UNIVERSITY
OF TWENTE.

Faculty of Electrical Engineering, Mathematics & Computer Science

Human Media Interaction (HMI)

Exploring Emotional Transmission Through Haptics in Mediated Social Interaction

Transmit happiness through haptic hugs

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23-08-2023

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Contents list

List of acronyms

Self-Assessment Manikin(SAM)

Interquartile range (IQR)

Confidence intervals (CIs)

Eccentric rotating mass (ERM)

Linear resonant actuators (LRA)

Acknowledgement

Words cannot express my gratitude to my professor Gwenn Englebienne and my external examiner Wouter Eggink, for their invaluable help and feedback.This journey could not have been undertaken without my supervisors Camille Sallaberry and Judith Weda, who generously provided knowledge and expertise. Additionally, this endeavor would not have been possible without the generous support from the HMI department that financed my research.
Thanks should also go to Luuk Lenders, the student who made the algorithm to visualize the overlapped areas in painted diagrams. He also provided technical support of the algorithm adaptation for my project.
Moreover, I also really appreciate the support from one of the most important people in my life, Sander Laout, who always supports me in my study and chasing my dream in the technology field.
Lastly, I would be remiss in not mentioning my family, especially my parents. Their belief in me has kept my spirits and motivation high during this process. I would also like to thank my adorable cats MiMi and Nero for all the entertainment and emotional support.

Abstract

This study explores the efficacy of haptic patterns and devices in transmitting users' emotions, particularly focusing on delivering happiness and comfort, two contradictory emotions during mediated social touch. The research consists of three main experiments conducted through online surveys and on-site investigations. In the online survey, participants were asked to identify suitable body locations for applying haptic stimuli, with 21 results collected and visually represented to highlight the most preferred locations. The second and third experiments involved 10 and 21 participants, we used a silicone skin and Bhaptic vest X40 to record and validate haptic hug patterns. Participants' emotions were assessed by using the Self-Assessment Manikin (SAM) and other survey questionnaires were used to see their sociability level and their feedback towards the experiments .

The findings indicate that senders of haptic hugs experienced varied emotions corresponding to the scenes portrayed. However, receivers of haptic hugs were unable to match the patterns with the corresponding emotions beyond chance levels. Nonetheless, they did perceive and acknowledge emotions to some extent. The study sheds light on the potential of haptic stimuli in inducing emotions in senders during mediated social interactions. Nevertheless, if receivers can accurately interpret these emotions through mediated social interaction devices warrants further investigation.

1. Introduction

Touch is a fundamental base of human communication and interaction, which plays an important role in social bonding, emotional expression, and relationship building (Hertenstein, Keltner, App, Bulleit, & Jaskolka, 2006; Gallace & Spence, 2010). Through touch, people can express and feel various emotions at a very young age and establish interpersonal level relations (Field, 2010). The human skin possesses intricate sensory and emotional mechanisms that render it exceptionally responsive to tactile signals and cues. This heightened sensitivity to touch empowers humans to accurately and precisely detect and interpret tactile information (Hertenstein, 2002).

Thus, understanding how touch works in touch interaction is a key to make mediated social interaction better, and for enhancing the quality of social relationships and emotional well-being.

The use of haptics in mediated social interaction is gaining popularity because it aims to emulate various sensations, thereby enhancing remote communication significantly. Nowadays' style of work, study and entertainment, we more actively use technological devices to help us interact remotely. However, machines and computers are not yet capable of imitating real human touch. Hence, the use of haptic devices to simulate human touch and deliver emotions remains a critical area of research.

This study is conducted based on the paper (Rognon, 2022) that aimed to evaluate the effectiveness of the emotional transmission of mediated social touch. It used haptic gloves to communicate tactile messages and collected patterns were assessed by naive participants to see the recognition rate.
Our study used a similar method to collect and evaluate 2 types of haptic hug patterns conveying distinct emotions. However, the paper of Rognon(2022) also measured the confidence level for each trial in both the social touch selection and the scenario selection, and rated how close they thought this haptic pattern was to a real one.
In this study we didn't do exactly the same as Rognon's study. The SAM is used to assess participants' emotions before and after they give or receive these patterns.This is for measuring their emotional changes after they give or receive the patterns, in this way to see if certain emotions get transmitted. Also due to time limitation and number of participants, we didn't analyze collected patterns in the second experiment for selecting the best one to represent the scenarios with their emotional content for naive participants in the follow-up third experiment.

2. Related work

In this chapter we aim to explore several question as below, and

- What is social interaction and emotions we express, why is happiness important to us in social interaction?
- Why are social cues important to social interaction and touch?
- How do different haptic pattern parameters affect on conveying or transmitting certain emotions in terms of intensity, speed, duration and bodily locations?
- How do different parts of our skin/body perceive touch differently?
- What is the state of art technology for wearable haptic devices in mediated interaction?

Social interaction and emotions

Social interactions and emotions are highly connected. Studies have shown that social interactions have a significant impact on emotions. Positive social interactions can lead to positive emotions such as happiness, joy, and contentment, while negative social interactions can lead to negative emotions such as anger, sadness, and anxiety (Kuppens et al., 2008; Reis et al., 2000). During social interactions, humans express a wide range of basic emotions, including happiness, sadness, anger, fear, surprise, and disgust. These emotions are universal and cross-cultural, as demonstrated by Paul Ekman & Friesen (1969), who identified them. Basic emotions have biological and social functions which are essential for humans in daily life. For example, anger protects humans from dangerous situations and gives the stimuli to defend or run away. Disgust can prevent humans from eating bad food and becoming ill. As for surprise and happiness, their primary function is to bond relationships when attention and affection are needed.

Happiness, why it's important to be conveyed

In our social life, emotions and social interaction complement each other through several ways. Among all types of emotion, happiness tends to be the one that people seek for the most. Many studies have supported the importance of happiness in social interaction. For example, a study by Lyubomirsky and colleagues (2005) proved that individuals who reported higher levels of happiness also showed greater social support, more satisfying relationships, and better physical health. Positive emotions, including happiness, were associated with increased sociability and openness to social interaction. Since, positive emotions lead people to be more willing to socialize with others and establish deeper connections with strangers(Diener et al., 2015) & (Waugh & Fredrickson, 2006). In addition, conveying happiness to others can help others to counteract negative emotions such as stress, anxiety, and depression, which can help you and those around you to create better social interactions and relationships. Therefore, conveying and expressing happiness can be an important aspect of social interaction and can lead to many positive outcomes for both the individual and those around them.

Different cues for social interaction and touch

During social interaction, there are different social cues to convey and communicate emotions. Such as signals expressed through body language, facial expressions, tone of voice or words that are intended to send a message from one person to another. Social cues are essential for effective communication and social interactions. Infants as young as four months are already able to distinguish different emotions based on social cues, indicating that the ability to read social cues develops early in life (Grossmann et al., 2008). In daily life, we can often see that when a baby is crying, parents usually hug the baby and pat the back to comfort them. The human sense of touch develops first in the womb, when the language and visual systems are not yet fully developed(Waddington, 2015). For grown ups, we have more methods to communicate social cues, phone calls, video chats and emails are the primary use for long distance communication. However, the lack of touch interactivity in mediated social interaction is still a problem. The importance of touch in social interaction is well-known. A gentle touch on the arm may convey empathy and support, while a firm grip may convey urgency or concern. Hugging and tapping each other's shoulders to show encouragement or holding hands and interlocking fingers to show affection. We use different touches to show different emotions.

Touch patterns, haptic parameters

Hertenstein (2006) did several experiments where participants touched a stranger's arm to communicate a specific emotion (e.g., anger, fear, happiness). The authors argue that touch can activate neural networks in the brain that are responsible for emotions, leading to the transfer of various emotions from one person to another. Result shows that the participants receiving the touch were able to correctly identify the intended emotion. The article discussed different ways in which touch can impact emotions, including the types of touch (e.g., comforting touch, affectionate touch), the context/ intentions behind the touch (e.g., supportive, hostile), and the relationship between the people involved (e.g., family, strangers). These factors can be important implications for us to understand how we can use touch to convey or transmit certain emotions. Additionally, according to a study by Darby and Frysztak (2014), there are four fundamental characteristics to the receptor influences us to perceive a stimulus, they are: the type of stimulus, the intensity/ strength of the stimulus, the perceived duration the stimulus presents, and the body location where the stimulus is perceived. These parameters

Moreover, Rognon et al. (2022) showed that certain haptic parameters were associated with specific emotional responses, and participants can perceive them accurately based on different combinations of pressure, speed, and duration. During the experiments of this study , the same type of touch with different pressure, speed, and duration was associated with different emotions. In addition, Hertenstein et al. (2006) also found the emotions were also characterized by differences in duration and intensity. For example, anger was characterized by a strong-intensity touch of moderate duration, whereas love and sympathy were characterized by a moderate-intensity touch that was of longer duration.

Where to touch in social interaction is also a crucial question. Different locations of touch can have different emotional and social meanings that can convey a range of nonverbal messages. Moreover, the distribution of touch receptors in our skin is not uniform across our bodies. Certain areas, such as our fingers and lips, have a higher density of touch receptors compared

to other parts, like our backs and shoulders, see figure 2.1 below. As a result, we tend to be more sensitive to touch on our fingers and face than on our backs. This discrepancy in receptor distribution contributes to the varying levels of sensitivity we experience in different body locations. This may result in different haptic cues being recognizable for different body locations.

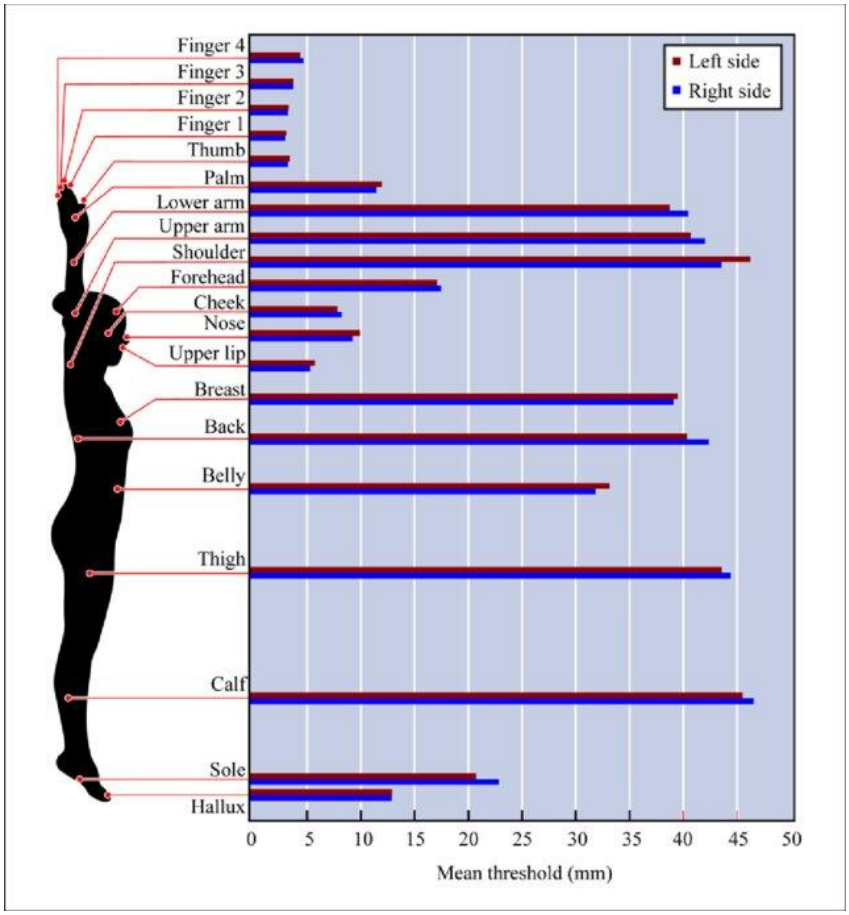


Figure 2.1. Bodily locations and their threshold distance sensitivity (Fitch et al., 2011)

For example, touching someone's back can be a common form of social touch in many cultures, and may be associated with feelings of support and reassurance. Research suggests that back-touching, such as a pat on the back or a gentle rub, can be an effective way to convey emotional support and social connection (Guéguen, 2002). Touching back can also be an important component of nonverbal communication, conveying social signals such as encouragement, congratulations, or approval. Touching someone's shoulders can be a common form of social touch in many contexts, and may be associated with a range of emotional and social implications. Research suggests that shoulder-touching can be an effective way to convey emotional support and social connection, also conveying social signals such as reassurance, empathy, or respect.particularly in situations where verbal communication is

limited (Hertenstein , 2006). The importance of the location of social touch may vary depending on cultural norms, social context, and individual preferences.
Context plays a crucial role in social interaction as it provides the framework for understanding and interpreting social situations. The way we communicate, behave and make decisions is greatly influenced by the context in which we find ourselves
Several studies have explored the importance of haptic touch in different social contexts. For instance, the study (Rognon et al., 2022) gives different scenario prompts for each social touch, which aim at triggering contrasting emotions by the same type of touch. It also found that social touch can express very different emotions depending on the relationship with the other social agent and the interaction context.

Mediated Touch and Technology
We use various haptic devices to help us to touch, feel and manipulate objects in different circumstances. However, current mediated social interactions heavily rely on sight and hearing which focus on facial expression and use text or voice call to deliver information/ social cues. However, they still only focus on profiles/visuals and sound, while neglecting the effect of touch. The importance of touch and body movement in the expression of emotion in social interactions is well understood. Therefore, technology for transmitting mediated touches in social interaction is a crucial task for communication nowadays.
There are few examples in Figure 2.2 showing wearable haptic devices for social interaction. The HaptiHeart can generate different heartbeat patterns according to the emotions from the sender: “sadness is associated with slightly intense heartbeat, anger with quick and violent heartbeat, fear with intense heart rate”. When people hold or hug each other, the heartbeat usually tends to be synchronized, thereby synchronizing sender and receiver’s heartbeat is possible to evoke the empathy of the receiver. Another example of a wearable device is HaptiHug which is designed to enable couples to deliver hugs. The device consists of two parts, a pillow to squeeze and a belt with hand shaped actuators. When the sender squeezes the pillow, the receiver who wears the belt around his/her chest and back will feel vibrations and warm temperature. The HaptiButterfly aims to represent the feeling of “butterflies in the stomach” when people fall in love. The butterfly device is located at the stomach area of the user and it has arrays of vibration motors.

