Effects of mediated social touch on affective experiences and trust

Stefanie M. Erk, Alexander Toet, Jan B.F. van Erp

This study investigated whether communication via mediated hand pressure during a remotely shared experience (watching an amusing video) can *(1)* enhance recovery from sadness, *(2)* enhance the affective quality of the experience, and *(3)* increase trust towards the communication partner. Thereto participants first watched a sad movie clip to elicit sadness, followed by a funny one to stimulate recovery from sadness. While watching the funny clip they signaled a hypothetical fellow participant every time they felt amused. In the experimental condition the participants responded by pressing a hand-held two-way mediated touch device (a Frebble), which also provided haptic feedback via simulated hand squeezes. In the control condition they responded by pressing a button and they received abstract visual feedback. Objective (heart rate, galvanic skin conductance, number and duration of joystick or Frebble presses) and subjective (questionnaires) data were collected to assess the emotional reactions of the participants. The subjective measurements confirmed that the sad movie successfully induced sadness while the funny movie indeed evoked more positive feelings. Although their ranking agreed with the subjective measurements, the physiological measurements confirmed this conclusion only for the funny movie. The results show that recovery from movie induced sadness, the affective experience of the amusing movie, and trust towards the communication partner did not differ between both experimental conditions. Hence, feedback via mediated hand touching did not enhance either of these factors compared to visual feedback. Further analysis of the data showed that participants scoring low on *Extraversion* (i.e., persons that are more introvert) or low on *Touch Receptivity* (i.e., persons who do not like to be touched by others) felt better understood by their communication partner when receiving mediated touch feedback instead of visual feedback, while the opposite was found for participants scoring high on these factors. The implications of these results for further research are discussed, and some suggestions for follow-up experiments are presented.

Effects of Mediated Hand Touching on Affective Experiences and Trust

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1   **Introduction**

3   **Aim of this study**

4   Touch provides a powerful means of evoking and modulating human emotion. Touching someone - as
5   well as being touched by someone - can have a positive and calming effect. People who are touched more
6   often by their partner also report better psychological well-being (Debrot et al., 2013; Debrot et al., 2014).
7   From nursing care it is known that human touch can promote physical, emotional, social and spiritual
8   comfort (Chang, 2001; Whitcher & Fisher, 1979; see also Field, 2010), for instance by effectively
9   reducing worries (Whitcher & Fisher, 1979), anxiety and pain (Anderson, 2001).

10 In daily life the action of touching or holding hands is an important empathic experience for dyads that
11 elicits a strong sense of togetherness, while signaling trust, understanding and social support (Field,
12 2010). Haptic devices that mediate the act of holding hands via the internet may therefore provide a
13 means to foster a powerful sense of intimacy and connectedness between physically separated dyads
14 (Toet et al., 2013; van Erp & Toet, 2015). The present study was performed to investigate whether
15 mediated touch can elicit some of the beneficial effects reported for direct touch and can therefore be used
16 to improve the quality of interpersonal contact and communication at a distance. In particular, this study
17 investigates whether sharing emotions via mediated social touch can *(1)* enhance recovery (i.e., the return
18 to a more positive emotional state) after a negative (sad) experience, *(2)* enhance a positive (amusing)
19 experience, and *(3)* increase trust towards the communication partner. At this stage the focus of our
20 research is primarily on eliciting affective responses similar to those that occur while holding hands, and
21 not so much on a realistic simulation of the feeling of a human hand (skin texture and temperature).

22 **The importance of interpersonal touch**

23 Touch is the preferred nonverbal communication channel for conveying intimate emotions like love and
24 sympathy (App et al., 2011). Interpersonal touch can promote physical, emotional, social and spiritual
25 wellbeing (Field, 2010). The gentle touch from another person influences our readiness to empathize with
26 and support that person (Guéguen & Fischer-Lokou, 2003). A handshake, an encouraging pat, a sensual
27 caress, a nudge for attention, or a gentle brush can all convey a vitality and immediacy that is at times far
28 more powerful than language (Jones & Yarbrough, 1985).

29 Geographically separated people in need of social support often long for each other's physical presence.
30 Typical examples are family members who are separated by great distances, such as grandparents who
31 live far from their grandchildren, a child who is sick in a hospital far from family members, a parent who
32 is away on a business trip, people with parents in nursing homes, etc. The development and diffusion of
33 internet-based technologies has enabled people who are globally separated to easily interact with each
34 other. However, most of the currently available technologies do not include the tactile aspects of
35 interpersonal communication, which are known to play a crucial role in establishing a sense of
36 togetherness.

37 **Mediated Touch**

38 Motivated by the fundamental importance of touch as a channel to convey human emotions, and the fact
39 that even simple haptic stimulation can carry emotional information (Salminen et al., 2008), there has
40 recently been an increasing interest in mediating touch for interpersonal communication in addition to

41 vision and audition (Toet et al., 2013; van Erp & Toet, 2015). Tactile or kinesthetic interfaces that enable
42 haptic communication between people who are physically apart, may thus provide the experiences of
43 connection and engagement, with all the physical, emotional and intellectual feedback it supplies
44 (Cranny-Francis, 2011). It has been shown that mediated handshaking can indeed enhance the feeling of
45 social presence (Nakanishi, Tanaka & Wada, 2014). Also, haptic telecommunication can increase the
46 quality of a shared experience and enhance the intimacy felt towards the other person (Takahashi et al.,
47 2011) by intensifying the emotional displays from other (e.g., visual, auditory) modalities (Knapp & Hall,
48 2010) and by conveying specific emotions (Hertenstein et al., 2006). Recent technologies like HugMe
49 (Cha et al., 2009), iFeel_IM (Tsetserukou et al., 2009) and the Frebble (Figure 1 ; see also Toet et al.,
50 2013 and http://myfrebble.com) therefore focus on the enhancement of social interactivity by enabling
51 online communication programs (like MSN or Skype) to convey affective and intimate haptic messages.
52 It has also been suggested that this technology can be used to record affective touch patterns from loved
53 ones for later replay (Brown, 2015). However, until now only few studies have actually investigated
54 affect conveyance through mediated social touch (Toet et al., 2013). Although it appears that mediated
55 touch can indeed to some extent convey emotions (Bailenson et al., 2007) and induce prosocial behavior
56 (the Midas effect Haans & IJsselsteijn, 2009), it is still not known to what extent it can also elicit affective
57 experiences (Gallace & Spence, 2010; Haans & IJsselsteijn, 2006).

58

Recovery from a sad experience

60 People feel a fundamental need to share their feelings (Rimé, 2009) and often seek haptic feedback (e.g.,
61 a hug, a pat on the arm or hand), especially after experiencing negative emotions since this type of
62 feedback is highly effective in conveying support and providing comfort (Dolin & Booth-Butterfield,
63 1993). Responsive social touch not only positively affects the receiver but also the touching partner
64 (Debrot et al., 2013; Debrot et al., 2014). A recent study found that even mediated touch can modulate
65 emotion: mediated pressure to the forearm reduced heartbeat rates of participants after they had watched a
66 sad video clip (Cabibihan, Zheng & Cher, 2012). Based on these findings we hypothesize that:

67   **H1**: Feedback via mediated hand touching enhances recovery from movie induced sadness to a larger
68   extent than visual feedback.

69

Intensified affective experience

71 People feel a need to communicate intense emotions with each other (Rimé, 2009). It has been found that
72 people who experienced negative emotions (sadness, fear, disgust) after watching negative emotional
73 movie clips shared more information and experiences with their friends than participants who watched
74 neutral movie clips (Luminet et al., 2000). But people also like to share positive emotions like happiness
75 and joy with each other, probably because sharing increases the possibility of personal rewards and
76 consequently results in even more optimistic and positive feelings (Bagozzi, Gopinath & Nyer, 1999).
77 Laughing together at a comedy show or sharing other moments of fun with each other improves and
78 strengthens relationships and is an opportunity to create connections and bonds between people (Klein,
79 1989). Laughing is a natural social response that is contagious (Rizzolatti et al., 1999): people laugh more
80 if others in their environment are also laughing (Robinson & Smith-Lovin, 2001). Touch can effectively

81   intensify affective feelings and communication, even when it is mediated. For instance, mediated touch
82   can enhance the affective quality of phone messages (Salminen et al., 2012) and remotely shared
83   experiences (e.g., the hilariousness of a movie: Takahashi et al., 2011). A study on the added value of
84   mediated touch enabled phone communication showed that couples are naturally inclined to use touch to
85   express their amusement (Park, Baek & Nam, 2013). Given that amusement can be communicated by
86   touching hands (Hertenstein et al., 2009), and that touch is capable to enhance affective feelings, our
87   second hypothesis is therefore:

88   **H2**: Feedback via mediated hand touching enhances the experience of an amusing movie compared
89   to visual feedback.

Increase of trust

91   In a supportive setting interpersonal touch tends to increase trust, even among strangers (Burgoon,
92   Walther & Baesler, 1992). It has been shown that mediated communication can also establish trust at a
93   distance (Bos et al., 2002; Zheng et al., 2002). Although the effectiveness of mediated communication
94   for establishing trust increases with media richness, trust is still highest when people can meet face-to-
95   face (Bos et al., 2002; Zheng et al., 2002). This observation has simply been stated as "trust need touch"
96   (Handy, 1995). The current study aims to investigate if mediated touch can also serve to establish trust.
97   Our third hypothesis is therefore:

98   **H3:** Feedback trough mediated hand touching increases trust towards another person compared to
99   abstract visual feedback.

Present study

101   To test the first two hypotheses (H1 and H2) participants first watched a sad movie clip to induce sadness,
102   followed by a funny one to stimulate recovery from sadness. While watching the funny clip they signaled
103   a hypothetical fellow participant (who was supposedly watching the same movies in an adjacent room)
104   every time they were amused. These conditions were chosen since *(1)* people feel a fundamental need to
105   share their feelings after watching a sad movie clip (Luminet et al., 2000), *(2)* they are inclined to use
106   touch to express their amusement (Park, Baek & Nam, 2013), *(3)* feelings of amusement can be
107   communicated by touching hands (Hertenstein et al., 2009), and *(4)* mediated tactile stimulation may
108   enhance the experience of an amusing movie (Takahashi et al., 2011). In the experimental condition the
109   participants responded by pressing a hand-held mediated touch device, which also provided haptic
110   feedback (from the ostensible fellow participant) via a simulated hand squeeze. In the control condition
111   they communicated by pressing a button and they received abstract visual feedback. Thus, participants
112   gave haptic response in both conditions, and received haptic feedback in the experimental condition and
113   abstract visual feedback in the control condition. Objective (physiological measurements) and subjective
114   (questionnaires) measures were obtained to verify the hypotheses H1 and H2. To test whether mediated
115   hand touching increased trust (H3) the participants played a trust game with their ostensible fellow
116   participant at the end of the experiment.

