturalness, pleasantness and post-touch OR were set as dependent variables. Given that cardiac OR tends
202 to be subject to habituation (Bradley, 2009), additional factor of phase (500 trials divided to three levels
203 each consisting from 167 to 166 trials) was included in the model when predicting ORs. To further
204 specify the effects of emotional expression, planned pairwise comparisons between emotional expressions
205 and the neutral control were conducted.

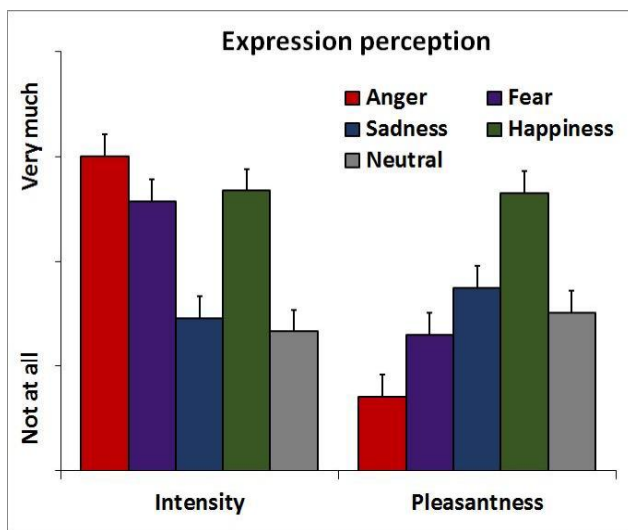
206 To investigate individual differences, we analyzed cross-level interactions between expressions
207 and subject-level factors (BIS and gender) using multilevel linear modeling (MLM). MLM was conducted
208 according to established guidelines of Tabachnick and Fidell (2007) using the mixed models as
209 implemented in SPSS 22.0. The use of MLM allowed us to investigate the cross-level interaction of
210 expression and BIS without violating the assumption of homogenous regression slopes. We ran three
211 separate mixed models for each outcome variable (intensity, pleasantness and OR). Each model included
212 the main effects of expression, touch type, intensity, gender and BIS as well as the interaction effects of
213 expression, gender and BIS. At this point the interaction terms of stimulus intensity and touch type were
214 not estimated unless they significantly interacted with the expression in a preceding ANOVA model. We
215 further investigated the interactions using a simple slope approach (Preacher, Curran, & Bauer, 2006). A
216 categorical condition variable defined by the (five expressions x two touch types x two intensity levels =)
217 20 within-subject condition combinations was set as the repeated measure. The intercept was then
218 specified as a random effect. No random slopes were included. Based on the Schwarz's Bayesian
219 criterion, scaled identity covariance structure was selected for the repeated measures while the structure

220 for random effects was set to variance components. Finally, all predictors and outcome variables were
 221 standardized.

222 3. RESULTS

223 3.1 Validation of VC's expressions

224 Before analyzing the results, we validated the emotional expressions by evaluating the
 225 recognition accuracy. Recognition performance was generally high, with 87% of cases accurately
 226 classified. Females had overall higher recognition accuracy ($91 \pm 14\%$) than males ($84 \pm 12\%$), $F(1, 37)$
 227 $= 5.08$, $p = .03$. Also, some of the expressions were recognized significantly better than the others $F(4,$
 228 $152) = 12.57$, $p < .001$. Bonferroni adjusted post hoc test revealed significantly ($ps < .001$) lower
 229 recognition for sad ($72 \pm 20\%$) compared to neutral ($91 \pm 14\%$), angry ($90 \pm 20\%$), fearful ($88 \pm 17\%$),
 230 and happy ($96 \pm 13\%$) expressions.



231

232 **Figure 3. Effect of expressions on expression intensity and pleasantness ratings.** Error bars
 233 reflect the within-subject standard error of the mean (see Loftus & Masson, 1994).