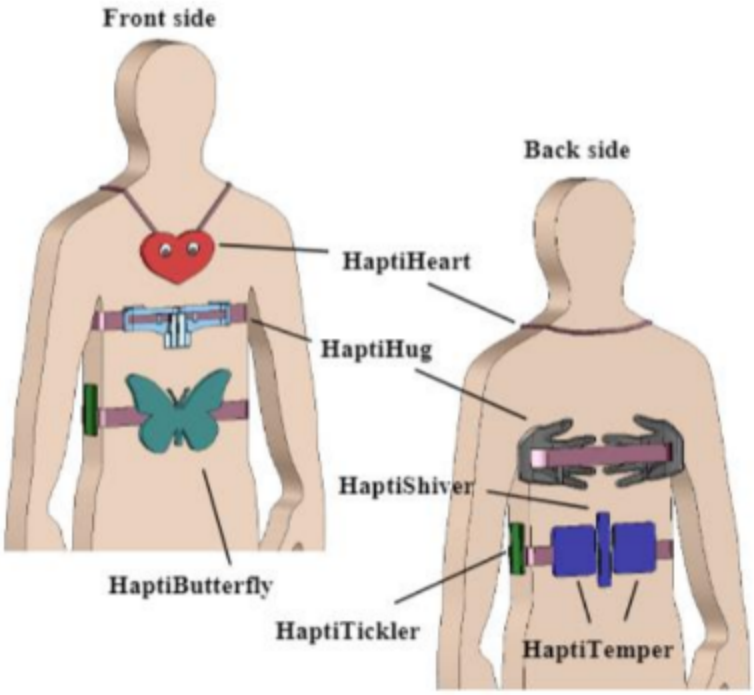


Figure 2.2. Wearable HapticHeart, haptiHug and HaptiButterfly front and back design(Tsetserukou et al., 2009)

In general, it is common to use pressure, vibration and temperature to emulate real touches. In our department the existing tools to represent tactile sensations are the pneumatic sleeve, vibrotactile glove, Bhaptic Vest X40 and etc.In this study, the Bhaptic vest X40 and silicon skin are used in experiment 2 and 3 to achieve emotional transmission during mediated social touch, based on the result of experiment 1 most participants only want to be touched on shoulders and hands by strangers. Therefore, only the vest and silicone skin can be used as tools. The advantage of Bhptics Vest is it employs 40 Eccentric Rotating Mass (ERM) vibration motors to replicate haptic sensations. Vibrational motors offer flexibility in simulating various haptic characteristics. While vibrations may be less realistic than force feedback devices, which provide a more accurate sense of pressure, they are more widely available and offer low latency feedback. However, force feedback devices tend to be bulkier and limit range of motion. Compared to this, tendon-driven mechanisms could be a more flexible and smaller solution to kinaesthetic force feedback simulation(Van Wegen et al., 2023).

Other researchers mostly focused on the ability of haptic interfaces or devices to simulate different types of touch and their impact on user’s feelings and emotional experiences. Researchers investigated various aspects such as the role of haptic parameters (e.g., pressure, speed, texture), the perception of emotions through touch, and the effects of touch on emotional responses, social bonding, and empathy. From our literature review, we found little work on the investigation of how same types of touch in different scenarios evoke different emotions. In

terms of mediated touch and emotion transmission, this study focuses on a particular type of touch which is hug and with two contradictory scenarios. The reason to choose two contradictory scenarios is that when we measure participants' emotions, it is easier to identify the change of arousal and valence of emotions. The experiments will collect and evaluate hug patterns, to find out under different scenarios with different emotions, if people give different touch patterns and what emotions can be transmitted through mediated social touch.

3. Experiment 1(pre-experiment)

To find out on which body parts people would like to receive touches to communicate happiness. There is an online survey as the pre-study for on-site experiments to see where to apply touch patterns to communicate happiness via a haptic vest. To gather bodily locations and what kind of touch patterns participants think are suitable to evoke happiness, a procedure using drawing on images was used, as well as open ended questions.

3.1Participants

We recruited 21 participants online for this experiment (male12, female9). Participants in this study are voluntary and are more than 18 years old and come from Asia, Europe and South Africa. Participants were recruited at the condition of no psychological impairment. The experiment was reviewed and approved by the Internal Review Board of the University of Twente under the number [230004].

3.2 Procedure

When participating, the participant needs to understand what the study is about. On the first page, the participant is also informed about what data will be gathered and they have the right to refuse to answer questions and withdraw their answers. While reading this information, the participant needs to answer two questions. The first one asks if the participant gives the consent voluntarily to participate in this study and understands that they can refuse to answer questions and they can withdraw from the study at any time, without having to give a reason. The second one asks if the participant is above 18 years or old.

On the next part of the survey, it contains open ended questions. Which consist of self report questions and drawing on the given images, see figure 3.1. We investigated social touch in terms of giving touch to others and receiving touch from others, meanwhile trying to find out if the relation between sender and receiver could influence the location of touch that is associated with happiness. We ask participants to describe in detail touch patterns that they typically associated with happiness in social touch, in terms of intensity, duration, location and type of touches.

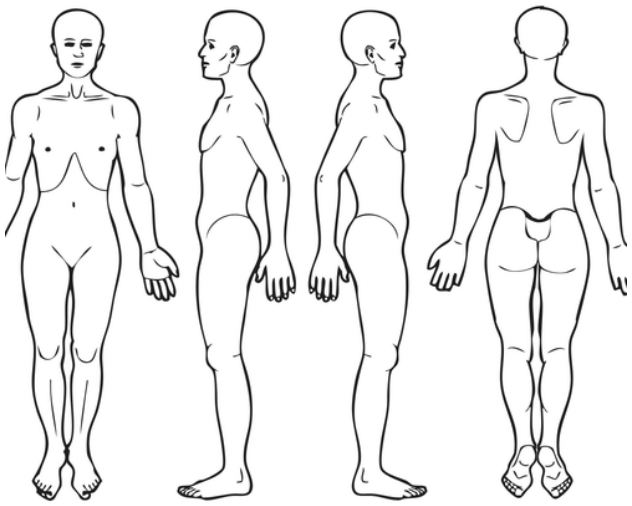


Figure 3.1. 4 sides body diagram (the image got unexpected tailoring during process, so on the survey participants used this one as their painting base, the result doesn't get affect due to it is 4 sides diagram, the missing hands of the front and back view are shown on the left and right view of the body diagram as well)

3.3 Materials

Google Forms was used for sending and presenting the survey, see Appendix. To fill in the survey, participants needed to use their computers/tablets/laptops, or the laptop provided by the researcher since they need to draw on provided .PNG images. The software for drawing on the image was free of participants' choices. After drawing on this image and saving in the.PNG format. Participants needed to upload them to Google Forms again.
To analyze the image, Python with version 3.8 and some image processing libraries are needed. The image analyzing method and Python scripts were used from Luuk Lenders (2022) which can be found on this GitHub[1] page. For this study Luuk adapted a few lines of the code to make it able to analyze the collected images of this survey.

3.4 Data Analysis Procedure

Based on Luuk's method(2022), first we need to make sure participants' uploaded images have the same size and type as the original PNG image for the algorithm to analyze them. As well as they need to use the correct drawing method. However, there were few issues that occurred,

[1] https://github.com/luuklsl/image-processing

for example participants uploaded images in JPEG or JPG format; participants uploaded PNG images in different sizes and bit depth; participants used different drawing methods, circled body locations instead of painting the locations with solid colors.
Therefore, after collecting all images, the software Photoshop was used to adapt all images' properties and way of drawing.
The example depicted in the figure 3.2 below demonstrates how we have modified the original image (a) to create image (b) by applying a solid color that covers the body areas. This adaptation allows the algorithm to generate a superior outcome. Without this adjustment, the circled images would have a negative impact on the resulting image, causing halos to appear around the pained body areas and preventing an accurate representation of the overlapping locations.

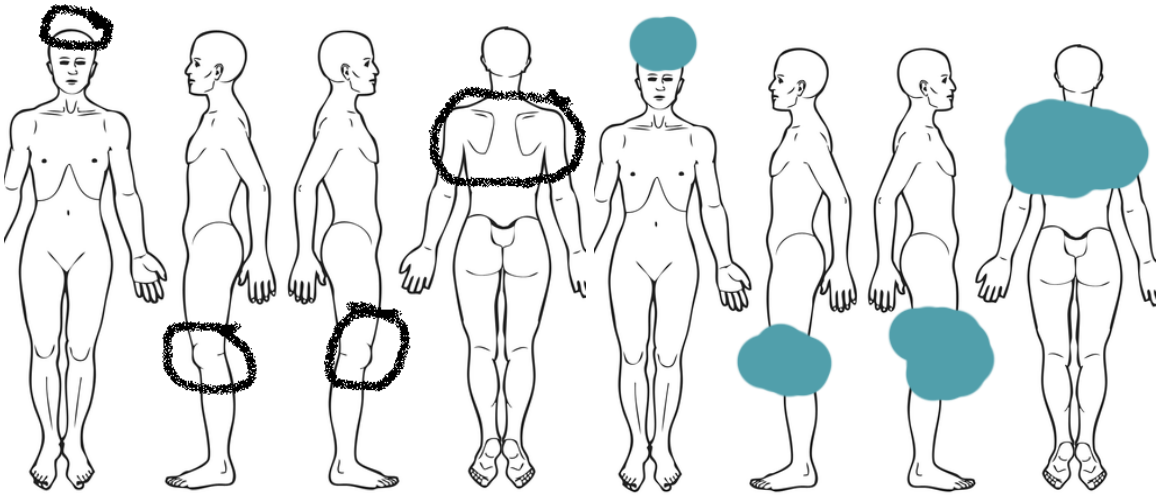


Figure 3.2. The right side image (a) is from a participant , The left side image (b) is photoshopped based on (a) for the algorithm able to process

Then 11 separate folders are needed, 1 folder for storing the original image and 5 folders for 20 images from each question. And another 5 folders for storing the processed images which are the result for the 5 questions.

3.5 Results of Experiment 1

The result images use more vivid color to indicate the most overlapping body locations, where most participants draw on. They are interpreted as the body locations where participants would like to be touched or to touch others.

In figure 3.3 can be seen, there are up to 16 overlapping body locations that have been selected the most by 20 participants. To show where they typically associate with happiness. The most selected body locations are indicated by the bright yellow and green colors, which are face, hands, chest, upper back and shoulders.

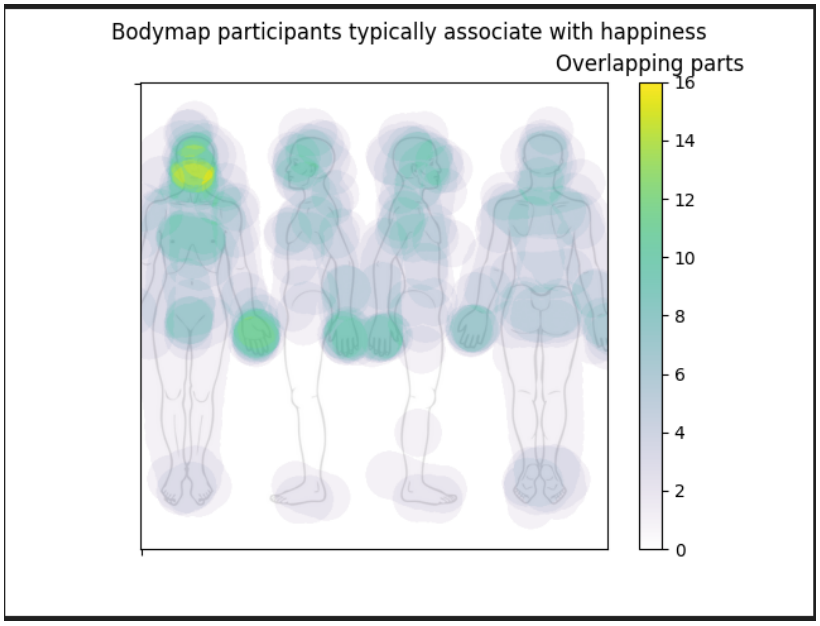


Figure 3.3. The body regions that participants typically associate with happiness

In figure 3.4 can be seen, there are in total 16 body locations that have been selected the most by 20 participants. To show where they think would be appropriate to be touched by a close family member and/or significant other to evoke happiness. The result is similar to the previous question, however, not only the upper back but also the whole back and legs are shown as new body locations that they think are appropriate to be touched by a close family member and/or significant other to evoke happiness.

Figure 3.4. The body regions that participants think would be appropriate to be touched by a close family member and/or significant other to evoke happiness

In figure 3.5 can be seen, there are in total 18 body locations that have been selected the most by 20 participants. To show where they think would be appropriate to touch a close family member and/or significant other to evoke happiness. The body locations are hands, back, shoulders and head.

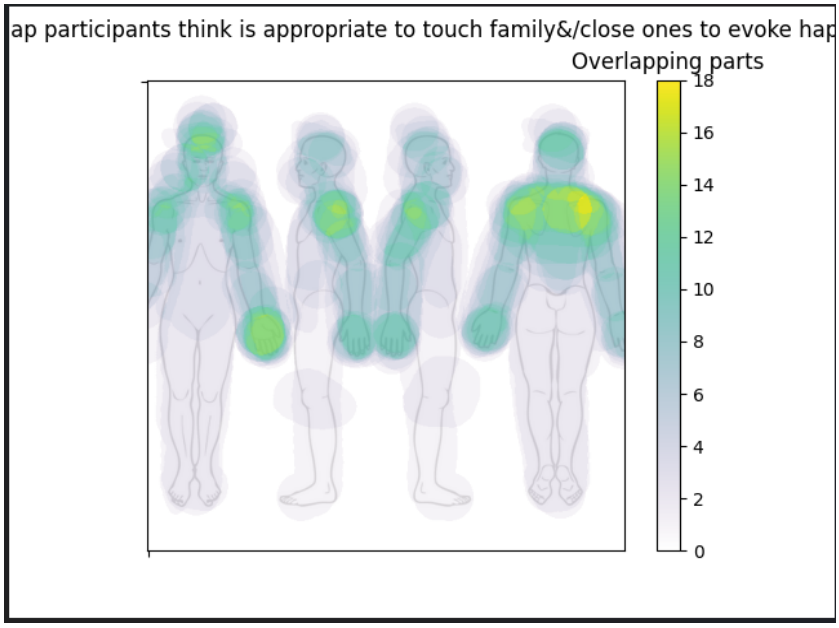


Figure 3.5. The body regions that participants think would be appropriate to touch a close family member and/or significant other to evoke happiness

In figure 3.6 can be seen, there are in total 12 body locations that have been selected the most by 20 participants. To show where they would accept to be touched by a stranger to evoke happiness. The overlapping parts became less and from participants' uploaded images can be seen, there are few blank images. There were some participants who thought that no body locations were appropriate to be touched by strangers.