Method

118

Participants

A total of N = 39 participants took part in this experiment. The data from two participants was excluded (one because of technical problems, and the other one was excluded because the participant provided no response during the experiment), resulting in a sample of N = 37. Of those, 23 were female and 14 were male, aged from 19 to 50 years (M = 30.16, SD = 10.49). The participants were recruited from the TNO database of volunteers and received 20 Euros for their participation. All participants gave their written consent. After the experiment the aim of the study was explained in a debriefing, with the exception that the participants were not informed that the feedback they had received during the experiment had been scripted and was not sent by a fellow participant. This was done to prevent that they could pass this information on to future participants.

None of the participants had critical heart diseases or used antidepressants that could affect heart rate. Participants were randomly assigned to either the control or the experimental condition. 18 participants performed in the control condition and 19 in the experimental condition. Table 1 shows how the participants were distributed over the experimental conditions with respect to sex and age.

Experimental design

In a between-subjects design participants watched two emotional video clips while sharing their emotions in one of two ways with an ostensible fellow participant. In the experimental condition they signaled their own emotion by squeezing a mediated touch device, and they received haptic feedback about the feelings of their fellow participant in the form of hand squeezes presented via the same device. In the control condition they signaled their own emotions by squeezing the button on a joystick , and they received feedback in the form of an abstract visual cue.

Emotional video clips are known to effectively evoke and sustain affective experiences over longer time periods at both subjective and physiological levels (Carvalho et al., 2012). In this study the participants successively watched two emotional video clips: a sad one that served to elicit feelings of sadness followed by a funny one that was supposed to stimulate recovery from sadness. The participants were led to believe that they would be able to communicate with a fellow participant who would simultaneously be watching the same video clips in an adjacent room. In reality the feedback was scripted and no fellow participant was present. The two (control and experimental) conditions of this study differed only in the communication mode during the presentation of the second (funny) video clip (Figure 2). In the control condition participants signaled which scenes they found funny by pressing a button on a joystick (haptic input), while visual feedback indicated whenever their ostensible fellow participant found a video segment funny. In the experimental condition participants held a mediated touch device in their hand which they could press (haptic input) to indicate which scenes they found funny. The same device squeezed their hand in return (haptic feedback) whenever their fellow participant supposedly found a video segment funny. Note that the haptic input modes in both conditions are equivalent since squeezing the joystick button required a similar action as squeezing the mediated touch device. The main difference between both conditions was the feedback mode, which was visual in the control condition and haptic in the experimental condition.

Apparatus and stimuli

Video clips and presentation

The clip that served to elicit sadness was a scene (with a duration of 686 s) from the 'The Champ' (Lovell & Zeffirelli, 1979) showing a boy who cries after his father's death. Several previous studies have shown that this scene successfully elicits feelings of sadness (Ellard, Farchione & Barlow, 2012; Goldberg, Preminger & Malach, 2014; Gross & Levenson, 1995; Rottenberg, Ray & Gross, 2007). The funny video (with a total duration of 595 s) was a compilation of 35 different scenes from funny home movies (www.youtube.com) showing hilarious scenes with animals and young children. In a pilot study this compilation was indeed rated (on a 10-point semantic differential Likert Scale (1 = *not funny at all* ; 10 = *very funny*) as being funny (M = 7.86; SD = 1.45; N=8). The video clips used in this study had a resolution of 1920 × 1080 pixels. A PC equipped with a Sanyo PLC-WL2500A beamer (www.panasonic.com) projected the video onto an area of 190 × 107 cm^2 of the wall-mounted projection screen. Custom-made software was used both to present the scripted feedback and to play the movies. In the control condition a grey square (60 × 60 pixels) in the middle of the right hand side of the screen turned blue to signal which scenes which the ostensible fellow participant found funny (visual feedback). The entire video presentation (including the instructions that appeared between the two video clips) lasted 21 minutes and 51 s.

Joystick

In the control condition participants squeezed the rapid-fire trigger of a Logitech Extreme 3D Pro joystick (www.logitech.com) to signal to their fellow participant which video segments they found amusing.

Frebble

In the experimental condition participants used a Frebble (Holland Haptics, Delft, The Netherlands; http://myfrebble.com) to communicate with their ostensible fellow participant. A Frebble is an ergonomically designed haptic device (Figure 1, see also Toet et al., 2013) that comfortably fits in (and encloses the back of) the hand and simulates both the touch of holding and squeezing another person's hand – and having that feeling reciprocated (see also http://vimeo.com/86103101). Frebbles can communicate with one another via internet or Bluetooth. When a Frebble is squeezed, the corresponding gadget gently applies pressure to the back of a partner's hand, to simulate the feeling of holding hands. Two pressure sensors at the front of the device register squeezing while two vibration motors and a 'squeeze bar' provide the sensation of squeezing back. The bar is like a little lever that extends against the back of the hand. Frebbles are designed to enable mediated affective touch between physically separated partners. Users can communicate and receive haptic signals simultaneously. The pair of Frebbles used in this study consisted of one slave and one master, identical in size (12 cm high with a scope of 17 cm at the bottom and 11 cm at the top of the extension) and shape. Both Frebbles communicated with each other via Bluetooth. The pressure of the haptic signals provided by a Frebbble can vary from soft to hard. In this study the master Frebble was connected to the computer of the experimenter (via a USB connection) and sent scripted feedback to the slave Frebble (which was held by the participant) using a fixed pressure intensity, which resulted in a firm but comfortable squeeze (as established in a pilot test). Participants squeezed the Frebble to signal which video segments they found amusing, and the Frebble squeezed their hand in return whenever their fellow participant was supposedly amused.

Scripted feedback

200 The scripted feedback for both conditions was determined from a pilot study in which 6 participants
201 watched the funny video clip. Three participants used a joystick and three others used a Frebble to signal
202 their response. They were instructed to press the button of the joystick or Frebble every time they were
203 amused by the video clip. It was their own choice how often, for how long, and how firm they applied the
204 pressure. The average of all participants' responses (duration and pressure level) was calculated and used
205 as scripted feedback for the experiment. Although the fine nuances of the touch were lost by using a
206 constant (average) pressure level, it makes the Frebble condition more comparable to the joystick
207 condition (both are on or off at the same moments during the video clip). The scripted feedback was
208 tested with two other participants to ensure that it was perceived as realistic and only occurred during
209 video segments that could indeed be classified as amusing. The final feedback, which was used for the
210 experiment, consisted of 57 presses with a total length of 191 seconds. The shortest response took 1
211 second and the longest 15 seconds.

212 During the experiment the same binary feedback track was used in both (visual and haptic feedback)
213 conditions. In the control condition it resulted in visual feedback and in the experimental condition it led
214 to a haptic (Frebble) feedback.

215

Physiological measurements.

217 Seven Ag-AgCL Flat electrodes were used to measure heart rate (HR) and skin conductance level (SCL).
218 For the ground and reference measurement one electrode was placed on the neck of the participant and
219 one behind each ear. The electrodes for the ECG signal were placed one at the right collarbone and one at
220 the left floating rib. Two electrodes for the GSR signal were placed on the palm of the non-dominant hand
221 of the participant (the hand not used to respond in the experiment), one right below the forefinger and the
222 other one in the middle of the hand palm. The physiological signals were recorded with a computer using
223 ActiView BioSemi software (www.biosemi.com) at a sampling rate of 512 Hz. The ECG signal was
224 filtered using a 0.5-100 Hz bandpass filter, and afterwards by a 2.5 Hz high-pass 2-sided Butterworth
225 filter. The GSC signal was filtered by a 30 Hz low-pass 2-sided Butterworth filter.

226

Set-up conditions

228 The experiments were performed in a small, well-ventilated, and sound-proof windowless room. The
229 lights were dimmed during the video presentation. The participants were seated comfortably on a coach
230 facing a wall mounted projection screen from a mean distance of 3.20 m. To enable later analysis of their
231 facial expressions participants were recorded on video during the experiment using a Panasonic WV-
232 BP330/GE camera (www.panasonic.com) in combination with an infrared light source.

233

234 **Measures**

235 **Objective measures**

236 Heart rate and skin conductance level were used to quantify a participant's physical reactions to the video
237 clips (Davydov, Zech & Luminet, 2011; Kreibig, 2010). Both heart rate (Mandryk, Inkpen & Calvert,
238 2006) and skin conductance level (Lang, 1995) are known to reflect emotional activity (Brouwer et al.,
239 2013). Sad film clips typically evoke a decreased skin conductance level and a decreased heart rate (i.e.,
240 when participants do not cry in response to watching the film: Kreibig, 2010). In contrast, amusing film
241 clips typically evoke an increase in skin conductance level, often accompanied by an increase in heart
242 rate (although the heart rate response is not unequivocal: Kreibig, 2010). The physiological data were
243 processed and analyzed in Matlab 8.0 (www.mathworks.com). The mean value of a participant's heart
244 rate and skin conductance level were computed over the following three time intervals (later referred to
245 as the *time of measurement*) : *(1)* the preparation period before watching the movie clips (this served as a
246 personal baseline), *(2)* the last four minutes of 'The Champ' (just after the father's death, which is the
247 saddest part of the movie) and *(3)* the first 90 s of the funny video clip (the period during which recovery
248 effects are most likely to occur).

249 In a previous study on empathic touch by relational agents Bickmore et al. (2010) observed that the
250 number of hand squeezes and squeeze duration were associated with affect valence when mediated touch
251 was used as the only feedback mode. In the present study we therefore adopted the number and duration
252 of Frebble responses and the total duration of smiling (estimated from the analysis of the video recordings
253 of a participant's facial expressions) during the presentation of the funny video clip as additional
254 objective measures of the participant's affective response to the clip.

255 The duration of a participant's smile while watching the funny video clip was measured from the video
256 recording of the participant's facial expressions using The Observer XT 11.5 software tool
257 (www.noldus.com). Therefore the experimenter watched the video recording of each participant and
258 judged once per second whether the participant was smiling or not. A smile was recognized according to
259 the definition of a Duchenne smile (Soussignan, 2002). To assess the reliability of this annotation method
260 two additional observers also annotated five randomly selected videos and their inter-rater reliability
261 (Person's *r*) with the experimenter was calculated. The inter-rater reliability between the observers and
262 the experimenter was high: $r = .89$ for both observers.

263 The amount of money set in during the trust game was used as an objective measurement of trust towards
264 the fellow participant.

265 **Subjective measures**

266 During the experiment each participant filled out three questionnaires: the first one at the start of the
267 experiment (70 questions and statements), the second one after watching the movie clips (32 questions
268 and statements) and the third one at the end of the experiment when the experimenter pretended to play a
269 trust game with the fellow participant (16 questions and statements).

270 **Questionnaire 1**

271 The first questionnaire contained demographic questions about gender, age, heart or other diseases, and
272 use of medicines. To explain possible outliers in the physiological data the participants were also asked

273   how much time had passed since they had smoked, drank coffee or alcohol, or had any physical exercise
274   before the experiment. Also, questions were asked about their current mood, personality and touch
275   receptivity. These questions served to check whether the groups of participants in both experimental
276   conditions were comparable in terms of current mood, personality and touch receptivity.