234 To see how VC's emotion affected evaluations of expression pleasantness and intensity, we
 235 conducted a set of three repeated measures ANOVAs with emotional expression as factor and intensity

236 and pleasantness ratings of avatar's *expression* as measures. Emotional expression affected participants
 237 ratings of intensity, $F(4, 152) = 51.62, p < .001, \eta_p^2 = .58$, and pleasantness, $F(4, 152) = 45.82, p < .001,$
 238 $\eta_p^2 = .55$. Bonferroni adjusted post hoc tests revealed that participants perceived angry, fearful and happy
 239 expressions as more intense than sad and neutral expressions ($ps < .016$). Angry expressions were
 240 perceived as least pleasant (all $ps < .001$) whereas happy and sad expressions were rated as most pleasant
 241 ($ps < .01$). Figure 3 (left panel) shows the means and within-subject standard errors of each expression
 242 category.

243 3.2 Affective touch perception

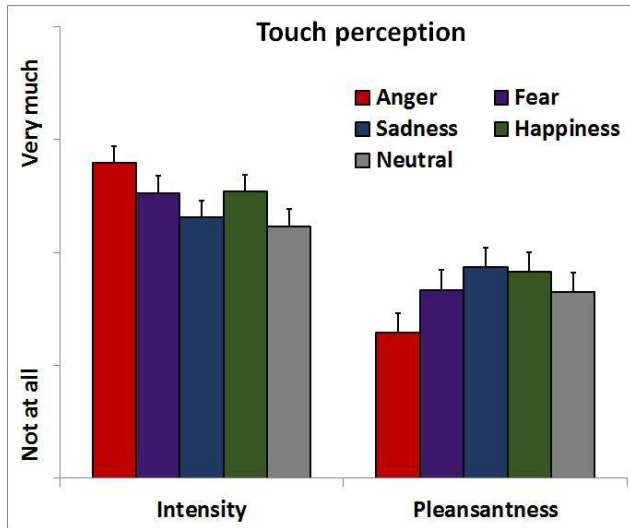
244 In order to investigate how touch perception was affected by its physical and emotional aspects,
 245 three repeated measures ANOVAs were conducted with touch type, stimulus intensity and emotional
 246 expression as factors and self-reported intensity, pleasantness and naturalness as measures.

247 3.2.1 Effects of expression, stimulus type, and intensity on self-reported tactile perception

248 As expected, stimulus intensity affected reported intensity, $F(1, 38) = 43.18, p < .001, \eta_p^2 = .53,$
 249 and pleasantness, $F(1, 38) = 10.38, p = .003, \eta_p^2 = .22$, but not naturalness, $p = .41$. Thus, participants
 250 indeed made predictable assessments regarding the touch itself, with high stimulus intensity eliciting
 251 higher reported intensity but lower pleasantness. Also the touch type affected reported intensity, $F(1, 38)$
 252 $= 6.02, p = .019, \eta_p^2 = .14$, naturalness, $F(F(1, 38) = 65.44, p < .001, \eta_p^2 = .63)$, and pleasantness $F(1,$
 253 $38) = 144.52, p < .001, \eta_p^2 = .79$. These comparisons revealed that the pressure was rated as more
 254 humanlike, pleasant and intense than the vibration.

255 More interestingly, emotional expression also affected reported touch intensity, $F(1.96, 74.49) =$
 256 $8.65, p = .00045, \eta_p^2 = .19$, and pleasantness, $F(2.98, 113.07) = 6.91, p = .00027, \eta_p^2 = .15$, establishing
 257 evidence for affective touch perception (see Figure 4). To further specify the effects, planned comparisons
 258 were conducted, revealing higher intensity reports after anger, fear and happiness ($ps < .05$), but not after
 259 *sadness* ($p > .36$). The same comparisons for ratings of pleasantness, however, revealed that anger

260 resulted in lower ratings ($p = .005$) whereas happiness resulted in higher ratings ($p = .038$). No other
 261 significant differences in pleasantness were found ($ps > .091$). Also, no significant two-way or three-way
 262 interactions were found between emotional expressions, touch type and stimulus intensity ($ps > .15$).