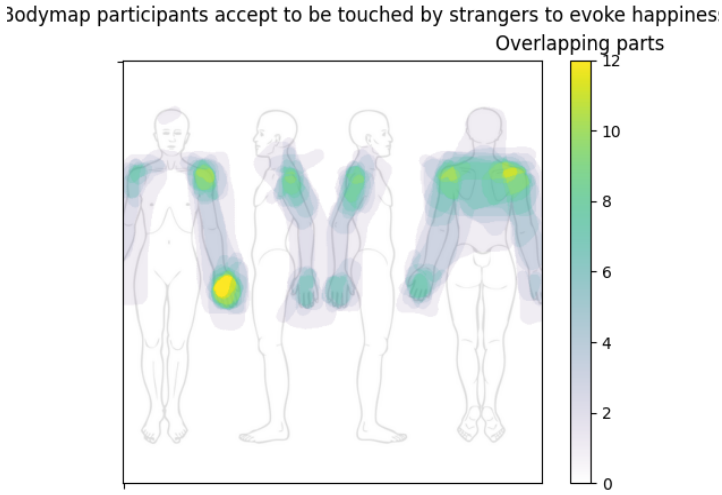


Figure 3.6. The body regions that participants would accept to be touched by a stranger to evoke happiness

In figure 3.7 can be seen, there are in total 12 body locations that have been selected the most by 20 participants. To show where they think is appropriate to touch a stranger to evoke happiness:

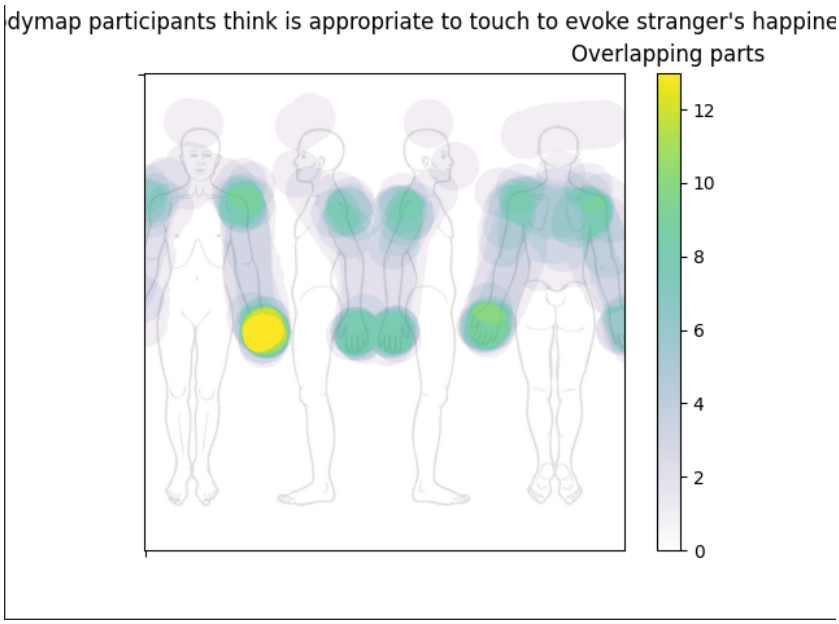


Figure 3.7. The body regions that participants would accept to touch a stranger to evoke happiness

In the survey besides painting on the body diagrams, there are 4 open ended questions about if participants are willing to use wearables for emulating social interactions; and what kind of touch they think strangers or family members and close ones give them can evoke happiness.

The first question asked is, do they mind using wearable devices which cover your arms and torso for emulating social interactions with friends or family members? Why? There are 21 responses, 15 participants hold positive to neutral opinions about using devices for simulating social interactions, in which half of them think situation and context are important and may influence their decision . 6 participants gave answers about whether they don't like using such devices or they can't think of a situation where they need to use devices for emulating social interactions.

The second question is, do they mind using wearable devices which cover their arms and torso for emulating social interactions with strangers? Why? Most participants are cautious about this or they don't want to do such activities, however, it still depends on the situation, if strangers need help from them, if it's for gaming. The reason why they don't want to do such a thing is because they feel uncomfortable to be touched by strangers in certain body locations, they think it's not necessary to emulate social interactions with strangers and awkward to do so. And of course their personalities may play a role here as well, if they are a touchy person or not .

The third question is about what kinds of touch do they think strangers can give them to evoke happiness? The answer is divided into two categories, half participants don't want to get touched or they don't think touches from strangers can evoke happiness. Another half participants gave answers like they would like to receive light touches on hands or shoulders, for example handshakes, high five and pat on shoulders for a short time, 1~ 5 seconds. However, there's one participant who gave an interesting answer, massage on the shoulders and arms for about 10 minutes might evoke his/her happiness (The participant hasn't done it, but he/she considers it is done by professionals).

The fourth question is what kinds of touch do they think a close family member and/or significant other gives them can evoke happiness?

Participants stated that they are willing to receive a wider range of touch as well as wider range of body locations than with strangers. They would prefer stronger and/or more brief touches with family members for example strong strokes, light pat on back, head, hair or knee, softer touches like caress, rub with a significant other. Moreover, the duration of touches they would like to receive from family members and significant ones is way longer than what they would like to receive from strangers. The duration varies between a few seconds to a few minutes depending on the participants and situations.

3.6 Discussion of experiment 1

The aim of this experiment is to find out where on the body mediated touch is most likely able to convey happiness. Therefore we assume those bodily locations are where we should place the silicon skin to collect touch patterns for future experiments.
Participants reported happiness can be evoked by touches on a few body locations with strangers, while more locations with family and closed ones. However, there are some body locations have been selected universally, such as hands, shoulders and upper back. Same for the duration, they would like to have longer duration social touch with people who have closer relationships with them, such as family members and significant ones.

In this case, based on the result, hands, shoulders and back these three areas should be considered as the most optimal locations for placing the silicon skin to conduct mediated social touch. This result is similar to what has been found by Zeagler (2017), which body locations people find is suitable for wearable technology, see figure 3.8 below.

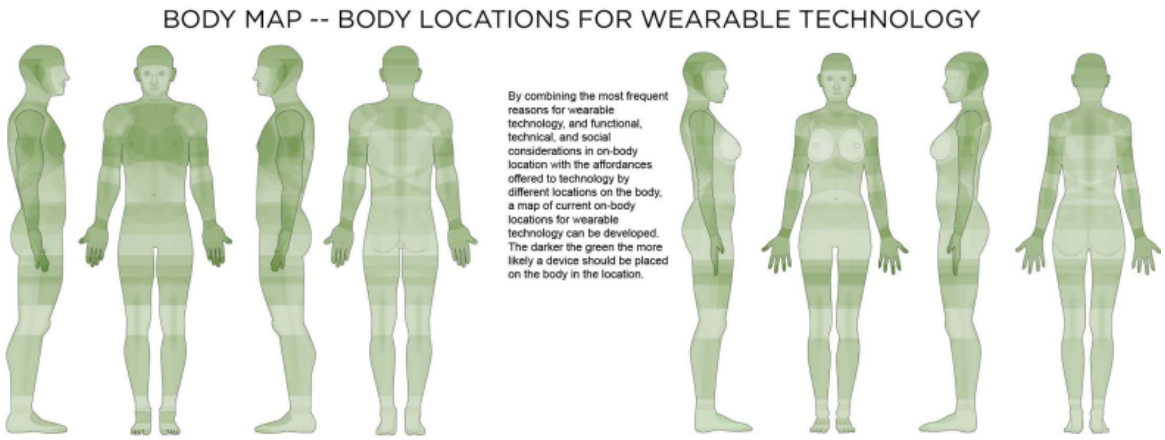


Figure 3.8. Most likely on-body locations for wearables for both men and women (Zeagler, 2017)

In a closer relationship, the physical contact to evoke happiness becomes more dynamic, and individuals who have mutual affection may use touch on more body locations to express their emotions instead of formal greetings such as handshakes, high-five and hugs. As strangers, people may start with safe gestures like handshakes or touching the arm to show, transmit and evoke happiness to others, but as their relationship deepens, their touches may become more intimate. They may place their hands on the lower back, wrap their arms around the shoulders, or touch knees and legs. Meanwhile the touch duration also lasts longer when people have a close relationship.
Based on the discussion above, the common body locations that are suitable for wearables to put on and for both strangers and people who have close relationships to touch are hands, shoulders and upper back. Thus, for the further experiments we considered putting our materials and apparatus on those body locations.

Lastly, based on the answers from the survey, different people can have different feelings towards the same type of social touch under different situations. It is necessary to control unexpected variables. In social interaction activities, participants' personalities can play an important role. Therefore, for the following on-site experiments, it would be useful to see participants' personalities related to social interactions. Moreover, the context of touch influences people to perceive the intention of touch as well. It is necessary to fix the context, type, body location, duration of the touch for the following experiments.

3.7 Limitation of experiment 1

The study focused on touch patterns associated with happiness in specific relationships (family members and significant others) without considering broader social contexts. This has been pointed out by participants as well. They would like to understand the scenarios first then point out the body locations that they associated with happiness with people who have different relationships with them. The participants' responses in the open-ended questions provided insights into their touch preferences, but they were specific to these particular relationships and may not fully capture the range of touch preferences and emotional responses in other social contexts.

For example, participants mentioned touch patterns such as hugs, pats, strokes, and rubs as ways to evoke happiness. However, the duration, intensity, and specific body parts mentioned varied among participants. While these responses provide valuable information about touch preferences within family and romantic relationships, they may not necessarily apply to other types of relationships, such as friendships or professional interactions.

To gain a more comprehensive understanding of touch patterns and emotional responses in different social contexts, future studies could consider expanding the participant pool to include a broader range of relationships. This would allow for a more nuanced exploration of how touch preferences and emotional responses may vary depending on the nature of the relationship and the specific social context. Therefore in the next experiment there are two explicit scenarios, where the relationship and context of the to be mediated touch is clear in the prompts.

4. Hypothesis of experiments

We conducted two lab experiments. To find out what are the hug patterns to express happiness in a given scenario during mediated social touch and to what degree emotions can be transmitted. We designed two hug scenarios,one is a happy scene and the other is a comforting scene. It is used to compare whether the tactile sender and the recipient can give answers that have differences between the two, so as to prevent the participants from giving random answers. There are four hypotheses that help to guide the direction of the research and collect data that can support the research goal.

H0: Touch patterns designed for the "happy" scenario and the "comfort" scenario can be distinguished from each other.
(The first scenario is a “happy” situation, prompted with “You just won a game where the score was tight, you are thrilled and you celebrate it with your game partner with a big hug. Good job!”. The second scenario is a “comfort” situation, prompted with “Your close friend failed their resit exam even after studying really hard, you want to comfort them with a big hug”.)

H1: For senders, the self-reported emotions differ between giving the "happy" hug and the "comfort" hug. For receivers, a touch stimulus from the "happy" scenario and "comfort" scenario gives different self-report emotions.

H2: The self-reported emotions of both senders and receivers are similar for the same scenario.

H3: Receivers can successfully match the touch patterns with their corresponding scenarios.

5. Design of experiments

The first experiment aims to collect touch patterns and the second one aims to validate all touch patterns from the first experiment. Bhaptics vest X40 and a silicone skin embedded with capacitive yarn are used as tools to achieve the mediated social interaction. Participants of these two experiments are strangers, based on the survey study result and equipment we have, so the given scenarios only ask them to give hugs instead of other types of social touch. This helps to avoid touching sensitive parts of participants and causes unpleasant feelings. Only shoulders and upper till middle back are the bodily locations to apply and receive tactile stimulus.

5.1 Materials and apparatus

In order to convey expressive touch features associated with participants’ intents and emotions, a Bhpatic Vest X40 and a piece of silicon skin developed by Antonio (unpublished 2022) based on the research of (Teyssier et al., 2019) are the key apparatus used in these experiments. In addition, a mannequin was needed as a carrier to wear the silicone skin. A tablet was used for participants to fill in the survey questionnaire digitally.

In the first experiment, participant one used both vest and skin to design and feel the touch patterns. In the second experiment, the Bhaptic vest was used to represent all the hug patterns collected from the first experiment. The script/code for collecting and replay the tactile stimulus/ touch patterns is adapted from Antionio's project, which can be found on this github page[2]. Few changes were made in the code to save each pattern in a separate file, the new code can be found on this github page[3]. Moreover, for both experiments a PC was used to connect the Bhaptic vest via bluetooth and silicone skin via usb cable.

Bhpatic vest: The Bhaptic vest is the Bhaptics vest X40, it is a commercial vest from the company Bhaptic mainly uses for gaming and VR settings, see Figure 5.1. There are 40 Eccentric Rotating Mass vibration motors (ERM motors) throughout the vest, 20 on the front and 20 on the back. The vest uses Bluetooth 4.0 to connect the Bhaptics player on the PC. The vest is wireless and adjustable which allows it to provide all users a comfortable fit. More information about the vest can be found on the website[4].