277   The *current mood* of the participants was measured with the 'Brief Mood Introspection Scale' (BMIS:
278   Mayer & Gaschke, 1988) which consisted of 16 adjectives (such as *lively*, *happy*, *sad* and *tired*) that could
279   be rated on a 4-point Likert Scale (1 = *definitely do not feel*; 4 = *definitely feel*). The reliability
280   (Cronbach's alpha) of the BMIS for the sample in this study was α = .82. The 'Self-Assessment Manikin'
281   (SAM: Bradley & Lang, 1994) was also used to assess the current mood. The SAM is a nine-point
282   pictorial rating scale that measures pleasure, arousal and dominance. The SAM provides a simple, fast,
283   and non-linguistic way of assessing a person's mental state along the principal emotional dimensions and
284   is highly suitable to measure transient (short term) emotional states. The reliability for this scale was α =
285   .63.

286   Three personality traits (*Extraversion*, *Openness* and *Agreeableness*) were measured with the Dutch
287   version (Van Heck et al., 1994) of the original 'Big 5' questionnaire (Goldberg, 1992). For each
288   personality trait 10 statements had to be answered on a 5-point Likert Scale (1 = *strongly disagree*; 5 =
289   *strongly agree*). An example question for measuring Extraversion was: "*I feel comfortable around
290   people*". The reliabilities were α = .88 for *Extraversion*, α = .85 for *Openness* and α = .56 for
291   *Agreeableness*.

292   Eight items from the Touch Receptivity Questionnaire (the same items used by Bickmore et al., 2010, for
293   example: "*I like people who shake hands with me.*") were used to measure how comfortable participants
294   were of being touched by someone else. The eight items were translated into Dutch and were answered on
295   a 7-point Likert Scale (1= *disagree completely*, 7 = *agree completely*). They had a reliability of α = .76.

296   **Questionnaire 2**

297   After watching both movie clips the participants were asked to fill out a second questionnaire to measure
298   their affective experience. In addition to questions about the movie itself this questionnaire also presented
299   the BMIS and SAM again (for the second time). This was done to identify possible changes in mood after
300   watching the movie clips.

301   Participants were asked to indicate how entertaining they found the funny movie clip on a 10-point
302   semantic differential Likert Scale (1 = *not funny at all* ; 10 = *very funny*). In addition they were asked to
303   rate their overall feeling while watching the funny clip by rating 10 adjectives (*interested*, *joyful, sad,
304   angry, fearful, terrified, contempt, disgusted, surprised, happy*) on a 6-point Likert Scale (1 = *not at all*; 6
305   = *very intense*; e.g. Davydov, Zech & Luminet, 2011; Schaefer et al., 2003). The reliability of these items
306   was α = .91. Together these questionnaires provided an impression of the overall affective experience of
307   the funny movie clip.

308   Participants were also asked whether they had ever seen the first movie clip ('The Champ') before and
309   rated on a 10 point scale how sad they experienced it (1 = *not at all*, 10 = *very intense*).

310

Questionnaire 3

A third questionnaire served measured the participant's impression of the (ostensible) fellow participant.

Affective trust is the confidence one places in a partner on the basis of feelings generated by the level of care and concern the partner demonstrates (Johnson & Grayson, 2005). In this study affective trust towards the fellow participant was measured with one item ("*I felt that the other person understood me.*") that was rated on a 7-point Likert Scale (1 = *completely disagree*; 7 = *completely agree*).

A single item ("*I felt that the other person had the same humor.*") rated on a 7-point Likert Scale (1 = *completely disagree*; 7 = *completely agree*) measured whether the participant thought that the fellow participant appreciated the same kind of humor.

Attachment was measured with an adapted version of a questionnaire that was originally developed to measure consumer-product attachment (Schifferstein & Zwartkruis-Pelgrim, 2008). This questionnaire contained five items ("*I felt emotionally connected with my fellow participant.*", "*The fellow participant was dear to me.*", "*I had a bond with my fellow participant.*", "*The fellow participant had no* special *meaning for me.*", "*I had no feelings for my fellow participant.*") that could be rated on a 7-point Likert Scale (1 = *completely disagree*, 7 = *completely agree*). This questionnaire had a reliability of α = .89.

Perceived trustworthiness of the fellow participant was measured on the dimensions trust, immediacy, reliability, and credibility (Rubin et al., 2009) using eight 7-Point bipolar semantic differential Likert scales (*cold – warm, familiar – unfamiliar, friendly - unfriendly, distant - close, kind - cruel, active - passive, reliable – unreliable, direct – indirect*). The reliability of this questionnaire was α = .73.

The 'Inclusion of Other in the Self' Scale (IOS: Aron, Aron & Smollan, 1992) is a single-item, pictorial measurement of closeness between two persons. It shows seven pairs of circles (one circle representing the Self and the other one representing the partner) with different degrees of overlap representing different degrees of interpersonal interconnectedness. The degree of overlap between the circles increases linearly from non-overlapping (1; representing *no interpersonal connection*) to almost completely overlapping (7; representing *a strong interpersonal connection*). The participants were asked to mark the picture which best described the relationship they experienced to their fellow participant.

Trust game

To test whether mediated hand touching can increase trust towards another person (H3) the participants were invited to play a trust game with their ostensible fellow participant at the end of the experiment. After watching both movies and filling out the second questionnaire the experimenter thanked the participants and handed them their show-up fee. At that time the experimenter informed the participants that they were given a chance to increase their fee by participating in a game. The participants were free to decide whether or not to participate in the game and how much of their fee they would send to their fellow participant. They were told that their fellow participant would receive twice the amount of money they sent and that he/she could decide whether to keep the money or to return a certain amount to the sender. In this game, sending money to the other player is risky but can also lead to an expanded profit, if returned by the other player. The amount of money that the sender decides to transfer to the recipient can be seen as a (behavioral) measure of the sender's trust towards the other person. This so called 'trust

350 game' is a well-established method to measure the degree of trust between persons (Berg, Dickhaut &
351 McCabe, 1995; Glaeser et al., 2000; Lazzarini et al., 2004). In the current study there was actually no
352 second player involved, and the experimenter returned all participants the same amount they gave away.

353

Statistical analysis

355 The statistical data analysis was done with IBM SPSS 20.0 (www.ibm.com). The dependent variables of
356 this study were: the physiological measurement of heart rate and skin conductance level, the variables of
357 the questionnaires, the Frebble and joystick response behavior (number and duration of responses) while
358 watching the funny movie clips, the amount of money set in at the trust game, and the facial expression
359 data (smile duration). Independent sample t-tests and mixed design analyses of variance (ANOVAs) were
360 conducted for the normally distributed dependent variables. A Wilcoxon-Mann-Whitney test was
361 conducted for the dependent variables of Frebble press behavior (duration and number of response) and
362 the smile duration, because these data were not normally distributed. Three participants incorrectly used
363 the "*movie rating*" answer categories. It was therefore decided to exclude their answers from the analysis
364 of the dependent variable '*movie rating adjectives*'. All analyses of the physiological measurements were
365 done both with difference scores (difference between the individual baseline and the measured value
366 during the movie clips) as well as with mean scores (mean value of all participants measured during the
367 movie clips). Because both analyses showed no difference in outcomes only the mean values of heart rate
368 and skin conductance level are reported this study.

369

Procedure

371 The timeline of the experimental procedure is shown in Figure 3. After having been picked up and greeted
372 in the entrance hall by the experimenter the participant was guided to the test room, sat down on a sofa,
373 and read and signed an informed consent form. The participant was then told that the experimenter had to
374 return to the entrance hall to pick up a second participant, who was intentionally invited 5 minutes later to
375 prevent both participants from meeting each other. The participant was informed that it was necessary to
376 avoid a physical encounter with the other participant since a first impression of the other participant based
377 on factors like gender and attractiveness might influence the outcome of the study. The experimenter
378 asked the participant to fill out the first questionnaire in the meantime and to wait until she would return.
379 In fact the experimenter waited outside the test room and returned 15 minutes later when the participant
380 had finished the questionnaire. This procedure served to enhance the illusion that there was indeed a
381 fellow participant present in a room next to the test room. The experimenter explained that the purpose of
382 the study was to investigate people's emotions while watching emotional video clips. Therefore the
383 participant would watch two video clips that were also simultaneously being watched by the fellow
384 participant in the adjacent room. The participant was asked to simply watch the first video clip, and to
385 signal the fellow participant in the other room whenever an amusing episode occurred in the second video
386 clip by pressing the Frebble (experimental condition) or by pressing the button of the joystick (control
387 condition). The participant was told that the fellow participant would do the same. The feedback of the
388 fellow participant was either in the form of a simulated hand press via the feedback mechanisms of the
389 Frebble (experimental condition - haptic feedback) or shown on the projection screen in the form of a
390 grey square that turned blue whenever the fellow participant signaled the occurrence of an amusing

391 episode (control condition - visual feedback). In the experimental condition the participants were led to
392 believe that their fellow participant also held a Frebble device and would experience their responses as
393 hand squeezes. In the control condition they were told that their fellow participant would see their
394 response as a color change of a square shown on the projection screen. The way to use the Frebble or the
395 joystick to send information and the meaning of the feedback (either presented via the Frebble or via the
396 colored square) were explained and the participant was given the opportunity to experience it and to ask
397 questions. If there were no further questions the electrodes to measure heart rate and skin conductance
398 level were attached to the participant. Then the participant was asked to sit calmly for a few minutes
399 before the video clips would start. The participant was informed that this was necessary because the
400 experimenter also needed to explain the experiment to the other participant. The participant was left alone
401 and the video clips would start automatically after eight minutes. The sound of the video clips was played
402 through headphones to exclude any noise from the Frebble's actuators. After the first video clip ('The
403 Champ') a text appeared on the screen instructing the participant to use the joystick or Frebble to
404 communicate with the fellow participant during the presentation of the second video clip. After the
405 second video clip the participant filled out a second questionnaire. After a short waiting period the
406 experimenter returned in the room, removed the sensors from the participant's body, placed the
407 participant's fee on the table (20 coins of 1 Euro) and asked if the participant would like to play a game
408 with the fellow participant. The experimenter explained the game and then played the first round with the
409 participant. Next she pretended to play the second round with the fellow participant in the adjacent room.
410 While the experimenter was outside the room pretending to play the game with the fellow participant, the
411 participant completed the last (third) questionnaire. The experimenter returned after a few minutes with
412 the same amount of Euros the participant had previously sent to the fellow participant. All of the 37
413 participants agreed to play the game. The total duration of the experiment was about 60 minutes for each
414 participant. The experimental protocol was reviewed and approved by the TNO internal review board on
415 experiments with human participants (TNO Soesterberg, The Netherlands), and was in accordance with
416 the Helsinki Declaration of 1975, as revised in 2000 (World Medical Association, 2000).