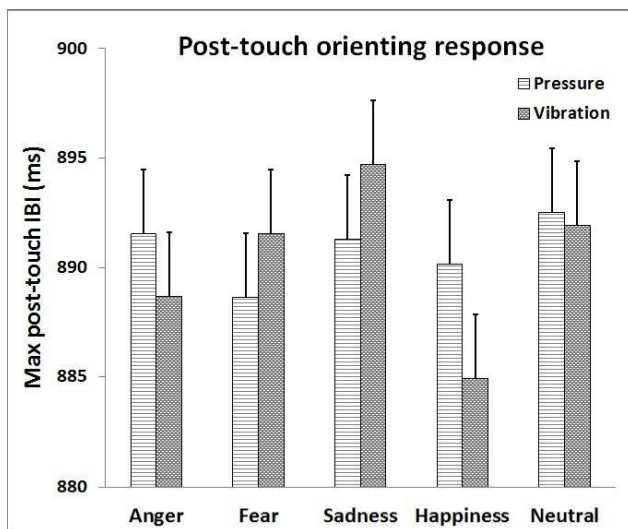
263
 264 **Figure 4. Effect of expressions on touch intensity, pleasantness, naturalness.** Error bars
 265 reflect the within-subject standard error of the mean (see Loftus & Masson, 1994).

266 Although VC's expressions significantly affected the touch perception, comparison of the effect
 267 sizes revealed that touch ratings were more strongly affected by the tactile features ($\eta_p^2s < .79$) than by
 268 VC's emotional expression ($\eta_p^2s < .19$) whereas the ratings of expression were strongly influenced by
 269 VC's emotion ($\eta_p^2s < .58$). The findings demonstrate that participants correctly evaluated items depending
 270 on their target category (touch vs. expression).

271 3.2.2 Effect of expression on post-touch OR

272 In order to investigate how facial expressions affected touch-related OR, a repeated measures
 273 ANOVA was conducted with phase, touch type, stimulus intensity and emotional expression as factors
 274 and maximum interbeat interval (OR) as a measure. The effect of phase was not significant, $F(1.27,$
 275 $48.19) = 2.07, p = .13$, indicating no habituation effect in the ORs. Also, no main effects of touch type or

276 stimulus intensity were found ($ps > .59$). However, as expected, expressions differently influenced the
 277 OR, $F(4, 152) = 4.42, p = .002, \eta_p^2 = .10$, but an interaction of expression and touch type was also found,
 278 $F(4, 152) = 4.78, p = .001, \eta_p^2 = .11$. To better understand this interaction, the ANOVA model was next
 279 calculated separately for each touch type. Expression significantly affected ORs evoked by vibrations, F
 280 $(4, 152) = 8.67, p < .001, \eta_p^2 = .19$, but not by pressure, $F(4, 152) = 1.24, p = .30$. Further bar graph
 281 analyses revealed that, in the context of vibration, the OR was lowest in the happy and highest in the sad
 282 condition, with neutral, fearful and angry in between (see Figure 5). No other significant interactions were
 283 found ($ps > .08$).



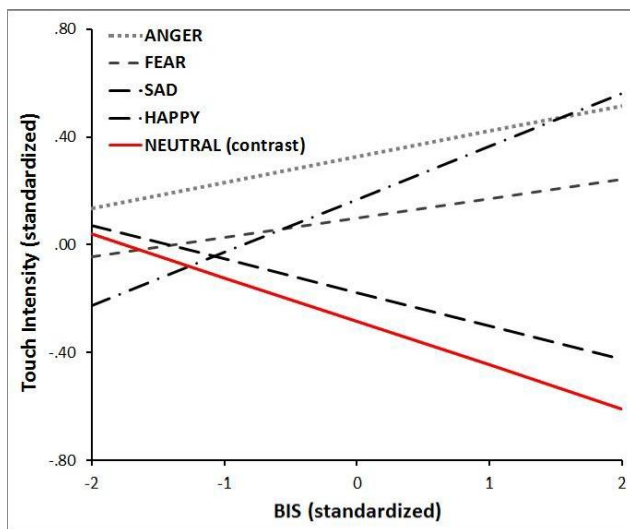
284
 285 **Figure 5. Interaction of expression and touch type on post-touch orienting response.** Error
 286 bars reflect the within-subject standard error of the mean (see Loftus & Masson, 1994).