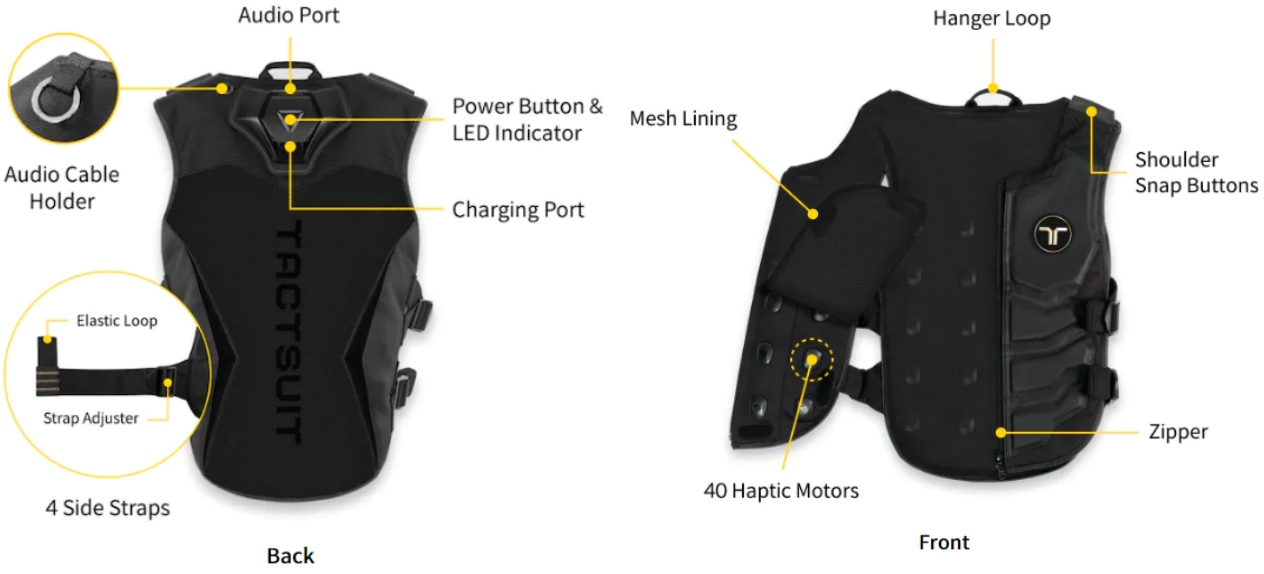


Figure 5.1. Bhaptics vest X40 and its specifications

Silicon skin: The silicon skin was made by Antoine Lorentz, which was created in the University of Twente based on the work of Teyssier et al. (2019). The function of the silicone skin is to record the sender's touch in terms of tactile intensity, bodily location and duration. In the visual studio, the program registers touch patterns as digital signals which can be replayed by the Bhpatic vest. The intensity is registered as integer values from 0 to 254. The bodily location is

[2] https://github.com/antNLocks/UT_skin/tree/main/ProcessingTools
[3] https://github.com/Joyce175/HugPatterns
[4] https://www.bhaptics.com/

registered on the crossponded motor from. The duration of touch is up to the touch sender, but the refresh speed is 130 ms second. The silicone skin has embedded capacitive yarn and is made from slightly stretchable silicone material. Therefore, it is soft, smooth and slightly stretchable. We put the silicone skin inside of a shirt so it is more realistic to the real life situation when you give a hug to someone, there are usually clothes on the person. The hardware connections are done on the lower back of the t-shirt, see figure 5.2, which makes it easier to wear and comfortable for participants to give touches. The yellow clothes are for fixing the silicone skin on the t-shirt, since we need a sturdy way to attach the silicone skin on the tshirt and mannequin.

(a) (b)

Figure 5.2. (a)left side picture, inside of the tshirt with the silicone skin and capacitive yarn grid (b)right side picture, outside of the tshirt and its hardware connection on the shower back.

Tablet: A Samsung Galaxy Tab S2 tablet was used to display survey questionnaires. By using digitized control, only when participants filled in the survey in a correct way, they can continue to the next page.

6. Experiment 2

6.1 Participants

We recruited 10 participants for the first experiment (5 male, 5 female) with a mean age of 26.1(Average x = 26.1, N = 10, min= 20, max= 47). Recruited participants were at least 18 years old. Participants were recruited at the condition of no psychological and upper body physiological impairment. Participants received 5 euro Hema bon as compensation.
The experiment was reviewed and approved by the Internal Review Board of the University of Twente under the number [230201].

6.2 Task of Experiment 2

Firstly, the participant fills in a questionnaire about their background information and social levels. Then they fill in an SAM emoji scale that has a scale between 1 to 5 for valence, arousal and dominance to reflect on their current emotions, valence (the pleasantness of a stimulus), arousal (the intensity of emotion provoked by a stimulus), and dominance (the degree of control exerted by a stimulus)(Warriner et al., 2013). Participant stands, a mannequin with textile skin is placed in front of them. The first scenario is a “happy” situation, prompted with “You just won a game where the score was tight, you are thrilled and you celebrate it with your game partner with a big hug. Good job!”. Participant is asked to stand in front of the mannequin to design a hug pattern to express the emotion related to the scenario. Then fills in the emoji grid to reflect on their current emotions. Participant has no time limit to make sure they are satisfied with their own design. The second scenario is a “comfort” situation, prompted with “Your close friend failed their resit exam even after studying really hard, you want to comfort them with a big hug”. Afterwards, participant fills in the third emoji grid to reflect on their current emotion. In the end, there is an open ended question, participants can give any thoughts, remarks or ideas about the experiment.

6.3 Procedure of experiment 2

At the start of the session, the participant enters the room and is introduced to the study. The participant reads the document about the experiment and is requested to sign the consent form. After the consent form, the researcher shows the participant how to use the silicone skin to design hug patterns and what will happen during the hug. After 5 minutes of trying out the equipment, the participant starts the task. During the task, the participant follows two scenarios. After each design, the participant has to fill in an SAM emoji scale. The task has no time limit as we want participants to completely define the patterns they want. In the end, there is an open ended question, participants can give any thoughts, remarks or ideas about the experiment. After the experiment, the researcher debriefs the participant about the study and gives them a compensation.

6.4 Result of experiment 2

In this chapter, visualization of hug patterns designed for the "happy" scenario and the "comfort" scenario are presented. We took pictures of the first, third, fifth and if it's a long duration hug then we also took a seventh second of the recorded pattern. In the figure 6.1, 6.2 and 6.3, the green dot means the motor is activated, the bigger the dot is, the stronger the intensity is. Pattern 7-1 is a short but intense pattern, the duration of it is too short so only can make three screenshots. In figure 6.1 is the visualization of a comforting haptic hug pattern that most partici[ants selected. In figure 6.2 is the visualization of a happy haptic hug hug pattern that most participants selected.

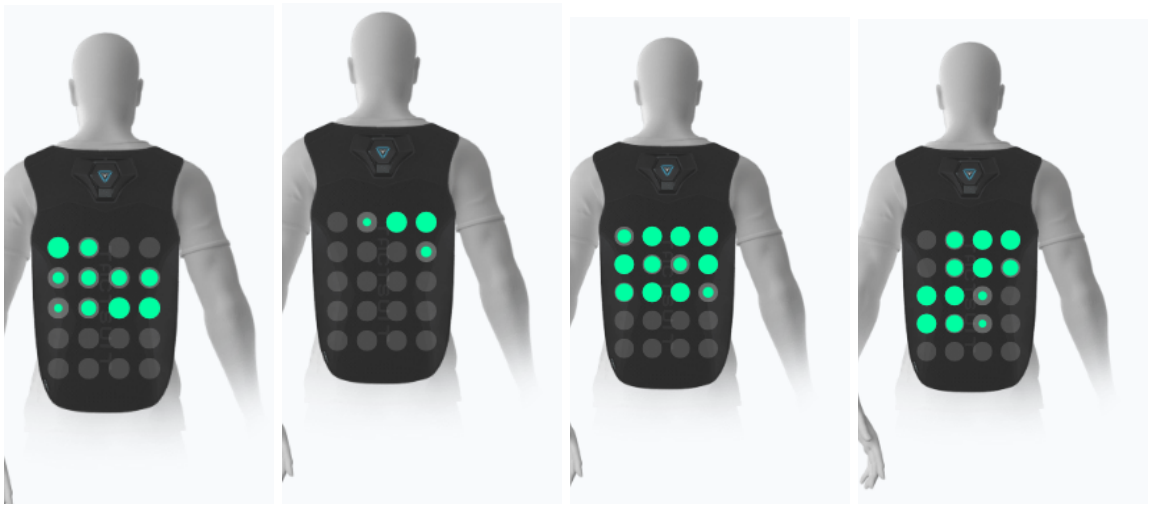


Figure 6.1. Comforting Hug pattern 4-2 represented on the haptic vest, from left to right four pictures are the moment of 1st second, 3rd second, 5th second and 7th second of hug patterns of Comforting scenario

Figure 6.2. Happy hug pattern 7-1 represented on the haptic vest, from left to right four pictures are the moment of 1st second, 3rd second, 5th second and 7th second of hug patterns of Happy scenario

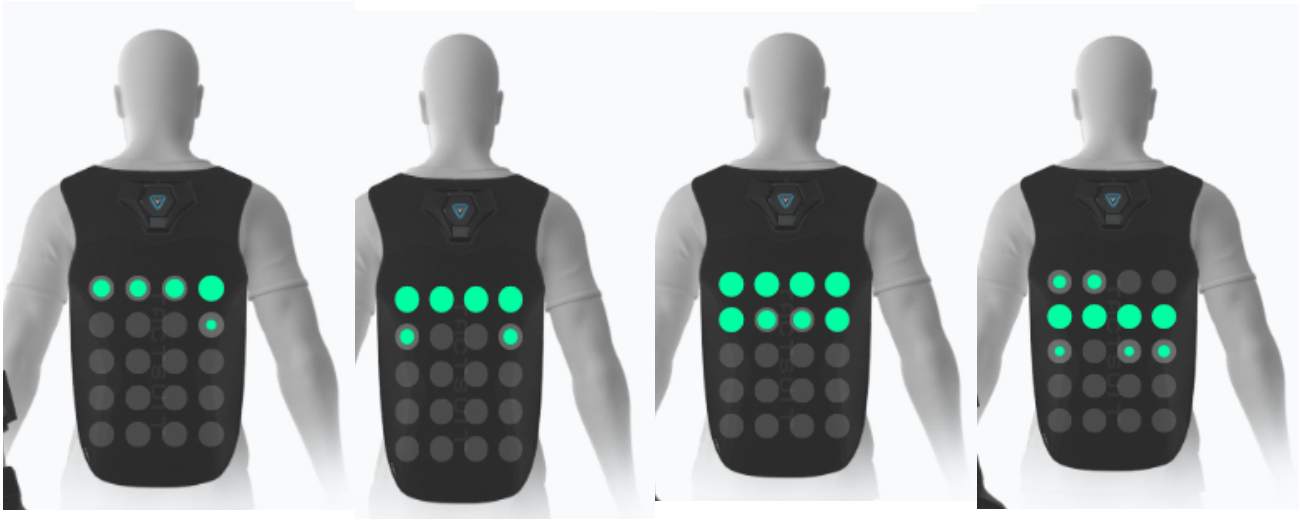


Figure 6.3. Comforting hug pattern 8-2 represented on the haptic vest, from left to right four pictures are the moment of 1st second, 3rd second, 5th second and 7th second of hug patterns of Comforting scenario

Results of One-way ANOVA test and Post Hoc Tukey are presented, which aims to measure the changes of emotions. To see the variances of valence and arousal between two different Scenarios and compared to the emotion states before designing the hug patterns. These two statistical tests determine whether the mean differences between these groups are significant. For one way ANOVA and Post Hoc Tukey, a significance of 0.05 (α= 0.05) was used. Tables in figure. list values extracted from the SAM scale from 10 participants. These values are used for the one-way ANOVA test in figure and Post Hoc Tukey test in figure 6.3.

ANOVA

VAR00001

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	20.600	2	10.300	16.753	<.001
Within Groups	16.600	27	.615		
Total	37.200	29			

ANOVA

VAR00001

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	7.917	2	3.958	3.524	.044
Within Groups	30.325	27	1.123		
Total	38.242	29			

Figure 6.3. One-way ANOVA test data top table results are for valence of before design, after design a happy hug and after design a comforting , bottom table results are for arousal

Post Hoc Tests

Multiple Comparisons

Dependent Variable: VAR00001

Tukey HSD

(I) VAR00004	(J) VAR00004	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-.70000	.35066	.132	-1.5694	.1694
	3.00	1.30000*	.35066	.003	.4306	2.1694
2.00	1.00	.70000	.35066	.132	-.1694	1.5694
	3.00	2.00000*	.35066	<.001	1.1306	2.8694
3.00	1.00	-1.30000*	.35066	.003	-2.1694	-.4306
	2.00	-2.00000*	.35066	<.001	-2.8694	-1.1306

*. The mean difference is significant at the 0.05 level.

Multiple Comparisons

Dependent Variable: VAR00001

Tukey HSD

(I) VAR00004	(J) VAR00004	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1.00	2.00	-.75000	.47395	.270	-1.9251	.4251
	3.00	.50000	.47395	.550	-.6751	1.6751
2.00	1.00	.75000	.47395	.270	-.4251	1.9251
	3.00	1.25000*	.47395	.035	.0749	2.4251
3.00	1.00	-.50000	.47395	.550	-1.6751	.6751
	2.00	-1.25000*	.47395	.035	-2.4251	-.0749

*. The mean difference is significant at the 0.05 level.

Figure 6.4. Post Hoc Tukey analysis data top table results are for valence, bottom table results are for Arousal

In Experiment 2, data were collected from participants who played the role of hug senders during the mediated social interaction. The participants' emotional states were assessed using the Self-Assessment Manikin scale, which measured their valence and arousal before and after

performing the hugging tasks in the happy and comforting scenarios. The data presented below provide a clear overview of the statistical analysis process:

Valence:
F-ratio value: 16.75301
Degrees of freedom: 29
P-value: 0.000019
Mean values (M): M1 = 3.8 (from the first SAM scale), M2 = 4.5 (from the second SAM scale in the happy scenario), M3 = 2.5 (from the third SAM scale in the comforting scenario)
Pairwise comparisons for valence:
T1 (M1 vs. M2) = 0.7
T2 (M1 vs. M3) = 1.3
T3 (M2 vs. M3) = 2

Arousal:
F-ratio value: 3.524
Degrees of freedom: 29
P-value: 0.043658
Mean values (M): M1 = 4.5 (from the first SAM scale), M2 = 3.65 (from the second SAM scale in the happy scenario), M3 = 3.3 (from the third SAM scale in the comforting scenario)
Pairwise comparisons for arousal:
T1 (M1 vs. M2) = 0.75
T2 (M1 vs. M3) = 0.5
T3 (M2 vs. M3) = 0.25

The significant F-ratio value for valence (16.75301, p = 0.000019) indicates that there are significant differences in self-reported valence ratings between the hug scenarios. Pairwise comparisons reveal that the mean valence ratings significantly increased from the first SAM scale (M1) to the second SAM scale in the happy scenario (M2) (T1 = 0.7) and significantly decreased when comparing M2 with the third SAM scale in the comforting scenario (M3) (T2 = 1.3). Additionally, there was a significant difference in valence ratings between M2 and M3 (T3 = 2).

For arousal, although the F-ratio value (3.524) did not reach conventional significance (p = 0.43658), the pairwise comparisons show interesting patterns. The mean arousal rating slightly decreased from M1 to M2 (T1 = 0.75) and from M1 to M3 (T2 = 0.5), while there was no significant difference between M2 and M3 (T3 = 0.25).

These findings suggest that the hug patterns in the happy and comforting scenarios elicited significant changes in self-reported valence ratings. However, the differences in arousal ratings were not statistically significant. The detailed statistics provided valuable insights into the emotional changes experienced by the hug senders during mediated social touch.

