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

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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

ABSTRACT

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

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

1. INTRODUCTION

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

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

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

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

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

Numerous lines of research on other perceptual modalities suggests also that facial expressions can critically affect basic perception of a stimulus (cf. Vuilleumier, 2005). For instance, the mere presence of a fearful face has been shown to potentiate attention and facilitate subsequent visual perception (Phelps, Ling, & Carrasco, 2006). This affective modulation has been suggested to arise from increased neural communication between visual cortical areas and emotion-related subcortical structures (Vuilleumier & Pourtois, 2007). Interestingly, the peripheral organs, such as the heart, also take part in enhancing the perception (Bradley, 2009). For example, presenting a threatening emotional cue results in brief cardiac deceleration, also called a cardiac orienting response (OR; Bradley, Lang, & Cuthbert, 1993). Cardiac orienting has been related to biological processes involved in extracting information from the environment and is thus used as an index of enhanced sensory intake (cf. Bradley, 2009).

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

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

1.1 Present study

The purpose of the current study was to investigate whether individual characteristics and emotional expressions influence the perception of interpersonal affective touch. We utilized an immersive virtual reality (VR) paradigm to measure affective touch perception in the context of an emotionally expressive virtual character (VC). Haptic technology was used in order to provide the illusion that, following a facial emotional expression, the VC touched the participant. This novel methodological approach allowed us to control for visual (reaching gestures, facial dynamics) and haptic (tactile location, intensity) aspects without compromising the ecological validity of the touch experience (Blascovich, Loomis, Beall, Swinth, Hoyt, & Bailenson, 2002).

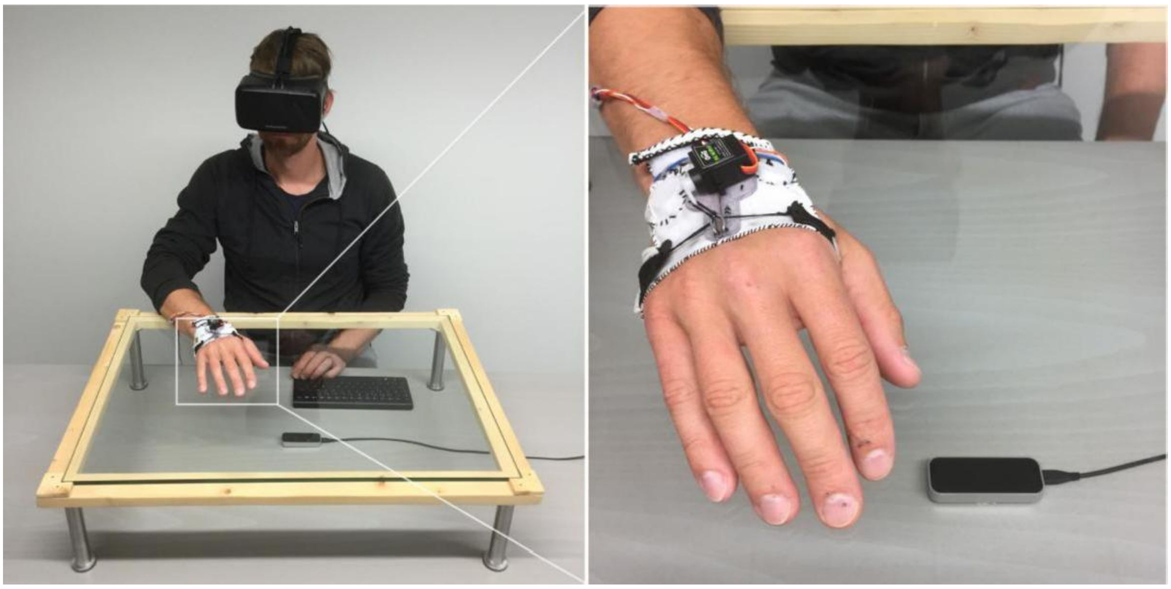

Figure 1. Experimental setup. A head-mounted display presented visual stimuli. A hand-tracking device underneath a glass table allowed participants to move their virtual hand in synchrony with their real hand. The tactile glove, presented at right, delivered vibrotactile and mechanical stimuli.

Supporting the notion of affective touch perception, we expected that emotional expressions would change how touch was experienced in terms of its intensity and pleasantness as well as cardiac OR. More specifically, we expected that a touch preceded by a VC's angry facial expression would be rated as less pleasant and more intense compared to other facial expressions. Furthermore, we investigated whether individual differences contributed to the affective touch perception. Taking into account the fact that high-BIS persons perceive angry faces as more hostile compared to low-BIS persons (Knyazev et al., 2008), we expected that high-BIS persons would rate touch preceded by angry expression as less pleasant and more intense and show more enhanced touch-related OR compared to low-BIS persons. Finally, given that males show usually more aversion of same-sex touch (Roese, et al., 1992) we assumed males to rate male VC's touch as less pleasant and more intense especially when accompanied by negative expressions.