287 3.3 Individual differences in affective touch

288 3.3.1 Effect of BIS and gender on self-reported tactile perception

289 Preliminary personality level analyses revealed that females scored higher in BIS sensitivity
 290 (20.71 ± 3.55) than males (17.45 ± 3.85) , $t(37)=2.70, p = .01$. Affective touch perception was expected to
 291 differ depending on the receiver's BIS sensitivity and gender. In order to investigate this, two mixed
 292 linear models (one for intensity and another for pleasantness) were conducted with touch type, stimulus

293 intensity, expressions and gender as factors and BIS as the covariate. The results revealed a significant
 294 interaction of expression, BIS and gender when the pleasantness ratings were predicted, $F(5, 141.59) =$
 295 $2.79, p = .019$. To better understand this interaction, the model was next calculated separately for males
 296 and females. The effect of expressions on touch pleasantness was significantly moderated by participants'
 297 BIS ratings in females, $F(4, 313) = 6.46, p < .001$, but not in males ($p = .75$). However, further inspection
 298 of the data revealed a single case with extremely low BIS rating (-3.10 SD from the females' BIS mean).
 299 After removing the case no interaction was found between the expression and BIS ($p = .61$), suggesting
 300 that the effect was caused by the outlier.



301
 302 **Figure 5. Interaction of expression and BIS on touch intensity ratings in males.** Separate
 303 regression slopes were calculated using the MLM estimates of the fixed effects. Neutral condition was
 304 used as the contrast. Touch intensity and BIS were both standardized.

305 A three-way interaction of expression, BIS and gender was also found when predicting the
 306 intensity ratings, $F(5, 141.59) = 7.34, p = .000004$. Again, the MLM model was next calculated
 307 separately for males and females to better understand the interaction. The BIS significantly moderated the
 308 effect of expressions on touch intensity ratings in both males, $F(4, 408) = 2.75, p = .028$, and females, F
 309 $(4, 313) = 6.10, p = .000098$. In females, However, the effect was again non-significant after filtering out

310 the case with extremely low BIS ratings ($p = .96$). A simple slope technique (Preacher et al., 2006) was
311 used to further investigate the nature of the interaction in males. This was done by plotting separate
312 regression slopes for each expression condition while varying the value of standardized BIS. As
313 demonstrated in the left panel of Figure 5, high-BIS males rated the touch as less intense when receiving
314 the touch from the sad or neutral VC than when being touched by a fearful, happy or angry VC.

315 3.3.2 Effect of BIS and gender on cardiac OR

316 Finally, another MLM was conducted in order to investigate the effect of BIS sensitivity and
317 gender on post-touch OR. Tactile stimulus type, stimulus intensity, facial expressions and gender were set
318 as factors and BIS as the covariate. Given that touch type significantly interacted with expression when
319 predicting OR, the interactions of touch type, BIS, gender, and expression were now included in the
320 model. Males were found to respond to the touch with more enhanced ORs (959.01 ± 138.33 ms) than
321 females (827.38 ± 166.80 ms), $F(1, 35) = 14.39, p = .001$, whereas the effect of BIS did not reach
322 significance, $F(1, 35) = 3.92, p = .056$. Besides the earlier found touch type*expression interaction, no
323 other interactions were found ($ps > .25$). Further analyses were carried out separately for each gender. The
324 results revealed that BIS, regardless of the expression, predict greater post-touch OR in males, $F(1, 20) =$
325 $7.95, p = .011$, but not in females ($p = .79$). In females the effect remained non-significant even if
326 removing the case with extremely low BIS rating, $p = .17$. No interactions were found between BIS and
327 expression ($ps > .49$).

328 4. DISCUSSION

329 Recent neuropsychological findings suggest that the emotional context of touch affects the way
330 touch is perceived (Gazzola et al., 2012; Spapé et al., 2015). Inspired by these findings, we investigated
331 whether individual characteristics of the receiver influence the affective modulation of touch perception.
332 In order to do so, we measured how individual differences related to gender and behavioral inhibition
333 sensitivity affected self-reported touch perception and post-touch OR in a VR scenario involving tactile
334 communication.