417 **Results**
418
419 An independent t-test on the scores on the Touch Receptivity Questionnaire, the BMIS, the three
420 dimensions of the SAM (pleasure, arousal and dominance) and the three personality traits of the BIG 5
421 (*Extraversion*, *Openness* and *Agreeableness*) from Questionnaire 1 showed no significant differences
422 between both experimental groups (all p-values > .05; see Table 2). Hence, both groups are indeed
423 equivalent, which makes any differences between their responses to Questionnaires 2 and 3 most likely
424 the result of the different experimental conditions.

425
426

427 **Emotion elicitation**
428 A prerequisite for testing the three hypotheses was that the video clip from 'The Champ' would elicit sad
429 emotions whereas the funny video clips would cheer people up. Objective and subjective measurements
430 were therefore analyzed to investigate if these manipulations had been successful.

Objective measurements

The mean value of a participant's heart rate and skin conductance level were computed over the following three time intervals: *(1)* the preparation period before watching the movie clips (this served as a personal baseline), *(2)* the last four minutes of 'The Champ' (the part after the father's death) and *(3)* the first 90 s of the funny video clip. Figure 4 shows the mean values of these measures over all participants. On first inspection the ranking of the mean heart rate and mean skin conductance levels during the three time intervals appears to agree with our expectations: the mean levels of these parameters during the sad and funny movie periods were respectively lower and higher than their corresponding values during the baseline period.

A repeated measures ANOVA was conducted to investigate whether the mean heart rate differed significantly between the three times of measurement. The results showed that the heart rate was indeed significantly affected by the time of measurement, $F(2,72) = 4.58$, $p = .013$, $\eta^2 = .113$. A Bonferroni post-hoc comparison of the three intervals indicated that the heart rate during the last minutes of 'The Champ' ($M = 68.20$, 95% CI [65.77, 70.63]) was significantly lower than during the first 90 s of the funny video clips ($M = 69.92$, 95% CI [67.08, 72.75]), $p = .020$. The baseline ($M = 69.03$, 95% CI [66.41, 71.64]) did not differ significantly from 'The Champ' ($p = .30$) and the funny video clips ($p = .46$).

A repeated measures ANOVA between the three times of measurement was also conducted for the mean skin conductance level. The analysis showed that the mean skin conductance level was significantly affected by the time of measurement, $F(2,72) = 13.73$, $p < .001$, $\eta^2 = .276$. A Bonferroni post-hoc comparison indicated that the skin conductance level was significantly lower during the baseline period ($M = 5.88$, 95% CI [5.05, 6.71]) than during the presentation of the funny video clip ($M = 7.09$, 95% CI [6.27, 7.91]), $p = .001$. The skin conductance level during the last four minutes of 'The Champ" ($M = 5.77$, 95% CI [4.84, 6.70]) was also significantly lower than the skin conductance level during the funny video clip, $p < .001$. There was no significant difference between the skin conductance level during the baseline period and during 'The Champ' ($p = 1.00$).

Subjective measurements

'The Champ' scored on average 7.09 (SD = 1.79) on a scale from 0 (*not sad at all*) up to 10 (*very sad*) on the self-reporting questionnaire. The funny video clip scored on average 6.84 (SD = 1.42) on a scale from 0 (*not funny at all*) to 10 (*very funny*). In addition, in response to the 10 questions about their feelings while watching the funny movie clips it appears that participants on average felt quite positive: M = 5.03 (SD = 0.57) on a 6 point Likert scale.

Conclusion

The subjective measurements indicated that both movies served their purpose: the 'The Champ' indeed elicited sad emotions while the funny video clip appeared to evoke more positive feelings. Although the ranking of the objective measurements (mean heart rate and mean skin conductance levels) agrees with the subjective measurements, this conclusion was only confirmed for the funny video clip (both heart rate and skin conduction level were significantly higher than the baseline value during the first 90 s of the

470   funny movie), but not for the sad video clip (both heart rate and skin conduction level while watching
471   'The Champ' were not significantly different from the baseline value).

472

Hypothesis I: Recovery from a sad experience

474   To test whether mediated touch communication enhances recovery from movie induced sadness to a
475   larger extent than visual feedback (H1) the physiological measurements (heart rate and skin conductance
476   level) in the control and Frebble conditions were compared between the 'The Champ' (last four minutes
477   after the father's death) and the recovery period during the funny video clip (the first 90 seconds) using a
478   mixed-model ANOVA.

479

Heart rate

481   A mixed-model ANOVA revealed that there was a main effect of *time of measurement* between 'The
482   Champ' and the funny video clip, $F(1,35) = 21.093$, $p < .001$, $\eta^2 = .376$ (Figure 5a). However there was
483   no significant main effect of *condition*, $F(1,35) = 0.172$, $p = .680$, $\eta^2 = .122$, and no interaction effect
484   between time *of measurement* and *condition*, $F(1,35) = 0.332$, $p = .568$, $\eta^2 = .014$. This indicates that the
485   participants' heart rate did not differ significantly between the control and Frebble conditions over the
486   period defined by the presentation of the 'The Champ' and the first 90 s of the funny video clip.

487

Skin conductance

489   A mixed-model ANOVA again revealed that there was a main effect of *time of measurement* between
490   'The Champ' and the funny movie clips, $F(1,35) = 329.62$, $p < .001$, $\eta^2 = .904$ (Figure 5b). However,
491   there was no significant main effect of *condition*, $F(1,35) = 0.62$, $p = .434$, , $\eta^2 = .072$. and no interaction
492   effect between *time of measurement* and *condition*, $F(1,35) = 0.627$, $p = .434$, $\eta^2 = .015$. This also
493   indicates that there was no significant difference between the joystick and Frebble condition during both
494   time intervals.

495

Conclusion

497   The variation in mean heart rate and mean skin conductance level over both measurement intervals (the
498   last four minutes of 'The Champ' and the first 90 seconds of the funny video clip) indicates that the
499   participants did indeed recover from the sad movie over the associated time period. However, mean heart
500   rate or mean skin conductance level did not differ significantly between both conditions over these
501   measurement intervals. Hence, feedback via mediated hand touching did not enhance the recovery from
502   movie induced sadness to a larger extent than visual feedback (H1). Hypothesis 1was therefore not
503   confirmed.

504

Hypothesis 2: Intensified affective experience

To test whether feedback via mediated hand touching enhances the experience of an amusing movie relative to visual feedback (H2) we compared the objective (press and smiling behavior) and subjective (questions about the affective experience in Questionnaire 2) measurements in the control and Frebble conditions.

Objective measurements

The objective measurements of the press behavior (duration and number of responses) and the time the participants were smiling were not completely normally distributed. Therefore, a non-parametric Kolmogorov-Smirnov test with ranked scores and a Wilcoxon-Mann-Whitney test were used to analyze these three dependent variables. Because the results were almost identical only the results of the Wilcoxon-Mann-Whitney test will be reported.

The time during which the joystick was pressed while watching the funny video clip (*Press duration*) in the control condition (Mdn = 59.56) did not differ significantly from the time during which the Frebble was pressed in the experimental condition (Mdn = 86.61), U = 227.00, z = -1.702, *p* = .092, ns. Also, the number of presses in the control condition (Mdn = 49.00) did not differ from the number in the Frebble condition (Mdn = 52.00), U = 151.50, z = -0.593, *p* = .563, ns. The annotation of the facial expression indicated that the time the participants were smiling while watching the funny video clip also did not differ significantly between both conditions (joystick: Mdn = 166.00; Frebble: Mdn = 225.00), U = 138.50, z = -0.988, *p* = .331, ns.

Press duration correlated significantly with: *Openness* (r = .34, p < .05), the amount of money set in the trust game (*r* = .35, p < .05), and with affective trust towards the fellow participant ("*I felt that the other person understood me*": *r* = .43, *p* < .01). *Number of presses* is significantly correlated with the amusement rating of the funny movie clip (*r* = .43, p < .01), the score on the second BMIS (after watching the funny movie: r = .35, p < .05), the *Pleasure* score on the SAM (r = .42, p < .01), affective trust towards the fellow participant (r = .52, p < .01), and the assessment of the fellow particpant's sense of humor ("*I felt that the other person had the same humor*" : r = .57, p < .01). *Number of presses* and *press duration* were also significantly correlated (*r* = .41, p < .05).

Finally, an independent samples t-test was used to investigate whether the mean heart rate and skin conductance measurements (both registered while watching the funny video clip) differed significantly between both conditions. For mean heart rate there was no significant difference between the control (M = 69.55; SD 7.76) and the Frebble condition (M = 70.27; SD = 9.37), t(35) = -0.253, *p* = .801, ns. For skin conductance the control (M = 7.60; SD = 2.69) and Frebble (M = 6.61; SD = 2.16) conditions showed no significant difference either, t(35) = 1.240, *p* = .223, ns.

Subjective measurements

An independent samples t-test was used to investigate whether the participants scored differently in the control and Frebble conditions on the questions about their affective experience of the funny movie clips. For the rating score (from 0 to 10) about how amusing the participants found the movie there was no

544 significant difference between the control (M = 6.67; SD = 1.65) and the Frebble conditions (M = 7.00;
545 SD = 1.20), t(35) = -0.707, p = .485, ns. For the rating of the movie using adjectives there was also no
546 significant difference (control: M = 5.09; SD = 0.65; Frebble: M = 4.98; SD = 0.51), t(32) = 0.526, p =
547 .603, ns.

548

Conclusion

550 Neither the objective nor the subjective measurements showed any significant difference between the
551 affective experience of the funny movie in both experimental conditions. Hypothesis 2 (feedback via
552 mediated hand touching enhances the experience of an amusing movie compared to visual feedback) was
553 therefore not confirmed.

554
555

Hypothesis 3: Increase of Trust

557 To test whether feedback through mediated hand touching increases trust towards another person relative
558 to abstract visual feedback (H3) we compared the objective (amount of money bet during the trust game)
559 and the subjective (questions concerning the impression of the other participant in Questionnaire 3)
560 measurements in the control and Frebble conditions.

Objective measurements

562 The amount of money bet during the trust game was used to measure trust towards the other person. An
563 independent t-test between the control (M = 6.83, SD = 5.76) and the Frebble condition (M = 6.21, SD =
564 5.91) showed that there was no significant difference between the amount of money set in in both
565 conditions; t(35)= 0.324, p = .748, ns.

Subjective measurements

567 At the end of the experiment questions were also asked concerning the impression of the other participant.
568 None of these items showed a significant difference between the conditions (all p-values > .05). The
569 results of the independent t-tests are shown in Table 3.

Conclusion

The results of both the objective and subjective measurements indicate that compared to visual feedback, mediated haptic communication leads neither to more trust nor to a different impression of the other person. Hypothesis 3 (feedback trough mediated hand touching increases trust towards another person compared to abstract visual feedback) was therefore not confirmed.