2.1 Participants

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

2.2 Procedure

After filling out the personality questionnaire, participants were seated at a desk equipped with a glass table and assisted in putting on a head-mounted display (HDM) and tactile glove. Within VR, they 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 Figure 2, Panel A). As they touched the area, the VC appeared, wearing a neutral expression (B). The emotional expression animation only started (C) after participants moved their hand forward to a blue cue. Then, after a randomized interval of 1 to 3 s, the VC reached out and, 1 s later, touched the participant's hand (D), at which time tactile stimulus was delivered. The VC remained in view for another 1 s after which participants were instructed to get ready for the next trial or to answer (in the first 20 trials of each block) a short questionnaire. There were 100 trials per block, and five blocks with breaks in between. The experiment took ca. 90-120 minutes.

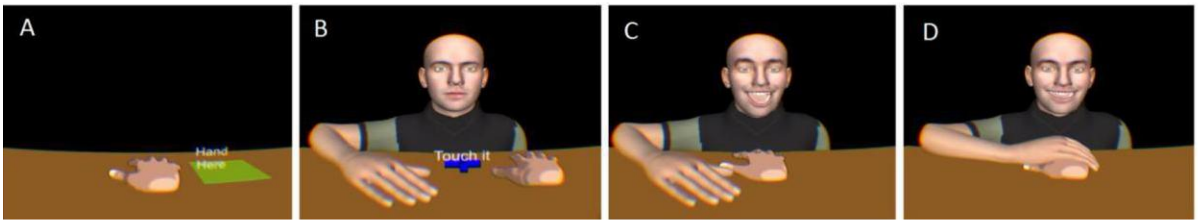

Figure 2. Experimental paradigm. VC was shown expressing an emotion before touching participant's virtual hand.

2.3 Stimuli and apparatus

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

2.2.1 Emotional expressions

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

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

2.2.2 Interpersonal touch

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

2.3 Self-report measures

2.3.1 Personality

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

2.3.2 Questionnaires concerning visual and tactile experience

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

2.4 Physiological measures

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

2.5 Design

Each of the five experimental blocks comprised five randomly ordered repetitions of each trial type obtained by crossing the two touch types (vibration, mechanical pressure) x the two intensity levels (low, high) x the five emotional expressions (anger, fear, sadness, happiness and neutrality). The perception of VC's expression was first investigated by using four full-factorial repeated measures ANOVAs with touch type, touch intensity and emotional expressions as factors and self-reported expression intensity, naturalness, and pleasantness as dependent variables. The affective touch was then investigated by using four repeated measures ANOVAs in which self-reported touch intensity, naturalness, pleasantness and post-touch OR were set as dependent variables. Given that cardiac OR tends to be subject to habituation (Bradley, 2009), additional factor of phase (500 trials divided to three levels each consisting from 167 to 166 trials) was included in the model when predicting ORs. To further specify the effects of emotional expression, planned pairwise comparisons between emotional expressions and the neutral control were conducted.

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

3. RESULTS

3.1 Validation of VC's expressions

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

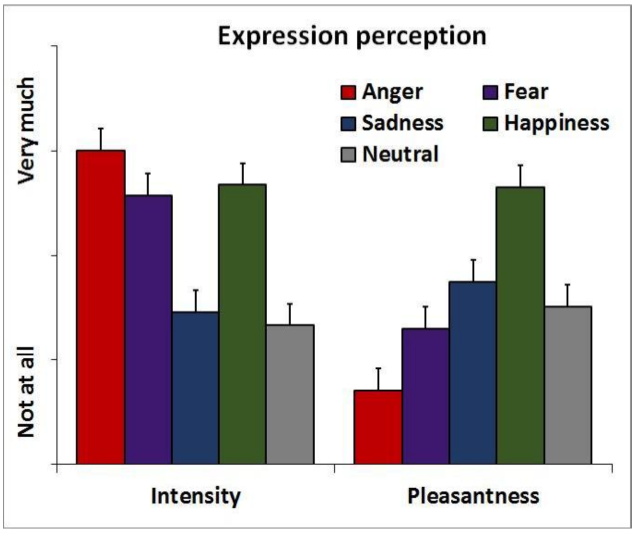

Figure 3. Effect of expressions on expression intensity and pleasantness ratings. Error bars reflect the within-subject standard error of the mean (see Loftus & Masson, 1994).