6.5 Discussion of experiment 2

Hypothesis H0 proposed that touch patterns designed for the "happy" scenario and the "comfort" scenario can be distinguished from each other. It is hard to define if they can be distinguished based on the result of experiment 2. It is only clear that hug senders they did tend to give different hugs

Hypothesis H1 proposed that self-reported emotions would differ between the "happy" and "comforting" hug scenarios for senders. The results of the one-way ANOVA analysis indicated a significant effect of the hug scenario on self-reported valence ($F(29) = 16.75$, $p < 0.001$). Participants reported a mean valence score of 3.8 (M1) during the neutral state, which increased to 4.5 (M2) after the "happy" scenario and decreased to 2.5 (M3) after the "comforting/sad" scenario. Post hoc pairwise comparisons revealed that the mean valence score significantly increased from the neutral state to the "happy" scenario (T1: T2 = 0.7, $p < 0.05$) and significantly decreased from the "happy" scenario to the "comforting/sad" scenario (T2: T3 = 1.3, $p < 0.05$). These findings indicate that senders experienced distinct emotional responses, with higher valence compared to the neutral state that before they imagine the happy scenario and lower valence reported after they imagine the comforting/sad scenario .

In the context of James Russell's Circumplex model, see figure below, valence represents the pleasantness or unpleasantness of an emotional experience. The observed changes in self-reported valence align with the model's proposition, demonstrating variations in the pleasantness of emotional experiences during different hug scenarios.

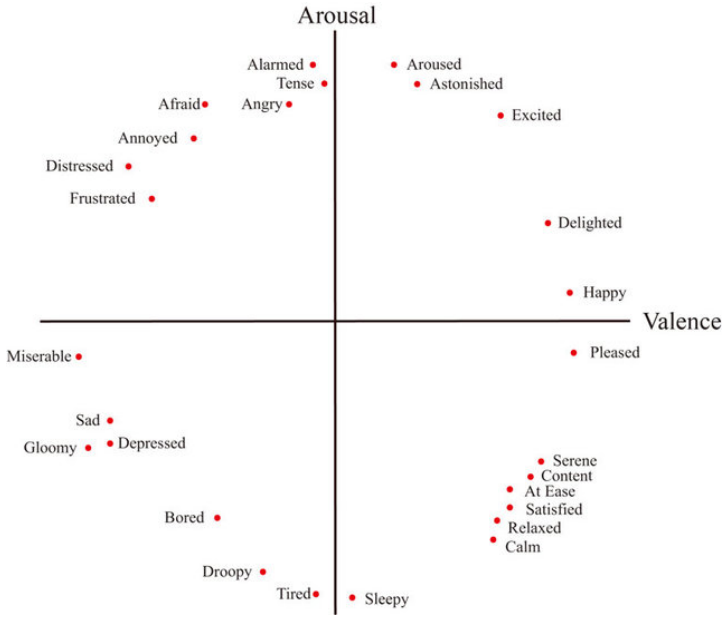


Figure 6.5. The circumplex model of emotion developed by James Russell.In the model, emotions are distributed in a two-dimensional plane. The x-axis represents valence and the y-axis represents arousal. Valence refers to the positive and negative degree of emotion and arousal refers to the intensity of emotion, Seo and Huh (2019)

However, the analysis did not yield significant differences in self-reported arousal between the scenarios ($F(29) = 3.25$, $p = 0.054$). Participants reported a mean arousal score of 4.5 (M1) during the neutral state, which decreased to 3.65 (M2) after the "happy" scenario and further decreased to 3.3 (M3) after the "comforting" scenario. The post hoc pairwise comparisons for arousal did not reach statistical significance, indicating no significant differences within the scenarios. Thus, the results do not provide definitive evidence for differential arousal responses between the hug scenarios.

It is important to note that while the p-value for arousal did not reach statistical significance, there is a trend indicating a potential difference that could be explored with a larger sample size or additional measures.

Considering the revised information, the discussion on H1 remains consistent, as the findings continue to support the notion that self-reported valence significantly differed between the "happy" and "comforting" hug scenarios for senders. However, the analysis did not yield significant differences in self-reported arousal, highlighting the need for further investigation to draw definitive conclusions regarding arousal responses within the context of the hug scenarios.

In summary, the updated analysis, taking into account the mean values and pairwise comparisons, confirms that senders reported significantly different levels of valence in response to the "happy" and "comforting" hug scenarios, supporting H1. The Circumplex model provides a framework for understanding the variations in valence-based emotional responses during mediated social touch. However, the results for arousal did not reach statistical significance. From participants' open ended answers about their feedback and ideas of this experiment, we may find the potential reason. The vest provides vibration stimulus, which does not imitate the real hug tactile sensations. It made participants feel more like a massage. Reported from participants”Didn't feel like hugs, more like massaging”, “The vibrations of the device feels very comforting”, “Vibrations feels a bit pulsating”, “The vibrations were sometimes a bit too long and felt more like a massage than a hug.” These responses may explain why there’s a lack of arousal changes between different scenarios. More reasons could cause this issue to be discussed in the chapter of limitations of experiment 2.
Lastly, it also shows the need for future research with a larger sample size or additional measures to explore the potential differences in arousal responses.

6.6 Limitations of experiment 2

This chapter shows the potential factors that could be the limitation of experiment 2.
Participants in this experiment hugged a mannequin wearing clothes embedded with capacitive yarn to record their hug patterns. The absence of real human live interaction may limit the generalizability of the findings to real-life social interactions. However, it actually relates to the intended situation which is mediated hugs.
The experiment used predefined scenarios (happy and comforting) for participants to enact their hugs. While these scenarios aimed to elicit specific emotional responses, they may not fully revert the complexity and variability of real-world scenarios.
It is important to consider the characteristics of the participants who played the role of hug senders. If the participants do not represent a diverse range of demographics or have specific traits that are not representative of the general population, the generalizability of the findings may be limited, especially if there are only 10 participants in this part of the experiment.
The use of self-report measures may be influenced by response biases or social desirability. Emotional responses rely on participants' subjective interpretations may not be accurate.
Lastly, using a mannequin for the collection of hug patterns, may lead to lack of emotional reciprocity and responsiveness of a real person. The absence of human feedback during the hug interactions may impact participants' emotional experiences and potentially limit the emotional transmission aspects of the study.

7. Experiment 3

7.1 Participants

We recruited 21 participants for the experiment 12 male , 9 female (Average x = 26.19, Count n = 21, min= 20, max= 47), min. Recruited participants were at least 18 years old. Participants were recruited at the condition of no psychological and upper body physiological impairment. Participants received 5 euro Hema bon as compensation.
The experiment was reviewed and approved by the Internal Review Board of the University of Twente under the number [230201].

7.2 Task of experiment 3

Participant two fills in a SAM emoji grid and survey questions to reflect on their current emotions. Participant is seated and wears noise canceling headphones. Researcher helps the participant to wear the vest and tells them that 20 different haptic patterns will be felt through the vest. After receiving each pattern, participant two has to fill in the SAM emoji grid and choose the corresponding scenario between the three choices of scenarios from the previous experiment and an extra option of “I don't feel any of these”.

7.3 Procedure of experiment 3

At the start of the session, the participant enters the room and is introduced to the study. The participant reads the document about the experiment and is requested to sign the consent form. After the consent form, the researcher helps the participant to wear the haptic vest and makes them feel the vibration by manipulating test parameters on the Bhpatics player. It is to avoid making the participant be surprised by the sudden vibratory touch. After 5 minutes of testing the vest, the participant starts the task. During the task, there are in total 20 haptic patterns played. In some situations. Participants can ask to replay each haptic pattern maximum twice to help them perceive the pattern and fill in the emoji grid. Participant has to fill in the emoji grid based on their true feelings and thoughts. It is allowed to take a break during the experiment to make sure the participant doesn’t get nauseous by feeling constant vibrations on their body. At the end they fill in an open ended question to evaluate the experiment and tools. After the experiment, the researcher debriefs the participant about the study and gives them a compensation.

7.4 Result of experiment 3

In this experiment participants matched the hug patterns they felt with 3 choices. All patterns were collected in experiment 2. On table 7.1, it shows for each pattern how participants matched them with the choices, in which 4-2 and 8-2 comforting hugs were chosen correctly by most participants as they think it is a “comforting hug”, 7-1 happy hug was chosen correctly by most participants as they think it is a “happy hug”.
In total there are 419 valid answers, in which 181 answers are participants felt comforting hugs,70 answers are participants felt happy hugs and 168 answers are participants didn’t feel any of these two.

Table 7.1. Hug patterns and their multiple choices answers chosen by participants.

Pattern	Participants choosing "I don't feel any of these"	Participants choosing "Comforting hug"	Participants choosing "Happy hug"
Pattern 1-1 Happy hug	9	10	2
Pattern 1-2 Comforting hug	6	11	4
Pattern 2-1 Happy hug	12	6	3

Pattern 2-2 Comforting hug	8	9	4
Pattern 3-1 Happy hug	9	9	3
Pattern 3-2 Comforting hug	7	10	4
Pattern 4-1 Happy hug	12	7	2
Pattern 4-2 Comforting hug	6	13	2
Pattern 5-1 Happy hug	11	6	4

Pattern 5-2 Comforting hug	8	11	2
Pattern 6-1 Happy hug	10	6	5
Pattern 6-2 Comforting hug	8	9	3
Pattern 7-1 Happy hug	8	7	6
Pattern 7-2 Comforting hug	9	9	3
Pattern 8-1 Happy hug	8	9	4

Pattern 8-2 Comforting hug	6	13	2
Pattern 9-1 Happy hug	7	10	4
Pattern 9-2 Comforting hug	13	6	2
Pattern 10-1 Happy hug	3	13	5
Pattern 10-2 Comforting hug	8	7	6
Total answers	168	181	70

The analysis of 168 responses indicates that 40% of participants did not perceive either of the two hugs, suggesting potential issues with the system or measurement. Out of the remaining 251 responses, we can determine the success rate at which participants accurately matched the hug patterns with their choices. When assuming random answers, the success rate would be approximately 50%, as the choice "I don’t feel any of these " is always incorrect.

Thus, there are four possible outcomes: participants correctly matching their felt happy hug with the choice of a happy hug, matching their felt happy hug with the choice of a comforting hug, matching their felt comforting hug with the choice of a happy hug, and matching their felt comforting hug with the choice of a comforting hug. Among these possibilities, two are correct pairs, yielding a 50% success rate if participants were selecting answers randomly.

For the scenario of happy hugs, a total of 38 correct answers were given out of 251, resulting in an observed success rate of 15.1%. For the scenario of comforting hugs, 95 correct answers were provided out of 251, leading to an observed success rate of 37.8%. Therefore, it indicates that the actual success rates of 15.1% and 37.8% are both below the random selection success rate of 50%.

In summary, the study reveals that participants' success rates in correctly matching hug patterns with choices varied based on the scenario, indicating that their ability to interpret haptic cues aligned more closely with comforting hugs than with happy hugs.

To answer H1:For receivers, a touch stimulus from the "happy" scenario and "comfort" scenario gives different self-report emotions.Below is the statistical calculation t-test with two independent variables (without outlier) to compare the means of two groups. The purpose of this is to see the emotion changes of hug pattern receivers, if the different haptic stimulus can change emotional status and the haptic stimulus of "happy" scenario and "comfort" scenario give participants different self-report emotions.

Table 7.2. Valence before happy hugs and after happy hugs

Group Statistics

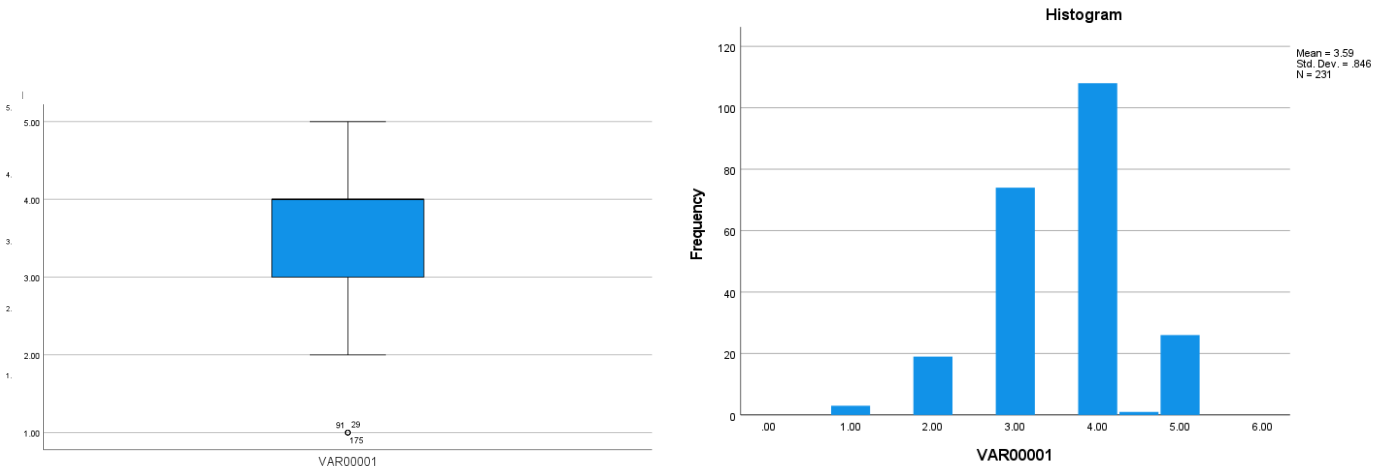
	VAR00004	N	Mean	Std. Deviation	Std. Error Mean
VAR00001	1.00	21	3.6667	.73030	.15936
	2.00	210	3.5833	.85781	.05919

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p			Lower	Upper
VAR00001	Equal variances assumed	1.172	.280	.430	229	.334	.668	.08333	.19395	-.29883	.46549
	Equal variances not assumed			.490	25.852	.314	.628	.08333	.17000	-.26621	.43288

Valence Before and After Happy Hugs:
The t-value for valence before and after happy hugs was 0.43, with a p-value of 0.334. The result is not significant at $p < 0.05$. This suggests that there is no significant difference in valence ratings before and after experiencing happy hugs, indicating that the haptic stimulus did not significantly change the participants' self-reported valence.

Why without outliers:
In the SPSS it denotes the outlier with a circle and its case number, in our case they're case 29 and 91, their values are 1, see figure ++ below. Data points situated more than 1.5 IQRs but less than 3 IQRs away from the box's ends are considered outliers (o).Values more than 1.5 IQR but less than 3 IQR from the end of the box are labeled as outliers (*). The box's boundaries are determined by Tukey's hinges(*IBM Documentation*, n.d.).
However, Hoaglin& Iglewicz (1987) demonstrated that the 1.5 multiplier was inaccurate approximately 50% of the time, suggesting that 2.2 is probably more valid in a lot of applied cases. Values more than 3 IQR's from the end of a box are labeled as extreme, denoted with an asterisk (*) in SPS, in our case we don't have any values like this. Moreover, the figure ** shows the histogram of frequency of each value shows up in this test. It matches the normal distribution bell curve, it proves the idea of the value 1 is actually normal to appear, it can be considered as not an outlier.