Sample characteristics

The current mood (BMIS) and emotional state (SAM) of the participants were again measured after watching both video clips. To test whether mood and emotional state were affected differently in both conditions, for all four dependent variables a mixed-design ANOVA with a within-subjects independent variable of *time of measurement* (before and afterwards) and a between-subjects independent variable of *condition* (control vs. Frebble) was conducted.

For the BMIS there were no main effects of *time of measurement*, $F(1,35) = 2.164$, $p = .150$, ns. and condition, $F(1,35) = 0.518$, $p = .518$, ns., nor was there an interaction between BMIS and condition, $F(1,35) = 0.102$, $p = .752$, ns.

For the *Pleasure* measurement (SAM) there were no effects of *time of measurement,* $F(1,34) = 0.003$, $p = .956$, ns. and *condition*, $F(1,34) = 0.007$, $p = .934$, ns. There was also no interaction between *time of measurement* and *condition*, $F(1,34) = 1.007$, $p = .323$, ns.

The *Arousal* measurement (SAM) showed a main effect of *time of measurement* , $F(1,35) = 4.513$, $p = .041$, $\eta^2 = .114$ and a significant interaction between *time of measurement* and *condition*, $F(1,35) = 7.674$, $p = .009$, $\eta^2 = .180$ (Figure 6). However, there was no main effect for *condition*, $F(1,35) = 0.151$, $p = .700$, ns. (Figure 6).

Main effects of *time of measurement* , *dominance* (SAM), $F(1,34) = 1.575$, $p = .218$, ns. and *condition*, $F(1,34) = 2.532$, $p = .121$, ns. as well as the interaction between the *dominance* and *condition*, $F(1,34) = 0.827$, $p = .370$, ns. were not statistically significant.

Explorative analyses

Besides testing the hypotheses of the present study there were also data collected concerning age, gender, mood (BMIS), emotions (SAM), Touch Receptivity, and personality traits (BIG 5). To investigate whether these factors may have an effect on the dependent variables some explorative analyzes were conducted. Therefore separate analyses of covariance for each dependent variable were conducted with each of the listed factors (age, gender, mood and emotions) as a covariate. The results showed no significant results. None of the factors influenced the outcome of the dependent variables as a covariate.

In addition, possible effects on the dependent variables were investigated by a two-way ANOVA having two levels for each factor (Table 4) and two levels of conditions (control vs. Frebble). Therefore each factor was subdivided in two levels based on the median score. The factors: *mood* (BMIS), *emotions* (all three SAM measurements), *Openness* and *Agreeableness* were excluded from this analysis because the scores were extremely right skewed with less than 15% of the scores being lower than the mean score.

611   The independent variables used for the analyses with their two levels are shown in Table 4. All effects
612   were statistically significant at the .05 significance level. It is chosen to only report significant results.
613
614
615   There were no main effects of *Touch Receptivity*, $F(1,33) = 1.584$, $p = .217$, ns, or *condition*, $F(1,33) =$
616   1.584, $p = .217$, ns, on the dependent variable of *Affective Trust*. However, there was a significant
617   interaction effect between *Touch Receptivity* and *condition* on *Affective Trust*, $F(1,33) = 4.537$, $p = .041$,
618    $\eta^2 = .121$. Specifically, participants who scored low on *Touch Receptivity* reported higher *Affective Trust*
619   towards their fellow participant when using a Frebble (M = 4.00, SD = 0.41) than when using a joystick
620   (M = 2.33, SD = 0.58; Figure 7a).
621
622   There were no main effects of *Extraversion*, $F(1,33) = 1.82$, $p = .187$, ns, or *condition*, $F(1,33) = 2.20$, $p =$
623   .148, ns. on the dependent variable of *Affective Trust*. However, again a significant interaction effect was
624   found between *Extraversion* and *condition* on *Affective Trust*, $F(1,33) = 5.56$, $p = .024$, $\eta^2 = .144$.
625   Participants who scored low on *Extraversion* reported lower *Affective Trust* towards their fellow
626   participant when using a joystick (M = 2.29, SD = 0.95) than when using a Frebble (M = 4.25, SD = 2.22;
627   Figure 7b).
628

629   **Discussion**
630   This study was performed to investigate whether mediated hand touching can have some of the same
631   beneficial effects as reported for interpersonal touch. Therefore participants successively watched two
632   emotional video clips and were led to believe that a fellow participant in an adjacent room simultaneously
633   watched the same clips. The first video clip was intended to induce sadness while the second one was
634   intended to cheer up the participants. While watching the second (funny) video clip the participants were
635   asked to signal their fellow participant whenever they were amused, either via a mediated hand touch
636   device or via a joystick. They received either haptic or visual feedback: whenever their fellow participant
637   found the video amusing they received a mediated hand press (experimental condition) or a visual cue (a
638   gray square on the screen turned blue - control condition). In reality there was no fellow participant
639   present and a computer sent standardized feedback that had been scripted in advance.

640   It was expected that, compared to the control condition, communication with mediated hand touch
641   feedback would (H1*)* enhance recovery from the sad mood, (H2) intensify the affective experience of the
642   funny movie clips, and (H3) increase trust towards the fellow participant.

643   **Experimental manipulation**
644   Analysis of the physiological measurements showed that the funny video clip indeed successfully elicited
645   the desired emotion of amusement. While watching the funny video clip the participants' heart rate and
646   skin conductance level increased significantly compared to both their baseline levels and their levels
647   during the sad video clip. The selected sad movie only resulted in moderate emotional effect: heart rate
648   and skin conductance level both decreased relative to their baseline levels but this difference was not
649   significant. An explanation for the different extent of the physiological reactions to respectively the sad
650   and funny video clips may be found in the dimensionality of emotions. Emotion has been conceptualized
651   as a dimensional construct with valence and arousal as the main dimensions (Mehrabian & Russell,

652 1974). Valence refers to whether an experience is pleasurable (pleasant vs. unpleasant), and arousal refers
653 to autonomic arousal associated with the experience (relaxed vs. aroused). In this view sadness can be
654 described as a negative experience with a neutral level of associated arousal, while amusement can be
655 described as a pleasant experience with a high level of associated arousal. The stronger physiological
656 reactions to the funny video clip are probably due to a higher level of arousal, whereas the neutral arousal
657 level induced by the sad video clip probably resulted in weaker physiological responses (Fernández et al.,
658 2012; Gunes & Pantic, 2010). Here we should note that results in the literature on skin conductance
659 responses to watching sad movies are also not unequivocal (both increases, decreases and the absence of
660 skin conductance responses have been reported: Kreibig, 2010). Therefore it is also important to take the
661 self-report questionnaires into account. The participants reported moderately high sadness scores on the
662 sad video clip and moderately high amusement scores on the funny video clip. It can therefore be
663 concluded that the induction of amusement was successful both on a subjective and on an objective level,
664 whereas the induction of sadness was confirmed on a subjective level. Although this is not the most
665 extreme manipulation thinkable, we consider the effects sufficient for the current experiment.

666 **Recovery from sad mood**

667 Previous studies indicate that interpersonal touch leads to a faster recovery from a sad mood or anxious
668 events (Debrot et al., 2013; Whitcher & Fisher, 1979). However, this effect has not been widely examined
669 for mediated touch (Haans, de Bruijn & IJsselsteijn, 2014). Only one study (Cabibihan, Zheng & Cher,
670 2012) reported a faster recovery during a resting period after watching a sad movie with both human and
671 mediated touch. The present study tried to replicate this effect for mediated hand touching and to extend
672 our understanding of this effect. But contrary to prior expectations, communication via a mediated touch
673 device did not lead to enhanced recovery from a negative mood induced by watching a sad movie clip.
674 Participants in both conditions showed a clear increase in heart rate and skin conductance level when
675 watching the funny video clip (as expected), but the extent of the increase was not significantly different
676 between the visual and mediated hand touching feedback conditions.

677 A possible reason that there was no difference in recovery between the two experimental conditions in the
678 present study could be due to the fact that the mediated touch used here differed in one important aspect
679 from the one used by Cabibihan and colleagues (Cabibihan, Zheng & Cher, 2012). In Cabibihan's study
680 the mediated touch device did not only provide haptic stimulation (like the Frebble did in the present
681 study), but also provided warmth. A lack of warmth could cause the unsuccessful replication of their
682 results in the present study. Generally, the effect of pleasant touch (strokes) is larger for stimuli at skin
683 temperature (Lucas et al., 2014).

684 As mentioned before, the communication of amusement from the participant to the imaginary fellow
685 participant was similar in both conditions (pressing the button on the joystick versus squeezing the
686 Frebble). The main difference between both groups was the feedback mode, which was either visual or
687 haptic. It is known that simple signals may be sufficient to mediate affective communication (Janssen,
688 IJsselsteijn & Westerink, 2014) and that sharing feelings per se may already account for a certain amount
689 of recovery. This effect could not be measured in this study because both groups communicated their
690 feelings. Hence, the fact that participants in both conditions were able to communicate their feelings
691 could account for the main effect independent of the actual nature of the mediated feedback (visual or
692 haptic) .
693

694   **Affective experience**

695   This study also investigated whether the affective experience itself can be influenced by the use of a
696   mediated hand touching device. Subjective measurements in the form of self-report questionnaires and
697   objective measurements like number and duration of presses and facial expressions served to assess the
698   affective experience. None of these measures revealed significant differences between the control and
699   experimental condition. However, all objective measurements showed a marginal trend towards a more
700   intense affective experience with the mediated touch device. Participants in the mediated touch condition
701   smiled for longer periods and pressed the device more often and longer than participants in the control
702   condition. Note that although these measures are taken to characterize a participant's affective response
703   to the video clip, they could also be influenced by the novelty of the interface. Despite these trends, it
704   remains unclear why the use of the mediated touch device did not lead to a more intense affective
705   experience.

706
707   The absence of a more intense affective experience may imply either that this effect cannot be induced by
708   mediated touch at all or that the used form of mediated touch in this study was inappropriate. It is
709   therefore important to investigate other aspects of mediated touch (like warmth) to get more insight about
710   the possible effects of mediated touch on affective experience. Another element of mediated touch which
711   is known to influence affective communication, but which was not tested in this study, is visual
712   stimulation. It has been found that adding a mutually shared haptic sensation to a video conferencing
713   system can significantly enhance the experience of social telepresence and mediated touch, provided that
714   the mediated social touch is mutual but not visually duplicated (i.e., one should be able to see the partner
715   and his movements to grasp the intention of the touch, but not one's own body part that is being touched,
716   since this disturbs the illusion: Nakanishi, Tanaka & Wada, 2014).