To see how VC's emotion affected evaluations of expression pleasantness and intensity, we conducted a set of three repeated measures ANOVAs with emotional expression as factor and intensity and pleasantness ratings of avatar's *expression* as measures. Emotional expression affected participants ratings of intensity, F (4, 152) = 51.62, $p < .001$, $\eta_p^2 = .58$, and pleasantness, F (4, 152) = 45.82, $p < .001$, $\eta_p^2 = .55$. Bonferroni adjusted post hoc tests revealed that participants perceived angry, fearful and happy expressions as more intense than sad and neutral expressions (*p*s < .016). Angry expressions were perceived as least pleasant (all *p*s < .001) whereas happy and sad expressions were rated as most pleasant (*p*s < .01). Figure 3 (left panel) shows the means and within-subject standard errors of each expression category.

3.2 Affective touch perception

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

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

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

More interestingly, emotional expression also affected reported touch intensity, F (1.96, 74.49) = 8.65, $p = .00045$, $\eta_p^2 = .19$, and pleasantness, F (2.98, 113.07) = 6.91, $p = .00027$, $\eta_p^2 = .15$, establishing evidence for affective touch perception (see Figure 4). To further specify the effects, planned comparisons were conducted, revealing higher intensity reports after anger, fear and happiness (*p*s < .05), but not after *sadness* ($p > .36$). The same comparisons for ratings of pleasantness, however, revealed that anger resulted in lower ratings ($p = .005$) whereas happiness resulted in higher ratings ($p = .038$). No other significant differences in pleasantness were found (*p*s > .091). Also, no significant two-way or three-way interactions were found between emotional expressions, touch type and stimulus intensity (*p*s > .15).

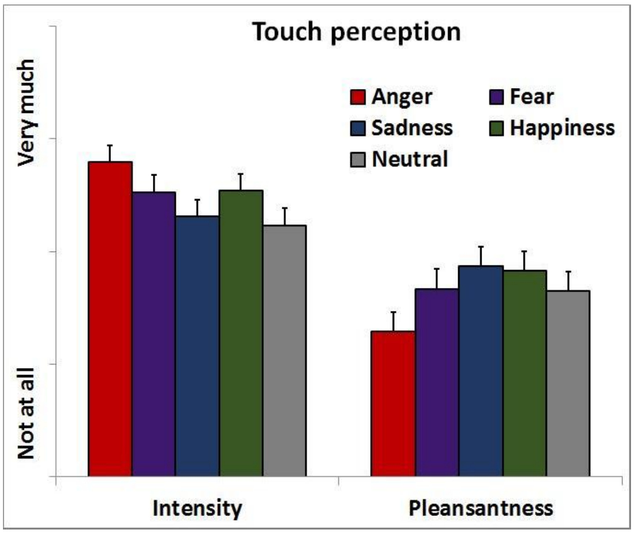

Figure 4. Effect of expressions on touch intensity, pleasantness, naturalness. Error bars reflect the within-subject standard error of the mean (see Loftus & Masson, 1994).

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

3.2.2 Effect of expression on post-touch OR

In order to investigate how facial expressions affected touch-related OR, a repeated measures ANOVA was conducted with phase, touch type, stimulus intensity and emotional expression as factors and maximum interbeat interval (OR) as a measure. The effect of phase was not significant, F (1.27, 48.19) = 2.07, $p = .13$, indicating no habituation effect in the ORs. Also, no main effects of touch type or stimulus intensity were found (*ps* > .59). However, as expected, expressions differently influenced the OR, F (4, 152) = 4.42, $p = .002$, $\eta_p^2 = .10$, but an interaction of expression and touch type was also found, F (4, 152) = 4.78, $p = .001$, $\eta_p^2 = .11$. To better understand this interaction, the ANOVA model was next calculated separately for each touch type. Expression significantly affected ORs evoked by vibrations, F (4, 152) = 8.67, $p < .001$, $\eta_p^2 = .19$, but not by pressure, F (4, 152) = 1.24, $p = .30$. Further bar graph analyses revealed that, in the context of vibration, the OR was lowest in the happy and highest in the sad condition, with neutral, fearful and angry in between (see Figure 5). No other significant interactions were found (*ps* > .08).

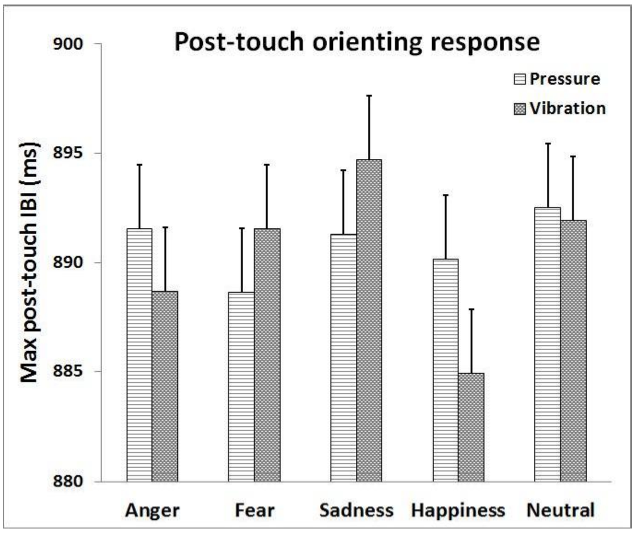

Figure 5. Interaction of expression and touch type on post-touch orienting response. Error bars reflect the within-subject standard error of the mean (see Loftus & Masson, 1994).