(a) (b)

Figure 7.2. (a) The left side is the vertical boxplot of values extracted from the table of valence before happy hugs and after happy hugs. (b)The right side is a histogram of frequency of each value shows up in this test

Table 7.3. Valence after happy hugs and after comforting hugs

Group Statistics

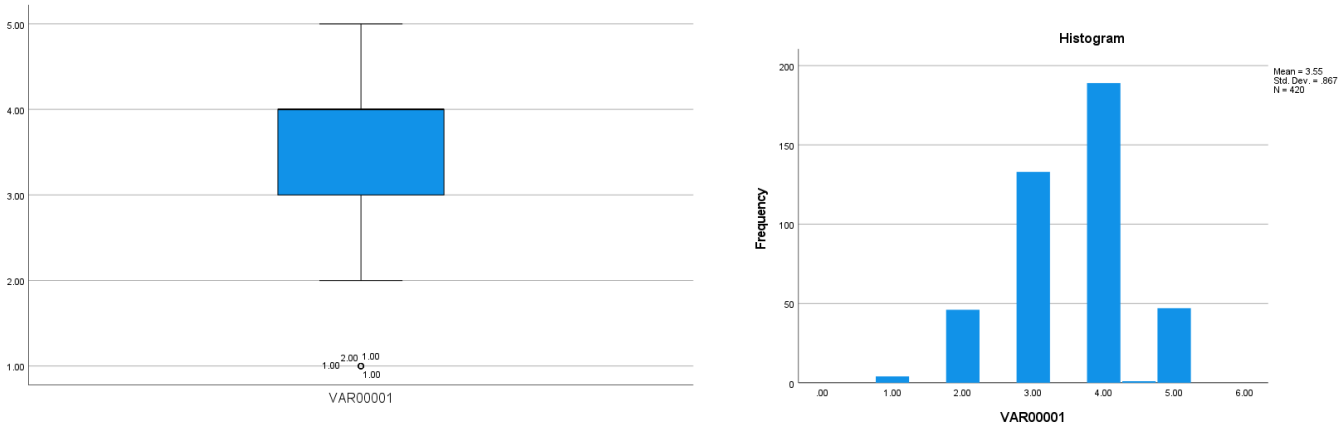
	VAR00004	N	Mean	Std. Deviation	Std. Error Mean
VAR00001	1.00	207	3.6208	.80496	.05595
	2.00	209	3.5263	.86075	.05954

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance		Mean	Std. Error	95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Difference	Difference	Lower	Upper
VAR00001	Equal variances assumed	1.884	.171	1.156	414	.124	.248	.09446	.08173	-.06620	.25511
	Equal variances not assumed			1.156	412.646	.124	.248	.09446	.08170	-.06615	.25506

Valence Before Happy Hugs and After Comforting Hugs:
The t-value for valence before happy hugs and after comforting hugs was 1.156, with a p-value of 0.124. The result is not significant at $p < 0.05$. This indicates that there is no significant difference in valence ratings before and after experiencing comforting hugs, suggesting that the haptic stimulus did not significantly affect the participants' self-reported valence in this scenario.

Why apply outlier:
Only three participants chose the valence value 1 when they received happy hugs. And there was only one participant who chose the value 1 to measure the valence of comforting hugs.



(a) (b)

Figure 7.3. (a) The left side is the vertical boxplot of values extracted from the table of valence after happy hugs and after comforting hugs in the experiment 3. (b)The right side is a histogram of frequency of each value shows up in this test

Table 7.4. T test for arousal before happy hugs and after happy hugs

Group Statistics

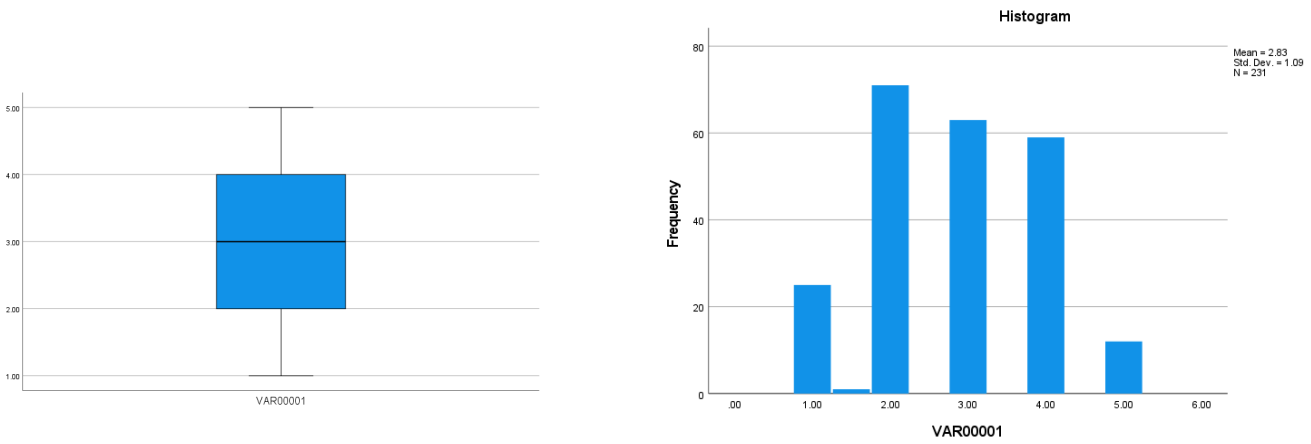
	VAR00004	N	Mean	Std. Deviation	Std. Error Mean
VAR00001	1.00	21	2.6190	.97346	.21243
	2.00	210	2.8500	1.10138	.07600

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	.764	.383	-.925	229	.178	.356	-.23095	.24965	-.72286	.26096
	Equal variances not assumed			-1.024	25.408	.158	.316	-.23095	.22561	-.69523	.23333

Arousal Before and After Happy Hugs:
The t-value for arousal before and after happy hugs was -0.925, with a p-value of 0.178. The result is not significant at $p < 0.05$. This implies that there is no significant difference in arousal ratings before and after experiencing happy hugs, indicating that the haptic stimulus did not significantly impact the participants' self-reported arousal.

Why no outliers:
The figure below is a vertical boxplot of values extracted from the table of arousal before happy hugs and after happy hugs and a histogram of frequency of each value shows up in this test. From the boxplot can be seen there are no denoted outliers.



(a) (b)

Figure 7.4. (a) The left side is the vertical boxplot of values extracted from the table of arousal before happy hugs and after happy hugs. (b)The right side is a histogram of frequency of each value shows up in this test

Table 7.5. Arousal after happy hugs and after comforting hugs

Group Statistics

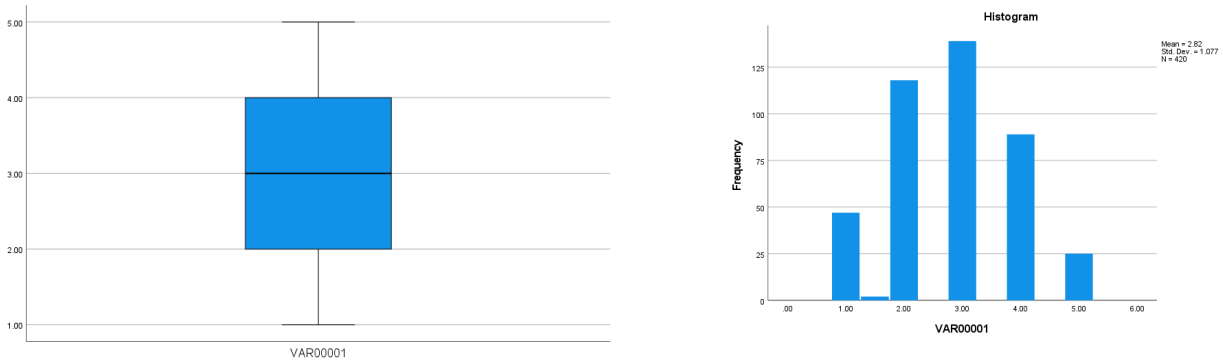
	VAR00004	N	Mean	Std. Deviation	Std. Error Mean
VAR00001	1.00	210	2.8500	1.10138	.07600
	2.00	210	2.7881	1.05318	.07268

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	1.862	.173	.589	418	.278	.556	.06190	.10516	-.14480	.26861
	Equal variances not assumed			.589	417.166	.278	.556	.06190	.10516	-.14480	.26861

Arousal Before Happy Hugs and After Comforting Hugs:
The t-value for arousal before happy hugs and after comforting hugs was 0.589, with a p-value of 0.278. The result is not significant at $p < 0.05$. This suggests that there is no significant difference in arousal ratings before and after experiencing comforting hugs, indicating that the haptic stimulus did not significantly influence the participants' self-reported arousal in this scenario.
Based on the analysis, the statistical data indicates that there were no significant differences in self-reported emotions (valence and arousal) before and after experiencing different hug scenarios. This suggests that the haptic stimuli provided during the experiment did not strongly influence the participants' emotional states.

Why no outliers:
The figure below is a vertical boxplot of values extracted from the table of arousal after happy hugs and after comforting hugs and a histogram of frequency of each value shows up in this test. From the boxplot can be seen there are no denoted outliers. Additionally, how values distribute in the histogram (b) matches the normal distribution bell curve.



(a) (b)

Figure 7.5. (a) The left side is the vertical boxplot of values extracted from the table of arousal after happy hugs and after comforting hugs in the experiment 3. (b)The right side is a histogram of frequency of each value shows up in this test

The results of the t-tests comparing the valence and arousal levels between different hug scenarios in Experiment 2 (E2) and Experiment 3 (E3) are as follows:

Table 7.6. Valence of happy hugs in E2 and Valence of happy hugs in E3

Group Statistics

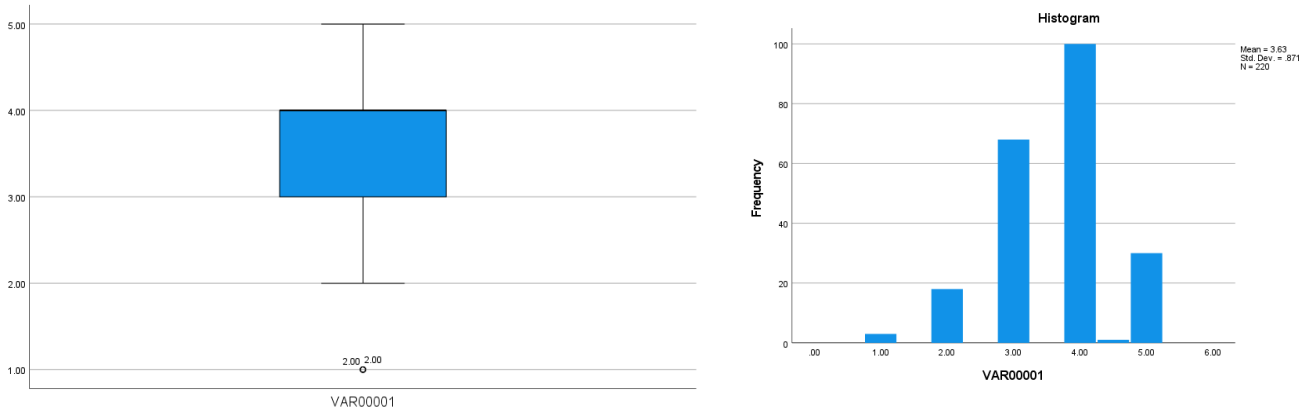
	VAR00004	N	Mean	Std. Deviation	Std. Error Mean
VAR00001	1.00	10	4.5000	.70711	.22361
	2.00	208	3.6082	.82332	.05709

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	.459	.499	3.364	216	<.001	<.001	.89183	.26508	.36935	1.41430
	Equal variances not assumed			3.864	10.210	.002	.003	.89183	.23078	.37905	1.40461

Valence of happy hugs in E2 vs. E3:
The t-value is 3.364, and the p-value smaller than 0.001. This result is significant at $p < 0.05$, indicating that there is a significant difference in self-reported valence levels between the "happy" hug scenario in E2 and E3. Participants in E2 reported higher valence levels after experiencing the "happy" hug compared to participants in E3.

Why apply outlier:
Only two participants chose the valence value 1 in the experiment 3.



(a) (b)

Figure 7.6. (a) The left side is the vertical boxplot of values extracted from the table of valence of happy hugs in E2 and E3. (b)The right side is a histogram of frequency of each value shows up in this test

Table 7.7 Valence of comforting hugs in E2 and Valence of comforting hugs in E3

Group Statistics

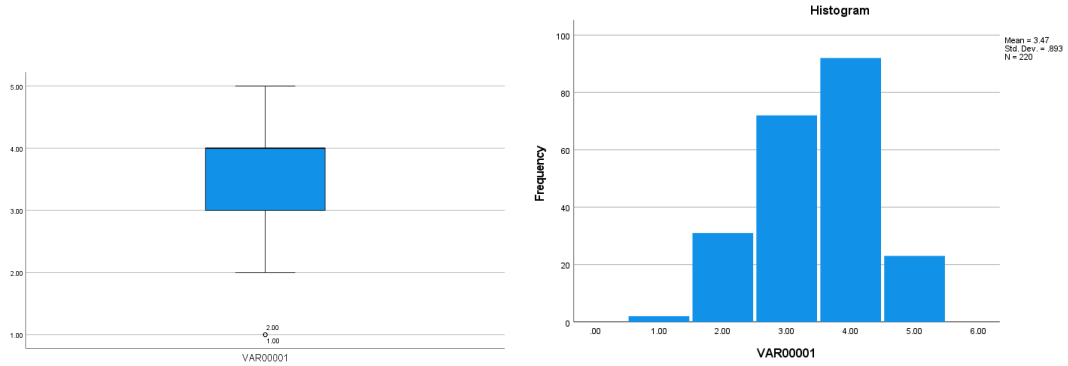
	VAR00004	N	Mean	Std. Deviation	Std. Error Mean
VAR00001	1.00	9	2.6667	.50000	.16667
	2.00	210	3.5143	.87621	.06046

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	4.168	.042	-2.878	217	.002	.004	-.84762	.29453	-1.42813	-.26711
	Equal variances not assumed			-4.781	10.238	<.001	<.001	-.84762	.17730	-1.24142	-.45382

Valence of comforting hugs in E2 vs. E3:
The t-value is -2.878, and the p-value is 0.002. This result is significant at $p < 0.05$, indicating that there is a significant difference in self-reported valence levels between the "comforting" hug scenario in E2 and E3. Participants in E2 reported lower valence levels after experiencing the "comforting" hug compared to participants in E3.