717
718   The absence of a difference between the control and experimental conditions may also be due to the way
719   feedback was provided during this study. Previous studies show that the quality of a conversation may
720   depend on the richness of its content (Haans & IJsselsteijn, 2006). In this study the participants used a
721   very simple, non-rich tactile code to communicate their feelings to their fellow participant (one press =
722   feeling amused) in both conditions. Although the haptic device was able to deliver richer touch cues, we
723   deliberately reduced the richness of its code to the level of richness of the visual cue (to make both
724   feedback modes more comparable). Also, the feedback of the fellow participant was clear and
725   unambiguous (color change of a square or haptic stimulation = feeling amused). The only difference
726   between both conditions was the channel used for the feedback: haptic feedback in the experimental
727   condition versus visual feedback in the control condition. It could be that the absence of a difference
728   between both conditions means that the most important requirement for a shared affective experience is
729   the ability to communicate feelings to another person, irrespective of the communication mode (as also
730   suggested by Spapé et al., 2015). If so, haptic feedback has no benefit over visual feedback for affective
731   communication. This hypothesis could be verified by including a condition in which the participants
732   cannot communicate their feelings. Finding *(1)* a difference between conditions in which feelings are
733   either shared or not shared, and finding *(2)* no difference between conditions in which feelings are shared
734   through different communication channels, would confirm the idea that the mere ability to share feelings
735   with another person is sufficient to mediate an affective experience (Spapé et al., 2015). However, this

736   does not exclude that increased haptic communication effects may occur when the haptic messages
737   become richer.
738
739   In addition, the mediated haptic feedback provided through a Frebble device (which resembles more a
740   mechanical contact than the touch of a real human hand) may require cognitive effort on the part of the
741   receiver to be understood and may therefore have lost its unique affective quality. Although laboratory
742   studies indicate that emotional information can to some degree be transmitted between two persons via
743   (even very simple) mediated haptics (Bailenson et al., 2007; Haans & IJsselsteijn, 2009; Rantala et al.,
744   2013; Smith & MacLean, 2007), and that real and simulated mediated handshakes are similar to some
745   degree (Giannopoulos et al., 2011), it is still unknown to what extent mediated haptic experiences can
746   actually approach direct interpersonal haptic interactions (Gallace & Spence, 2010).
747
748   Participants in both conditions reported that the constant feedback of their fellow participant led them to
749   press their device more often than they would have done without feedback. They felt committed to
750   reciprocate the presses of their communication partner. This may indicate a high social conformity in both
751   conditions. Social conformity means that people change their behavior and confirm to the expectations of
752   the other person (Aarts & Dijksterhuis, 2003; Aronson, Wilson & Akert, 2010; Kiesler & Kiesler, 1969).
753   If so, a ceiling effect may have occurred caused by the set-up with pre-scripted communication, which
754   makes it difficult to find differences in press behavior between the experimental and control condition.
755
756   Although there was no difference in affective experience the arousal level of the participants in the
757   experimental condition (the Frebble users) was significantly higher after watching both movie clips
758   compared to the arousal level before the experiment. In contrast, the arousal level of the joystick users
759   decreased. A high arousal level can indicate two emotional states: stress or excitement (Russell, Weiss &
760   Mendelson, 1989). In combination with positive feelings measured after the funny movie clips, it most
761   likely indicates excitement here. This result suggests that mediated touch does not influence the valence
762   of the affective experience directly, but only indirectly through increasing arousal levels. It may be that
763   haptic communication in itself is arousing (especially with an unfamiliar partner), or that the use of a new
764   haptic gadget is interesting and exciting for the participants and thus increases the self-reported arousal
765   level.
766

767   **Trust**

768   Finally the hypothesis (H3) that mediated touch increases trust towards another person more than abstract
769   visual feedback was tested by playing the trust game. This game is designed to measure trust towards
770   another person (Berg, Dickhaut & McCabe, 1995; Kreps, 1990; Lazzarini et al., 2004). When used in
771   combination with self-report questionnaires it can provide an accurate and reliable picture of trust
772   (Glaeser et al., 2000). However, the average amount of money set in, as well as self-report questions
773   concerning the other person, showed no indications that mediated touch enhanced feelings of trust relative
774   to visual feedback. Because it is known that social touch generally tends to increase trust (Bailenson et al.,
775   2007), the question arises whether the lack of an effect indicates that some essential elements of mediated
776   touch were missing in this study, with the result that mediated social touch was not able to affect trust.
777   Again, it is also possible that the ability to share feelings is by itself already sufficient to establish a
778   certain level of trust (independent of the mode of communication) and that the difference between visual

779   or mediated feedback therefore does not add any extra value. Another option is again the lack of warming
780   actuators. Using warmth as an element of mediated touch is not only important for building the feeling of
781   comfort, it is also essential for building trust (Cabibihan et al., 2010; Haans & IJsselsteijn, 2006).
782

Limitations

784   Although the present study provides new insights on the effects of mediated touch some limitations
785   should be mentioned. The experiment took place in a laboratory setting with only binary (visual or tactile)
786   feedback. The fully scripted protocol did not resemble a natural conversation between two persons, and
787   made it complicated to test acquainted dyads. The advantage of this controlled set-up is that the results are
788   analyzable in a standardized way. However, a disadvantage is that the content of the conversation is
789   strictly limited by the experimental paradigm and does not resemble real life content (Haans, de Bruijn &
790   IJsselsteijn, 2014). Although squeezing each other's hand over distance while watching a funny movie
791   may currently not be a common practice, there could be (subtle) effects of touch which might make this
792   new technique interesting for certain applications. Note that techniques like texting and apping were
793   initially also considered highly unnatural while they have become common practice in many situations
794   nowadays. A second limitation of this study is that the experiment was not conducted with two persons
795   who are related with each other or who have even met before. Previous studies have shown that the
796   effects of mediated touch strongly depend on the familiarity of the persons and their relationships
797   (Bickmore et al., 2010). In general, people consider mediated touch only appropriate as a means of
798   communication between partners in close personal relationships (e.g. Rantala et al., 2013), and even
799   mediated touch communication between strangers can cause discomfort (Smith & MacLean, 2007).
800   Although feelings of amusement can effectively be communicated between unacquainted dyads by
801   touching hands (Hertenstein et al., 2006) and although (mediated) social touch can positively affect
802   human feelings and behavior even between strangers (e.g., the Midas touch; Haans & IJsselsteijn, 2009),
803   touch may not be the right modality to share feelings of sadness or amusement between strangers. It is
804   also uncertain whether the illusion of a fellow participant really worked and whether all participants
805   believed that there was a fellow participant in the other room. This was intentionally not checked
806   afterwards to avoid raising suspicion which might be communicated to future participants. A third
807   limitation was the fact that participants reported that a Frebble squeeze resembled more a mechanical
808   contact than a real human hand. In addition, squeezes may not have been the most appropriate form of
809   interaction, since they are typically associated with unpleasant and aroused emotional intentions, while
810   finger touch (stroking, tickling) is more often associated with pleasant and relaxed emotional intentions
811   (Rantala et al., 2013). However, given the fact that simple mechanical pokes can effectively convey
812   affective messages and elicit a Midas Touch effect (Haans & IJsselsteijn, 2009; Spapé et al., 2015), it has
813   been suggested that it is not so much the type of touch but more its meaning that determines the receiver's
814   response in a certain context (Haans & IJsselsteijn, 2009; Hoggan et al., 2012).
815

Future research

817   The mediated touch device used in this study was a prototype and should be improved before being used
818   in further studies. Other studies indicate electromechanical actuators alone may not simulate accurately
819   the feeling of being touched by a human hand (Haans, de Bruijn & IJsselsteijn, 2014). Therefore it would
820   be beneficial to add warmth to the device as well as to a more humanlike surface of the device (softer and

821   smoother). Bickmore et al (2010) also state that mediated touch should resemble more a stroke than a
822   pressing contact. The form of the device (which evoked the feeling of another hand enclosing the own
823   one), as well as the fact that the device was held in the hand, was evaluated during the debriefing as
824   positive by the participants and should not be changed. This impression corresponds to studies which
825   confirm that touching hands is associated with loving, friendly and pleasant feelings (Bickmore et al.,
826   2010).
827
828   Second, it may be interesting to conduct research in a more natural setting. First of all this involves the
829   use of participants who know each other. On the one hand this may lead to more realistic communication
830   and on the other hand it is known that this can improve the effects of mediated touch (Tolmie & Boyle,
831   2000). In a future laboratory study it is recommendable to use the mediated touch device in an open and
832   more realistic conversation rather than a strict and limited conversation with only binary feedback as used
833   in the present study. For a field study the mediated touch device could be integrated into the daily lives of
834   dyads who know each other well and regularly use mediated communication. It is also known that long
835   term effects of emotions are different from short living emotions, like film induced emotions (Haans &
836   IJsselsteijn, 2006). Therefore, it could be useful to conduct a longitudinal study wherein mediated touch
837   communication is observed over a longer period and can be compared to communication without a
838   mediated touch device. Including these aspects will lead to a more natural context and thereby increase
839   the ecological validity of the study.
840
841   Third, the present study used touch in isolation from vision and sound. It is known that visual and
842   auditory cues are the major factors that influence the outcome of virtual communication (Hammick &
843   Lee, 2014) and that the provision of facial expressions and speech enhances arousal and valence during a
844   conversation (Bickmore et al., 2010). Although previous studies have shown that specific emotions can
845   be encoded and decoded using touch, the effectiveness of touch in real life may also be in its
846   complementary role to visual and auditory information. It would therefore be interesting to investigate
847   how mediated touched moderates communication through other channels
848
849   Finally, exploratory analyses of the present results revealed some interesting findings on the effects of
850   *Extraversion* and *Touch Receptivity*. Using mediated touch via a Frebble device enabled participants
851   scoring low on *Extraversion* or on *Touch Receptivity* to achieve the same level of trust towards their
852   communication partner as participants scoring high on these factors, while they only achieved much
853   lower levels when using a joystick. This suggests that people who are not extrovert or who do not like to
854   touch other persons felt better understood by their fellow participant when using mediated touch. These
855   findings agree with the observation that introvert people communicate their 'real me' on the internet (i.e.,
856   in the absence of physical interaction) more easily than in real (physical) social interactions (Amichai-
857   Hamburger, Wainapel & Fox, 2002), are more inclined to form online relationships (McKenna & Bargh,
858   1999), and feel more successful in online than in face-to-face interactions (Shalom et al., 2015). Since the
859   present results are only explorative, future research should try to gain more insight on the effects of
860   *Extraversion* and *Touch Receptivity* on mediated touch communication.