335 Results revealed that the expressions of the VC modulated touch perception, supporting the
336 earlier findings of affective touch perception. Similarly to Ellingsen et al. (2017), participants evaluated
337 the touch as most pleasing when being touched by a happy VC and least pleasing when anger was shown.
338 Moreover, participants reported the touch as most intense in angry, fearful and happy expression
339 conditions and least intense following sad and neutral expressions. In earlier studies, anger, fear and
340 happiness have been linked to increased arousal and high motivational intensity, whereas sad and neutral
341 stimuli are related to decreased arousal and low motivational intensity (Gable & Harmon-Jones, 2010;
342 Lang et al., 1993). Similarly, in the present study participants rated angry, fearful and happy faces as the
343 most intense expressions. The findings thus suggest that expressions' motivational intensity would
344 underlie the modulation of touch intensity ratings.

345 The affective touch perception was likewise apparent in terms of the OR. As previous studies
346 suggested that threatening social cues result in cardiac ORs that are associated with enhanced sensory
347 intake (Bradley, 2009), we expected negative emotions to result in stronger post-touch cardiac ORs.
348 Indeed, the OR to angry and fearful touch was stronger than the OR to happy touch. However, the OR
349 was even more enhanced when sad or neutral expression was displayed. Previous studies have shown that
350 the cardiac OR is also enhanced in response to novel or unexpected stimuli (Bernstein, 1979). Thus, it is
351 possible that the low motivational intensity communicated by expressing sad or neutral states makes a
352 subsequent touch more surprising. In other words, people may use facial cues to anticipate the other
353 person's bodily acts: a passive motivational state (e.g., sadness) does not prepare the receiver for physical
354 contact. If, conversely, physical contact follows, the touch is unexpected and thus requires more
355 elaboration. It should be noted, however, that the effect of expression on touch-related OR was significant
356 only when vibration was used. Although unclear, this effect might have been caused by the more gradual
357 beginning of the pressure stimulus which may have attenuated the OR causing less clear peaks in the IBI
358 waveforms of the pressure trials.

359 Moreover, we suspected that a receiver's characteristics related to tactile communication
360 preferences (i.e., gender and motivational style) would influence the affective touch perception. Earlier
361 studies have shown that especially socially anxious and behaviorally inhibited people avoid physical
362 contact (Wilhelm et al., 2001) and show enhanced sensory processing in response to threatening social
363 cues (Balconi et al., 2012; Gomez & Gomez, 2002). Gender has also been shown to affect both touch
364 preferences and emotional perception (McClure, 2000; Roese et al., 1992). Thus, we assumed that both a
365 receiver's gender and BIS sensitivity would influence the affective touch perception. The study confirmed
366 this, although the relationship between gender, BIS and affective touch perception was more complex
367 than expected. That is, BIS sensitivity was associated with higher ratings of touch intensity when high-
368 arousal expressions (anger, fear, and happiness) were displayed and stronger touch related ORs regardless
369 of the expression. However, these effects were only present in males. In females, the expression*BIS
370 interactions vanished after removing the case with extremely low BIS score. Given the relatively small
371 group of females (N=17), it is, however, too early to conclude that only in males the affective touch
372 perception is modulated by recipient's personality.

373 Some earlier findings suggest that the observed interaction could also be due to the fact that a
374 male VC was used. It has been demonstrated, for instance, that cross-sex (male–female) touch usually
375 communicates sexual interest whereas same-sex (male–male) touch is considered as a reminder of
376 receiver's lower social status (Major & Heslin, 1982). Perceiving the touch as a status threat may thus
377 explain the observed differences between males and females. However, as no female VCs were used in
378 the present study, it is impossible to test whether the observed results are due to the gender relation
379 between receiver and sender or only due to the gender of the receiver. Supporting the latter view, men
380 have been shown to use more touch and other dominance-related behaviors (Hall & Friedman, 1999;
381 Summerhayes & Suchner, 1978) and feel more uncomfortable when being touched by a same-sex partner
382 (Floyd, 2000; Roese et al., 1992). It is thus now clear that the gender should be considered as a relational
383 feature rather than receiver's characteristic per se. The present design thus limits the interpretation of the

384 found gender differences but does not dismiss the general finding that the effect of BIS on affective touch
385 perception seem to depend on gender. In future, the relational nature of gender should be taken into
386 account more carefully.