Why apply outlier:
Only one participant chose the valence value 1 in the experiment 2. And in experiment 3 there was no one who chose the value 1 to measure the valence of happy hugs.



(a) (b)

Figure 7.7.(a) The left side is the vertical boxplot of values extracted from the table of valence of comforting hugs in E2 and E3. (b)The right side is a histogram of frequency of each value shows up in this test

Table 7.8 Arousal of happy hugs in E2 and arousal of happy hugs in E3

Group Statistics

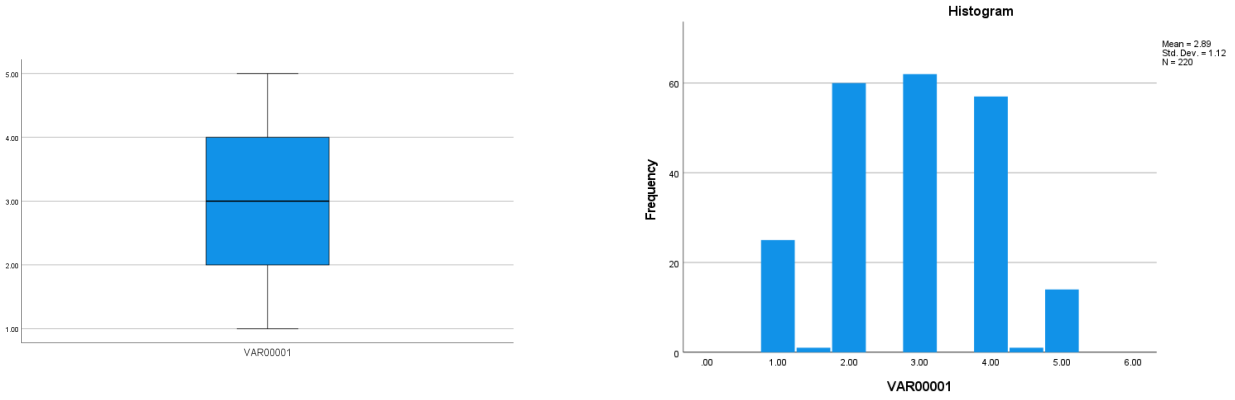
	VAR00004	N	Mean	Std. Deviation	Std. Error Mean
VAR00001	1.00	10	3.6500	1.29207	.40859
	2.00	210	2.8500	1.10138	.07600

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	.434	.511	2.227	218	.013	.027	.80000	.35924	.09197	1.50803
	Equal variances not assumed			1.925	9.633	.042	.084	.80000	.41560	-.13081	1.73081

Arousal of happy hugs in E2 vs. E3:
The t-value is 2.227, and the p-value is 0.013. This result is significant at $p < 0.05$, indicating that there is a significant difference in self-reported arousal levels between the "happy" hug scenario in E2 and E3. Participants in E2 reported higher arousal levels after experiencing the "happy" hug compared to participants in E3.

Why no outliers:
The figure below is a vertical boxplot of values extracted from the table of arousal before happy hugs and after happy hugs and a histogram of frequency of each value shows up in this test. From the boxplot can be seen there are no denoted outliers. Additionally, how values distribute in the histogram (b) matches the normal distribution bell curve.



(a) (b)

Figure 7.8. (a) The left side is the vertical boxplot of values extracted from the table of arousal of happy hugs in E2 and E3. (b)The right side is a histogram of frequency of each value shows up in this test

Table 7.9. Arousal of comforting hugs in E2 and arousal of comforting hugs in E3

Group Statistics

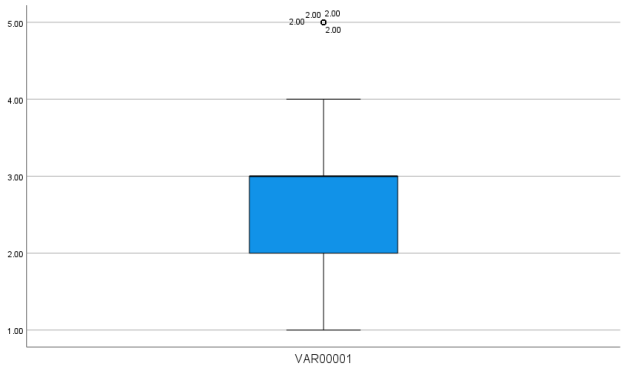
	VAR00004	N	Mean	Std. Deviation	Std. Error Mean
VAR00001	1.00	10	2.4000	.96609	.30551
	2.00	210	2.7881	1.05318	.07268

Independent Samples Test

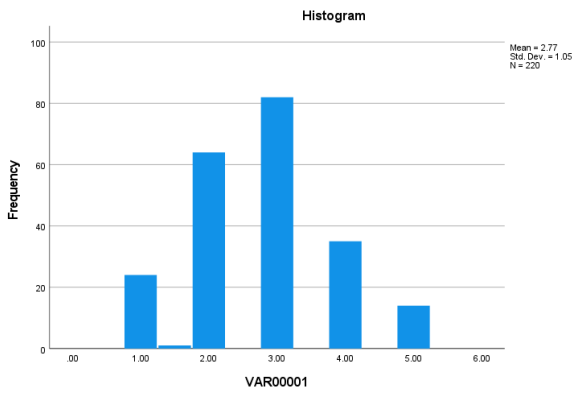
		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	.151	.698	-1.142	218	.127	.255	-.38810	.33976	-1.05774	.28155
	Equal variances not assumed			-1.236	10.046	.122	.245	-.38810	.31403	-1.08736	.31117

Arousal of comforting hugs in E2 vs. E3:
The t-value is -1.142, and the p-value is 0.127. This result is not significant at $p < 0.05$, indicating that there is no significant difference in self-reported arousal levels between the "comforting" hug scenario in E2 and E3. Participants in E2 and E3 reported similar arousal levels after experiencing the "comforting" hug.
The t-tests provided interesting insights into the emotional responses of participants in different hug scenarios in E2 and E3. There is a significant difference in self-reported valence levels for both the "happy" and "comforting" hug scenarios between the two experiments. The results show a significant difference in self-reported arousal levels for the "happy" hug scenario between E2 and E3, with participants in E2 reporting higher arousal levels. However, there was no significant difference in arousal levels for the "comforting" hug scenario between the two experiments.

Why without outliers:
First, the reasons for values in the table 7.2 can be analyzed without outliers can be applied here as well. Second is there are 14 participants who chose the value 5, in this case value 5 shouldn't be considered as an extreme case anymore.



(a)



(b)

Figure 7.9. (a) The left side is the vertical boxplot of values extracted from the table of arousal of comforting hugs in E2 and E3. (b)The right side is a histogram of frequency of each value shows up in this test

7.5 Discussion of experiment 3

Comparing the random success rate of 50% to the current success rate of 15.1% (happy hugs) and 37.8%(comforting hugs), we can see that the current success rates are lower than the random success rate. This suggests that participants' ability to match the hug patterns with the scenarios is below chance level.

These findings indicate that participants may have difficulty accurately perceiving the intended emotions conveyed by the hug patterns, especially for happy hugs. In this case the answer for hypothesis 3 is receivers can not successfully match the touch patterns with their corresponding scenarios.

Moreover, participants chose the option "I don't feel any of these" or "Comforting hug" instead of the expected "happy hug" for certain patterns. This suggests that the design of hug patterns may have caused confusion or inadequacy in conveying the intended emotions.

Analyzing the data, we can see that the hug pattern perceived as most conveying happiness by participants is happy hug pattern 7-1 and comforting hug pattern 10-2. 6 participants chose them as "Happy hugs". These hug patterns tend to have short duration, reach max intensity immediately and fixed bodily locations. Meanwhile, for pattern 7-1 and 10-2 the bodily locations they cover are different. Pattern 7-1 triggers motors mainly on shoulders and sides of the upper back. Pattern 10-2 shows unique bodily locations than all the other hug patterns. It applies stimulus on the lower back and it feels like someone’s arms around your waist, one participant reported it feels like a squishy cuddle.
The hug patterns perceived as most comforting are patterns 4-2, 8-2, 13 participants chose them as "Comforting hugs". They tend to have longer duration and the intensity changes on different bodily locations when hug senders move their hands like giving gently stroke on receivers’ backs.

The hypothesis H1, which states that a touch stimulus from the "happy" scenario and the "comfort" scenario gives different self-report emotions, was not supported. The results of the t-tests for both valence and arousal did not show significant differences in self-reported emotions before and after experiencing the different hug scenarios. Therefore, there is no strong evidence to prove that the haptic stimuli from the "happy" and "comfort" scenarios elicited different self-reported emotions in the receivers.

To answer hypothesis h2, there are the results of the t-tests that compare the self-reported emotions of senders and receivers in the same scenario, which has been done in the previous chapter. And the results suggest for comforting hugs, the self-reported emotions of both senders and receivers are similar, which supports the hypothesis h2. However, for happy hugs, it doesn’t support the hypothesis.

Based on the participants' feedback and remarks in the experiment 3, there are several factors that could potentially explain why hypothesis H2 couldn’t stand. First, participants mentioned

feeling different emotions and sensations during the experiment. Some participants might be more sensitive to certain types of vibrations, leading to variations in self-reported emotions between senders and receivers. Some participants also found it difficult to imagine what was happening as the vest vibrated. Second, participants mentioned that it was challenging to associate specific emotions with the vibrations, especially without a scenario or context provided. Third is some participants commented on the strength, duration, and location of the vibrations. Stronger and longer vibrations were associated more with comforting or massage-like sensations, while vibrations starting on the side of the heart were perceived as more pleasurable. The differences in vibration characteristics might have contributed to variations in emotional responses. Moreover, there are participants mentioned being tired and sleep-deprived during the experiments, since the experiments were conducted during the exam weeks, most participants were university students, external factors could have influenced their emotional responses. Fatigue might have led to a tendency to perceive all vibrations as comforting, potentially biasing the results.

7.6 Limitation of the participants

Participantsin experiment 2 & 3 filled in the single choice to self report how social they're and if they like to be touched and how much they can perceive others emotions from their touches. The mean value of the sociability level test score in experiment 3 is slightly higher than the average, however, the score of experiment 2 is significantly higher than experiment 3, calculation is listed below in the table 7.10. We don't know if this had an influence on our result, and if this means participants in experiment 3 in general have less empathy. Controlling human factors can be difficult. Moreover, there are no outliers, see figure 7.10.

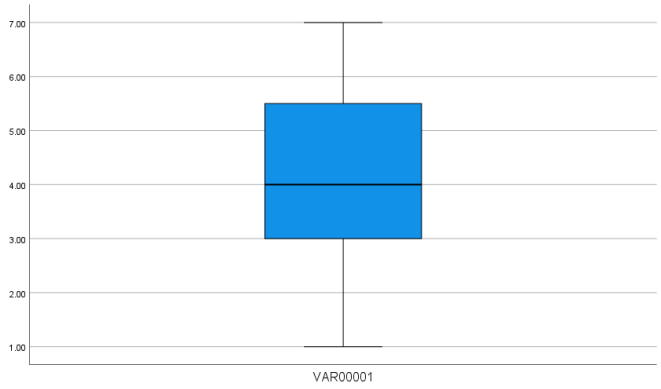
Table 7.10 . Participants sociability test score in the second experiment treatment 1 and in the third experiment treatment 2

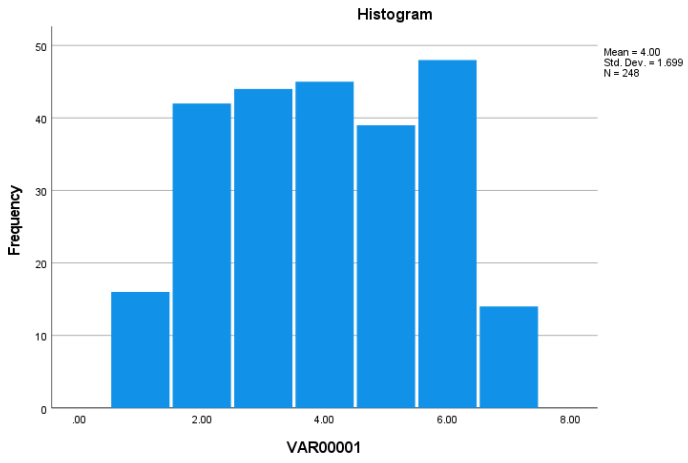
Group Statistics

	VAR00004	N	Mean	Std. Deviation	Std. Error Mean
VAR00001	1.00	80	4.5500	1.70554	.19068
	2.00	168	3.7440	1.63786	.12636

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means							
						Significance				95% Confidence Interval of the Difference	
		F	Sig.	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	Lower	Upper
VAR00001	Equal variances assumed	.217	.642	3.574	246	<.001	<.001	.80595	.22548	.36184	1.25007
	Equal variances not assumed			3.523	149.942	<.001	<.001	.80595	.22875	.35395	1.25795





(a) (b)

Figure 7.10. (a) The left side is the vertical boxplot of values extracted from the table of participants' sociability level questionnaires in E2 and E3. (b)The right side is a histogram of frequency of each value shows up in this test

In this study participants can select values ranging from 1 to 7 to measure the sociability test, and for SAM scales used to assess emotions, the options are numbers from 1 to 5. This creates challenges during data analysis when attempting to identify values that lie beyond 3 IQRs.

Furthermore, we may need more participants. A larger number of participants can enhance the statistical power and reliability of the study. Then research findings are more likely to represent trends within the entire population, reducing the impact of random error.This can really help to gain a more comprehensive understanding of relationships between variables and behavioral patterns among different groups.

8. Conclusion

This chapter answers all the hypotheses of the study. This study focused on haptic patterns and devices in transmitting emotions during mediated social touch. Through online surveys and on-site experiments, we examined the effectiveness of haptic hugs in inducing emotions in both senders and receivers. We formulated four research hypotheses to guide our exploration:

H0: Touch patterns designed for the "happy" scenario and the "comfort" scenario can be distinguished from each other. The results demonstrated that haptic hugs triggered different emotions in senders corresponding to the presented scenarios. This finding supports the hypothesis that touch patterns can be distinguished based on the emotional context they are designed for.

H1: For senders, the self-reported emotions differ between giving the "happy" hug and the "comfort" hug. The results confirmed that senders experienced different emotions while giving haptic hugs in response to the corresponding scenarios. These findings support the hypothesis that self-reported emotions differ between giving the "happy" and "comfort" hugs.

H2: The self-reported emotions of both senders and receivers are similar for the same scenario. The data analysis indicated that the self-reported emotions of senders aligned with the presented scenarios. However, for receivers, their ability to accurately interpret and match haptic patterns with the corresponding emotions was limited, leading to inconclusive results regarding the similarity of self-reported emotions between senders and receivers for the same scenario.