861   **Conclusion**
862

863   This study investigated whether mediated hand touching has the ability to *(1)* enhance recovery from
864   sadness (i.e., the return to a more positive emotional state) after watching a sad movie, *(2)* enhance a
865   positive experience (watching a funny movie), and *(3)* increase trust towards the communication partner.
866   The analysis of objective and subjective measurements showed no significant benefits of mediated touch
867   communication (two-way tactile communication) above a control condition (tactile response and visual
868   feedback). The present results do not allow us to conclude whether mediated touch is not able to do so in
869   general or whether the used mediated touch device with only haptic stimulation is not sufficient and
870   should be adapted. In both experimental conditions participants used a haptic channel to express their
871   emotions. Only the feedback modality differed and was either visual or haptic. Giving and receiving
872   mediated feedback can play a different role and giving input may already be sufficient to achieve the
873   desired effects. This study therefore only allows conclusions about the reception of mediated touch. All-
874   in-all, we were not able to replicate earlier favorable effects of mediated touch. This may indicate that
875   these favorable effects may only occur under specific conditions. Future research should investigate the
876   influence of personality, type of relationship with the other person, the effects of giving mediated versus
877   non-mediated feedback, the role of intention, and the added value of respectively warming actuators and
878   the visualization of the conversation partner to mediated touch.
879
880   Limitations of this study were that the participant was unfamiliar with the fellow participant and that the
881   device was used in a limited and unnatural conversation. Besides adapting the mediated touch device, a
882   suggestion for further research is to use a realistic conversation between dyads who are acquainted.

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1102

Sample Size (N), Mean (M) and Standard Deviations (SD) for both conditions.

	age					
	Men			Women		
	N	*M*	*SD*	*N*	*M*	*SD*
control condition	7	29.57	11.55	11	28.00	10.46
experimental condition	7	34.14	11.38	12	30.17	10.13

Sample Size (N), Means (M), Standard Deviations (SD) for the joystick and Frebble condition.

Also shown are the p-values of the independent samples t-test for each variable between both conditions.

	joystick			Frebble			t-test
	N	M	SD	N	M	SD	p
Brief Mood Introspection Scale (BMIS)	18	3.14	0.23	19	3.13	0.35	.915
Self-Assessment Manikin (SAM) - pleasure	17	6.94	0.75	19	6.68	1.34	.476
Self-Assessment Manikin (SAM) - arousal	18	3.50	1.76	19	2.58	1.54	.098
Self-Assessment Manikin (SAM) - dominance	17	4.94	0.83	19	5.42	1.84	.313
BIG 5 - extraversion	18	3.17	0.68	19	3.56	0.63	.078
BIG 5 - openness	18	3.49	0.56	19	3.61	0.61	.567
BIG 5 - agreeableness	18	3.47	0.46	19	3.48	0.31	.958
Touch Receptivity	18	4.76	1.01	19	4.57	0.95	.565

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Sample Size (N), Means (M), Standard Deviations (SD) for the variables concerning the other person, split up for the control and Frebble condition.

Also shown are the *p*-values of the independent samples t-test for each variable between both conditions.

	joystick			Frebble			t-test
	N	M	SD	N	M	SD	p
Affective Trust	18	3.44	1.38	19	3.84	1.61	.426
Humor	18	3.83	1.89	19	3.58	1.58	.658
Attachment	18	3.03	1.21	19	3.31	1.54	.557
Impression of the other person	18	4.43	0.80	19	4.45	0.73	.926
Inclusion of Other in the Self (IOS)	18	2.33	0.97	19	2.58	1.35	.531

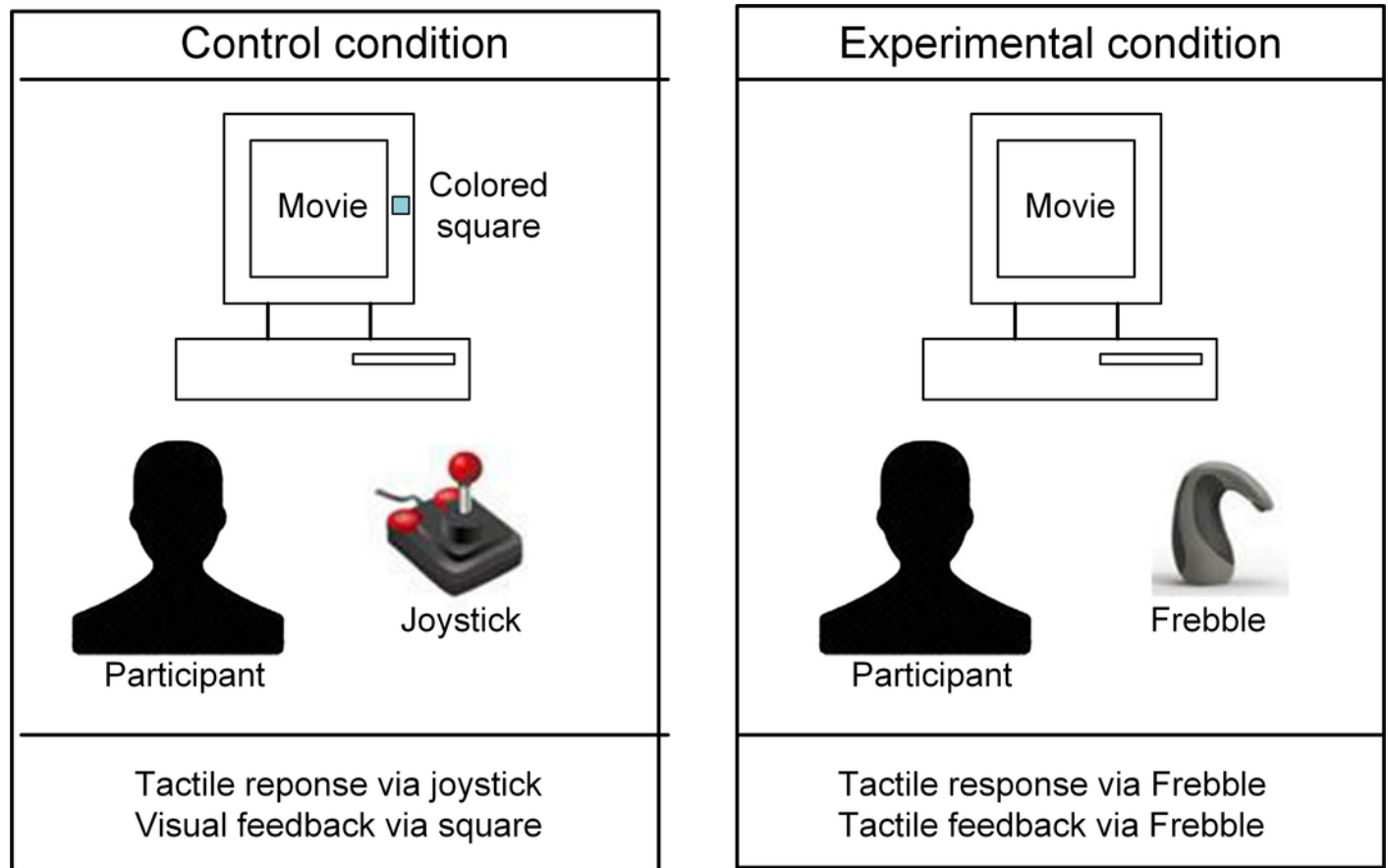
Sample Size (N) and values for both levels of each factor based on the mean scores.

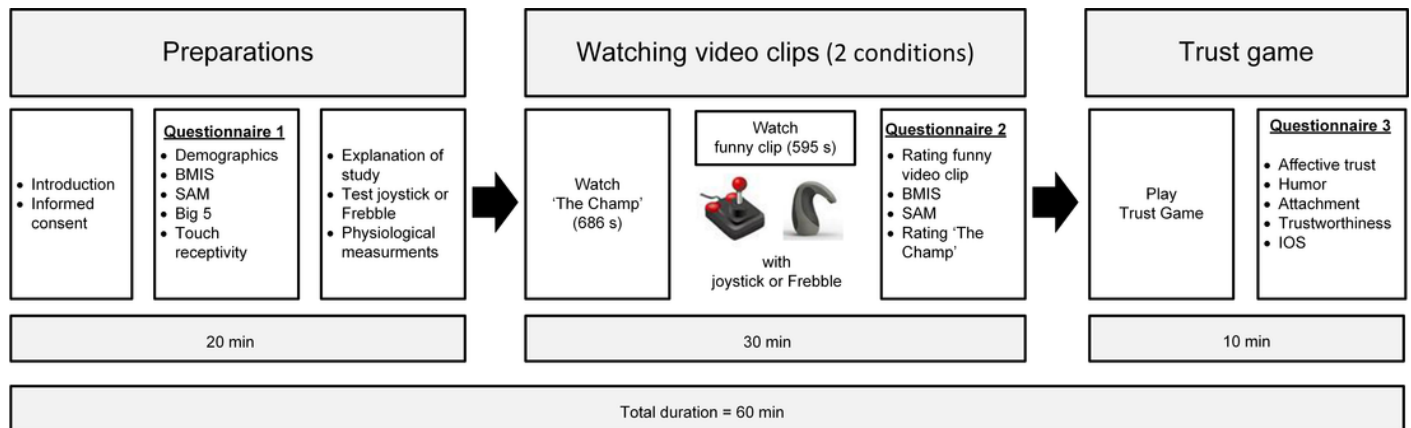
Measurements were obtained before seeing the videos (baseline), during the last part of the 'The Champ', and during the funny video clip. (* indicates that Bonferroni post-hoc comparison was significant ; $p<0.05$).