387 Of course, perceiving a simple vibrotactile or pressure stimulus is not necessarily the same as
388 receiving a warm touch from a fellow human being. Thus, one could argue that the obtained findings are
389 only applicable to mediated touch, but not to nonmediated tactile communication. While possible, the
390 accumulated evidence shows that even relatively simple tactile actuators can communicate a wealth of
391 socio-emotional information (Gallace & Spence, 2010). For instance, studies show that mediated touch
392 reliably evokes psychological consequences similar to those found in natural touch: it reduces stress
393 (Takahashi, Mitsuhashi, Murata, Norieda, & Watanabe, 2011), elicits helping behavior (Haans &
394 IJsselsteijn, 2009) and increases generosity (Spapé et al., 2015).

395 Similarly, one could argue that the artificial, virtual character may compromise the external
396 validity of the findings. In particular, it has previously been shown that people feel uncomfortable when
397 interacting with virtual agents that look almost, but not quite, realistically human (Seyama & Nagayama,
398 2007). While this “uncanny valley” effect may elicit a generalized unease with the presence of the VC, it
399 is not clear how this can account for the differences between emotional expressions in terms of how they
400 affect touch perception (cf. Cheetham, Suter, & Jäncke, 2011). As it is, the use of VCs in VR has
401 previously been validated (for a review see Fox, Arena, & Bailenson, 2009), with the argument
402 commonly being made that it sidesteps the common trade-off in psychological science between ecological
403 validity and experimental control (Blascovich et al., 2002). Here, we further prove the point by providing
404 the illusion of embodied, affective interpersonal touch without relying on confederates or static, black-
405 and-white pictures of emotional expressions. It is also worth noting that similarly to earlier studies
406 utilizing dynamic facial stimuli (Dyck, et al., 2008), the VC’s facial expressions were classified correctly
407 in almost 90 % of cases.

408 While we therefore see no fundamental reason why our findings should not be generalizable
409 towards direct interpersonal interaction, it is also clear that the study of individual differences in VR-
410 mediated communication is becoming steadily more important in its own right. Currently a considerable
411 amount of our daily interactions are conducted remotely via social networks and instant messaging.
412 Likewise, the research on how individual differences contribute to our online behavior is constantly
413 increasing (e.g., Nadkarni & Hofmann, 2012; Marshall, Lefringhausen, & Ferenczi, 2015). In recent
414 years, many globally established companies have made big investments in VR technology; Facebook, for
415 instance, has acquired an HMD manufacturer and formed a new group called “Social VR.” According to
416 Facebook CEO Mark Zuckerberg, “VR is going to be the most social platform” (Chaykowski, 2016),
417 suggesting that in the future human communication will be further enriched by immersive virtual
418 experiences. Unlike current forms of communication media, virtual reality creates the sense of social and
419 physical presence allowing an illusion of shared physical space (IJsselstein & Riva 2003; Schroeder,
420 2012). Given the embodiment of future online behavior, it becomes increasingly important to understand
421 how individual differences influence the way people act and feel in these new virtual circumstances.

422 In conclusion, the present findings show that sender’s emotional signals as well as receiver’s
423 motivational style and gender all contribute to the way interpersonal touch is perceived. Male VC’s high-
424 intensity emotional expressions intensify the tactile perception especially in males with high BIS
425 sensitivity. We conclude that investigating computer-mediated affective touch brings us one step closer to
426 the intimate aspects of human social life. Examining the interplay of personality, gender and emotional
427 states in the context of interpersonal touch may give us a closer look into the fabric of social interaction
428 and reveal new territories for personality research.

429

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