3.3 Individual differences in affective touch

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

Preliminary personality level analyses revealed that females scored higher in BIS sensitivity (20.71 ± 3.55) than males (17.45 ± 3.85), $t(37)=2.70$, $p = .01$. Affective touch perception was expected to differ depending on the receiver's BIS sensitivity and gender. In order to investigate this, two mixed linear models (one for intensity and another for pleasantness) were conducted with touch type, stimulus intensity, expressions and gender as factors and BIS as the covariate. The results revealed a significant interaction of expression, BIS and gender when the pleasantness ratings were predicted, F (5, 141.59) = 2.79, *p* = .019. To better understand this interaction, the model was next calculated separately for males and females. The effect of expressions on touch pleasantness was significantly moderated by participants' BIS ratings in females, F (4, 313) = 6.46, *p* < .001, but not in males (*p* = .75). However, further inspection of the data revealed a single case with extremely low BIS rating (-3.10 SD from the females' BIS mean). After removing the case no interaction was found between the expression and BIS (*p* = .61), suggesting that the effect was caused by the outlier.

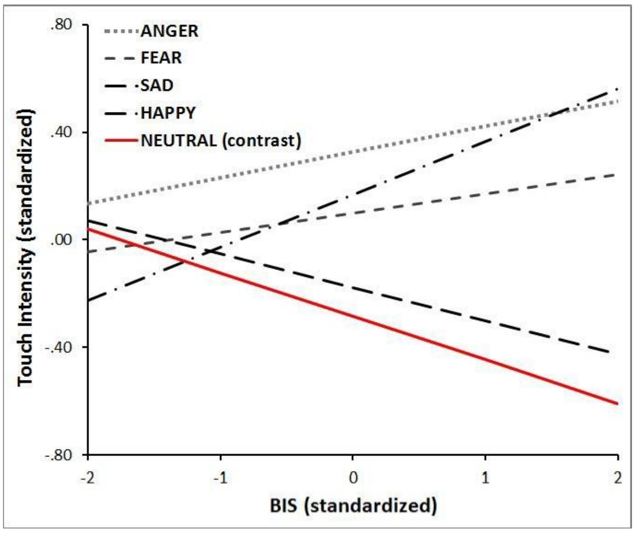

Figure 5. Interaction of expression and BIS on touch intensity ratings in males. Separate regression slopes were calculated using the MLM estimates of the fixed effects. Neutral condition was used as the contrast. Touch intensity and BIS were both standardized.

A three-way interaction of expression, BIS and gender was also found when predicting the intensity ratings, F (5, 141.59) = 7.34, *p* = .000004. Again, the MLM model was next calculated separately for males and females to better understand the interaction. The BIS significantly moderated the effect of expressions on touch intensity ratings in both males, F (4, 408) = 2.75, *p* = .028, and females, F (4, 313) = 6.10, *p* = .000098. In females, However, the effect was again non-significant after filtering out the case with extremely low BIS ratings (*p* = .96). A simple slope technique (Preacher et al., 2006) was used to further investigate the nature of the interaction in males. This was done by plotting separate regression slopes for each expression condition while varying the value of standardized BIS. As demonstrated in the left panel of Figure 5, high-BIS males rated the touch as less intense when receiving the touch from the sad or neutral VC than when being touched by a fearful, happy or angry VC.

3.3.2 Effect of BIS and gender on cardiac OR

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

4. DISCUSSION

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

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

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

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

Some earlier findings suggest that the observed interaction could also be due to the fact that a male VC was used. It has been demonstrated, for instance, that cross-sex (male–female) touch usually communicates sexual interest whereas same-sex (male–male) touch is considered as a reminder of receiver's lower social status (Major & Heslin, 1982). Perceiving the touch as a status threat may thus explain the observed differences between males and females. However, as no female VCs were used in the present study, it is impossible to test whether the observed results are due to the gender relation between receiver and sender or only due to the gender of the receiver. Supporting the latter view, men have been shown to use more touch and other dominance-related behaviors (Hall & Friedman, 1999; Summerhayes & Suchner, 1978) and feel more uncomfortable when being touched by a same-sex partner (Floyd, 2000; Roese et al., 1992). It is thus now clear that the gender should be considered as a relational feature rather than receiver's characteristic per se. The present design thus limits the interpretation of the found gender differences but does not dismiss the general finding that the effect of BIS on affective touch perception seem to depend on gender. In future, the relational nature of gender should be taken into account more carefully.

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

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

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

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

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