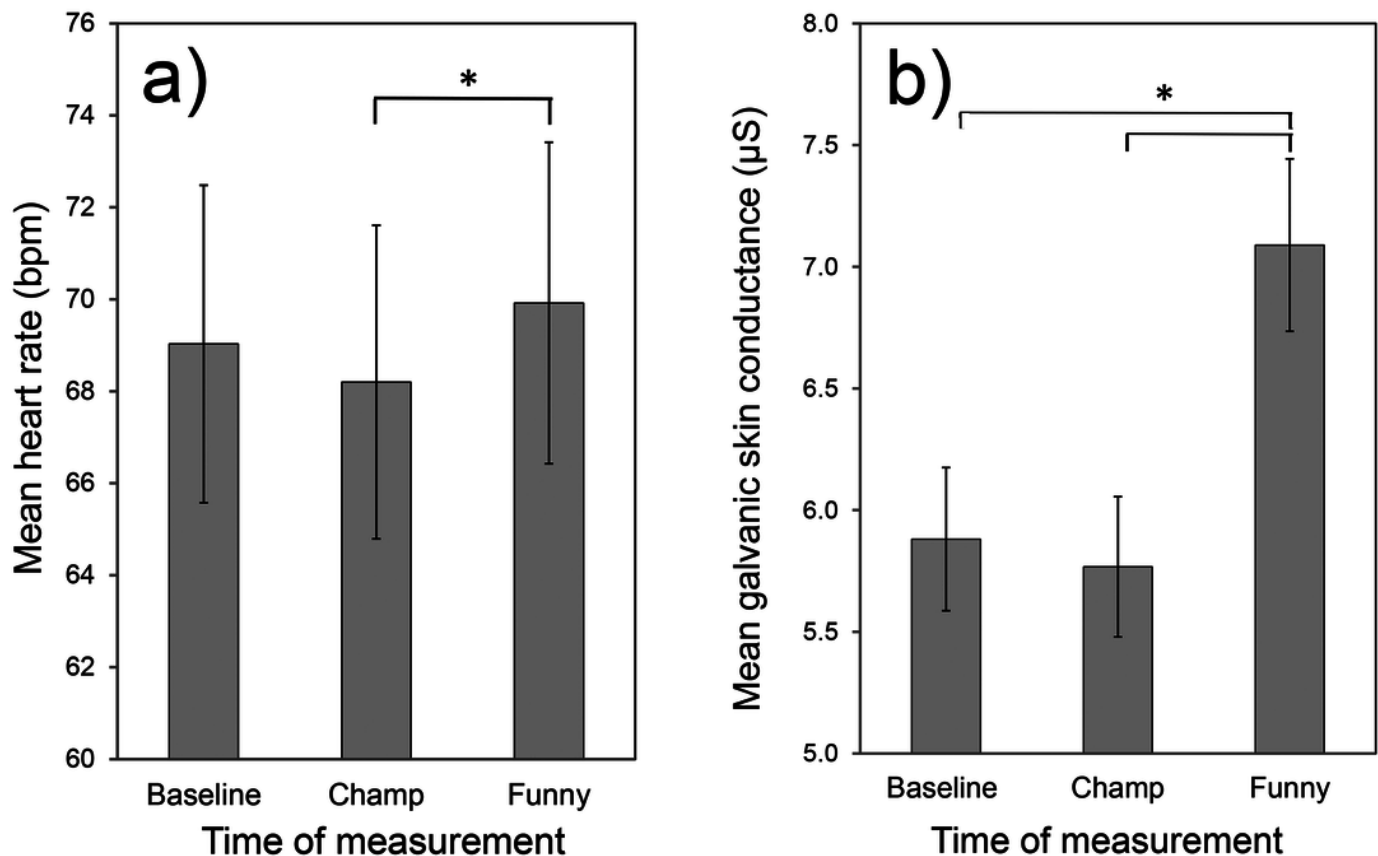
	Level 1		Level 2	
	N	Values	N	Values
Age (in years)	25	young (18-35)	12	old (36-50)
Gender	14	men	23	women
Touch Receptivity	18	low (1-4,5)	19	high (4,6 – 7)
Extraversion	11	low (1-3)	26	high (3,1 – 5)

1

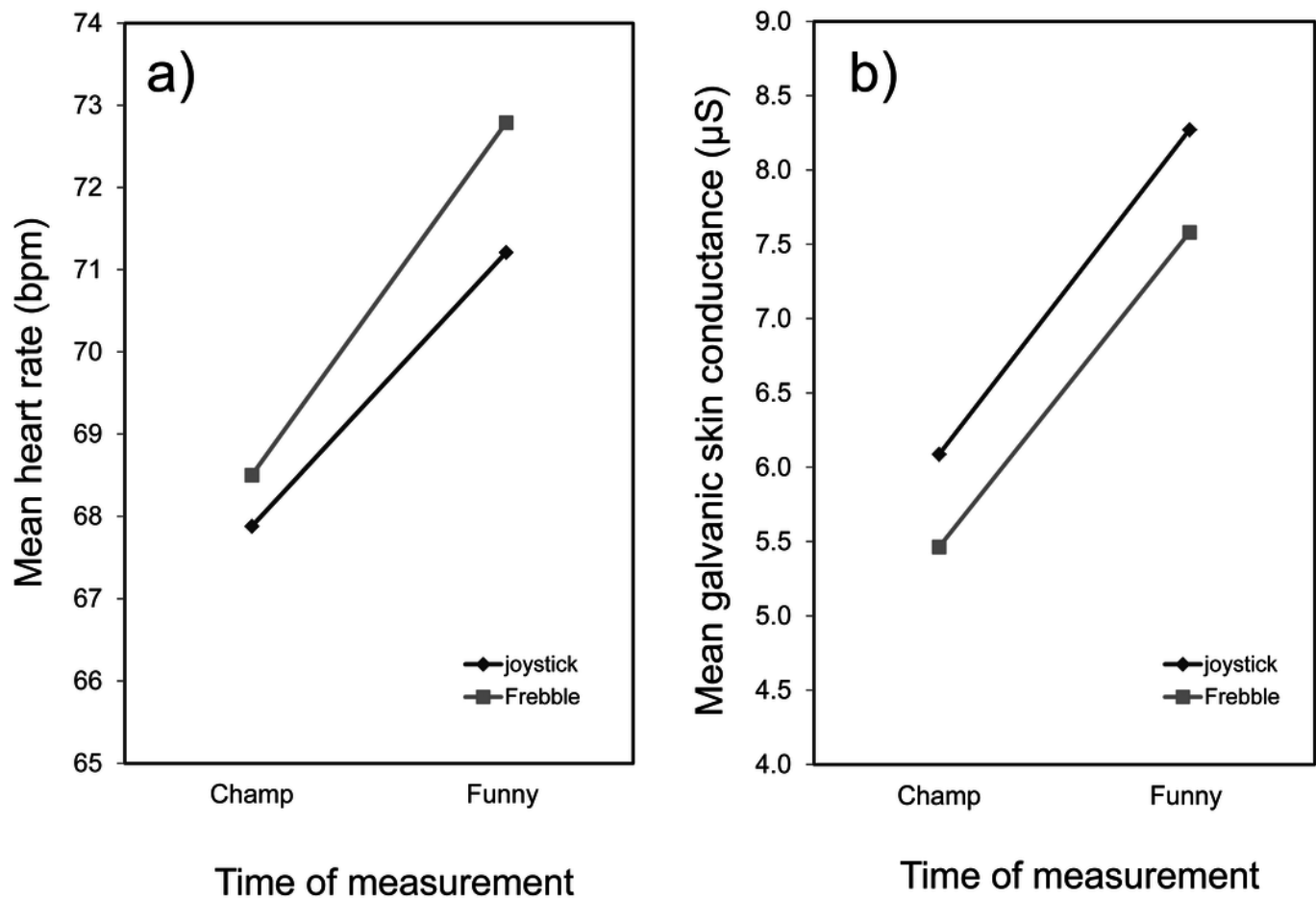
A participant's hand holding a Frebble mediated touch device.

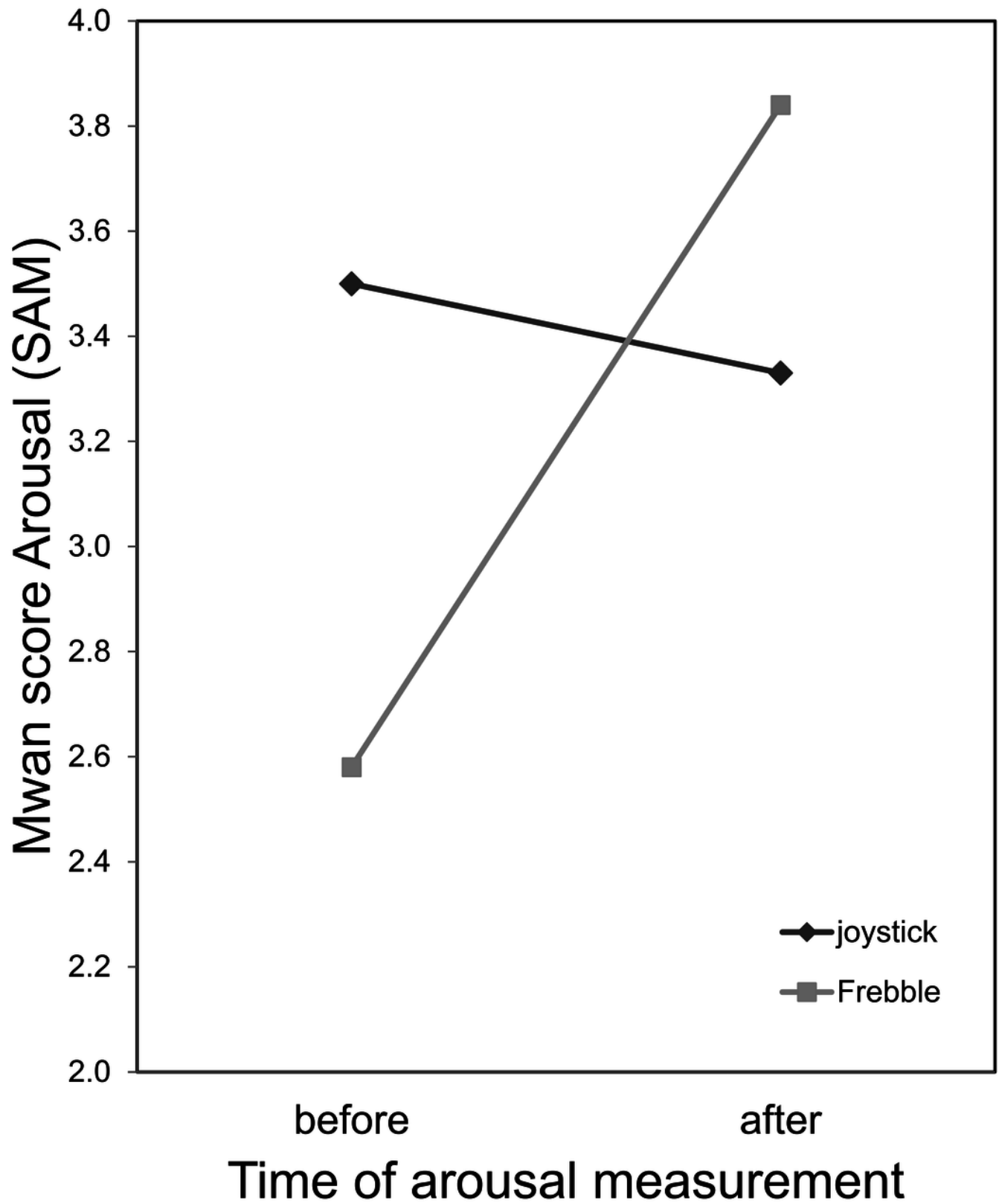
Control (left) and experimental (right) conditions with response and feedback channels.

3

Timeline of the experimental procedure.

Mean (over all participants) heart rate (a) and galvanic skin conductance (b) at different times of measurement.

Measurements were obtained before seeing the videos (baseline), during the last part of the 'The Champ', and during the funny video clip. The error bars represent confidence intervals., while * indicates that Bonferroni post-hoc comparison was significant (p<0.05).

5

Mean heart rate (a) and mean galvanic skin conductance (b).

Measurements were obtained during the Champ and at the beginning of the funny movie clips in respectively the joystick and Frebble conditions.

6

Mean arousal scores (SAM) before and after the experiment, for the joystick and Frebble conditions.

Mean scores on Affective Trust in the joystick and Frebble conditions for respectively the factors Touch Receptivity (a) and Extraversion (b).