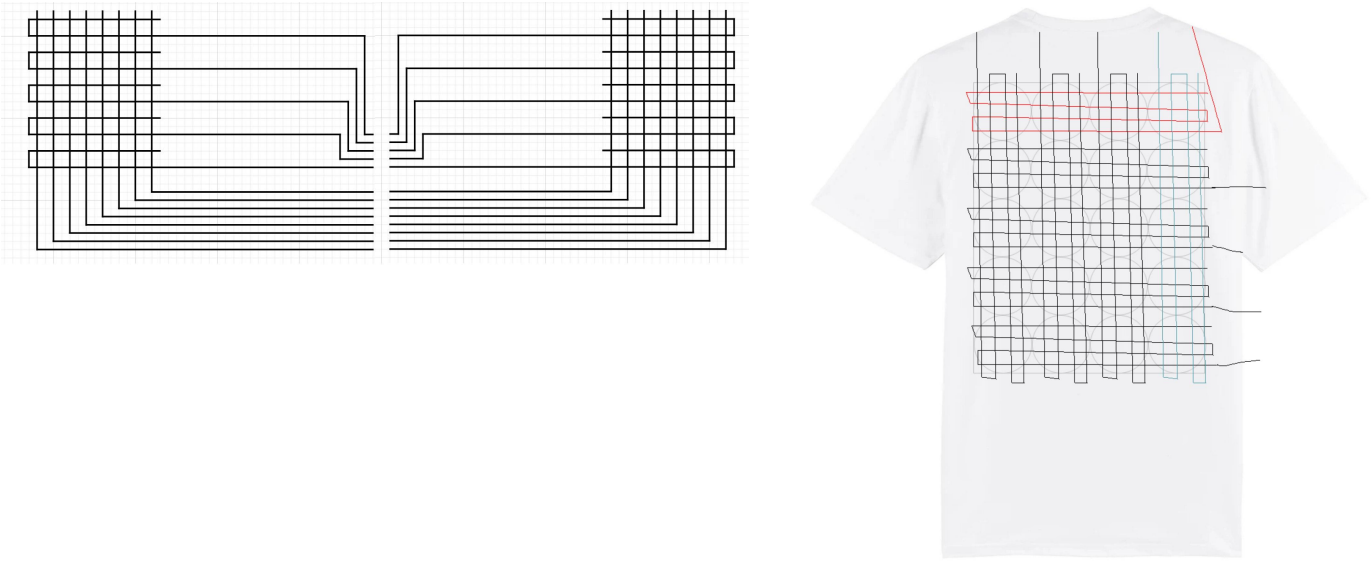
H3: Receivers can successfully match the touch patterns with their corresponding scenarios. However, the data analysis revealed that receivers were unable to match the haptic patterns with the corresponding emotions beyond chance levels. Nevertheless, they demonstrated some ability to perceive and acknowledge emotions conveyed through the haptic hugs. Thus, the hypothesis that receivers can successfully match touch patterns with their corresponding scenarios was not fully supported.

9. Future development

This chapter provides an in-depth look at potential future directions for touch-sensing communication systems, highlighting advances in vest technology that have improved the design of scenarios, discussing individual differences in emotional expression and difficulty evoking emotions from similar situations

In our study, eccentric rotating mass (ERM) motors were mainly used in the Haptic Vest to generate tactile patterns. However, work by Poyraj and Tamar (2019) showed that linear resonant actuators (LRAs) can offer significant benefits in specific haptic interactions. LRAs operate on AC drive voltages, providing precise waveform control and faster response times compared to ERM motors. This property can be particularly useful in situations where specific tactile signals need to be transmitted quickly. By combining the LRA with the ERM, haptic vests will be able to transmit subtle sensations and social touch, enabling a wider range of tactile sensations

Moreover, besides implementing different types of motors to enhance the performance during the replay of the haptic hug, we could also stitch the capacity yarn in fabric directly with smaller space to record haptic hugs more accurately. Since right now our system uses a piece of silicone skin embedded with the yarn inside, the shape and size of it doesn't really match the human body. The figure 9.1 below shows a brief idea of the array if we only use a single muca board and arduino. If we use more muca board, it is possible to use more yarn and stitch each of them closer to record more accurate patterns.



(a) (b)

Figure 9.1. Left side picture (a) shows for the front and back side of the clothes how to arrange the yarn, the middle parts connect to the muca board. Right side picture (b) shows how the location of the yarn cooperate with each motors

Additionally, emotions are inherently individual and can manifest differently among individuals. Although the aim of our study was to evoke specific emotions through specific tactile techniques, the results suggested that even well-designed systems may not evoke the same emotions of participants that they get it all the way through and under the same scenario participants may not perceive the same emotions. This highlights the difficulty of trying to justify sensory interpretation through tactile stimuli.

In summary, using the current system to transmit happiness between users during mediated social interaction is still a challenge. However, through this study we explored the potential of the setting and system, we understood that it is able to trigger different emotions in the senders, aligned with the presented scenarios. However, receivers had difficulty accurately matching the haptic patterns with the corresponding emotions, although they were able to perceive some emotions conveyed through the haptic hugs. It might be because the features of ERM motors gave participants massage feelings, so it is more suitable to represent comforting instead of happiness. In the end we also discussed several possible ways to enhance the usability of the system for making it possible to transmit more emotions. Future research is needed to discover more potentials of the current system, and new systems for transmitting emotions during the mediated social interactions.

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Appendix A- Online Survey questionnaire

Survey for finding out which bodily parts can evoke happiness by wearables

*Required

Taking part in the study

You are invited to participate in a research study. The goal of this research study is to find out on which body parts people would like to receive touch to communicate happiness. This study is being conducted by Yizhen Jia (Joyce). The study was approved by the Ethics Committee Information and Computer Science under number... if you want to discuss the study with an independent individual please email (ethics-create-itech@utwente.nl) Participation in this study is voluntary and you need to be more than 18 years old. Participating in this study may not benefit you directly, but it will help us learn where to place wearable haptic devices.

This online survey may take you up to 15 mins to fill in. The survey contains single choice questions and open ended questions. Open ended questions consist of self report questions and drawing on the given images. It is required to save images as .PNG format by using any painting tool of your own choice. You may skip any survey questions you don't want to answer and you may end the survey at any time. The information you will share with us if you upload your survey, will be kept completely confidential. The data and personal information will be anonymous, all the information you shared with us will only be used for this thesis. If you have any questions or suggestions, feel free to contact the email y.jia-2@student.uwtente.nl.

1. Are you above 18? *

Mark only one oval.

- ◯ Yes
- ◯ No

2. I have read and understood the study information dated [DD/MM/YYYY], or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason. I understand that information I provide will be used for this project anonymously. *

Mark only one oval.

- ◯ Yes
- ◯ No

Survey questions

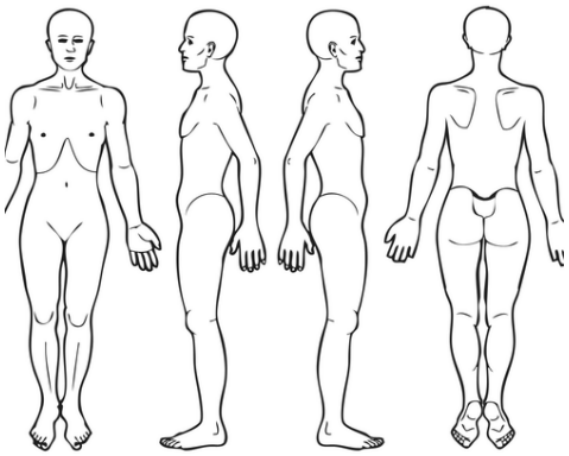
3. What is your sex? *

Mark only one oval.

- ◯ Female
- ◯ Male
- ◯ I prefer not to say

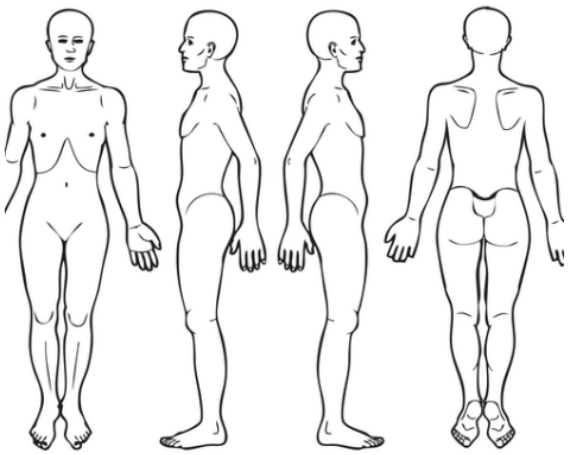
4. Where are you from? (Nationality(s)) *

5. Downland the graph and paint the body regions that you typically associate with happiness? Upload the PNG.



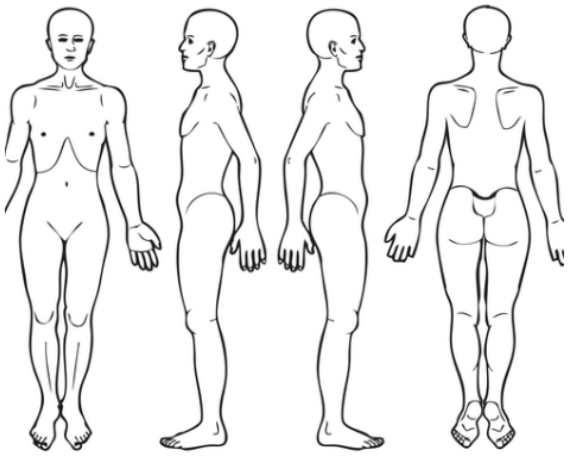
Files submitted:

6. Downland the graph and paint the body regions that you think would be appropriate to **be touched by** a close family member and/or significant other to evoke happiness? Upload the PNG.



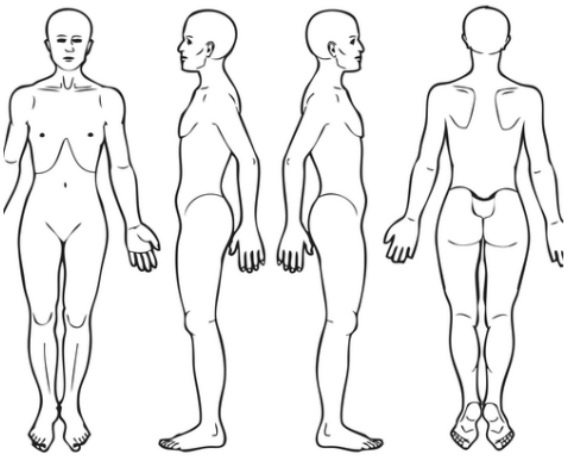
Files submitted:

7. Downland the graph and paint the body regions that you think would be appropriate **to touch** a close family member and/or significant other to evoke happiness? Upload the PNG.



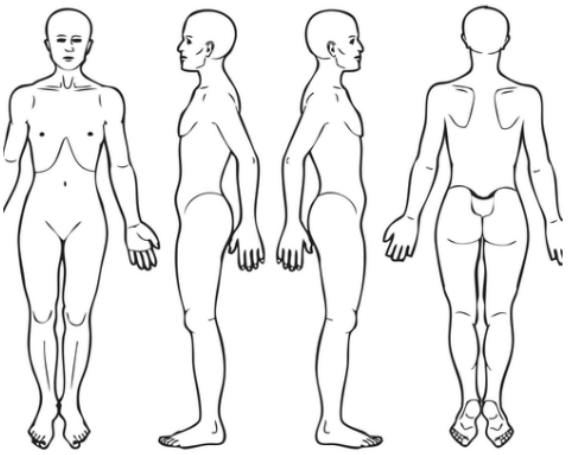
Files submitted:

8. Downland the graph and paint the body regions that you would accept to **be touched by** a stranger to evoke happiness? Upload the PNG.



Files submitted:

9. Downland the graph and paint the body regions that you think is appropriate **to touch** a stranger to evoke happiness? Upload the PNG.



Files submitted:

10. Do you mind to use wearable device which covers your arms and torso during social interactions with friends or family members? why?

11. Do you mind to use a wearable device which covers your arms and torso during social interaction with strangers? why?

12. What kinds of touch do you think strangers give you can evoke happiness? Like strong stroke, light pat, soft rub and etc... And how long do you want the touch to last (seconds)? Describe it as detail as possible.

13. What kinds of touch do you think a close family member and/or significant other give you can evoke happiness? Like strong stroke, light pat, soft rub and etc... And how long do you want the touch to last (seconds)? Describe it as detail as possible.

Appendix B- Survey questionnaire experiment 2

Survey questions-experiments of collecting hug patterns

You are invited to participate in a research study. The goal of this research study aims to collect and evaluate hug patterns in deliver emotions during mediated social interaction. This study is being conducted by Yizhen Jia (Joyce). The study was approved by the Ethics Committee Information and Computer Science under number 230201 if you want to discuss the study with an independent individual please email (ethics-create-itech@utwente.nl) You need to be more than 18 years old. When you complete the experiment, you will receive 5 euro as compensation. Thank you for joining!

* Indicates required question

1. I have read the information letter and give the consent for the researcher to process the data I provided. *

   Mark only one oval.

   - ◯ Yes
   - ◯ No

2. My sex is

   Mark only one oval.

   - ◯ Female
   - ◯ Male
   - ◯ I prefer not to say

3. My gender is

_____

4. My age is

_____

5. My unique id number is *

_____

Background information

6. 1. Do you consider yourself a social person?

Mark only one oval.

strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6 ◯

7 ◯

strongly disagree

7. 2. I can feel others' emotions during social interaction

Mark only one oval.

strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6 ◯

7 ◯

strongly disagree

8. 3. Others can feel my emotions during social interaction

Mark only one oval.

Strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6 ◯

7 ◯

Strongly disagree

9. 4. I consider myself to be a "touchy" person ("touchy" person means I think touch is a good way to express, transform, empathize and evoke emotions during social interactions with others, and considering both giving and receiving touches)

Mark only one oval.

strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6 ◯

7 ◯

strongly disagree

10. 5. When I interact with people, I often use touch to make them feel my emotions

Mark only one oval.

strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6 ◯

7 ◯

strongly disagree

11. 6. I feel more comfortable initiating touch than most

Mark only one oval.

strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6 ◯

7 ◯

strongly disagree

12. 7. I do not mind if someone touches my shoulders and back

Mark only one oval.

strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6 ◯

7 ◯

strongly disagree

13. 8. During interaction with others, I don't mind if people touch me

Mark only one oval.

strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6 ◯

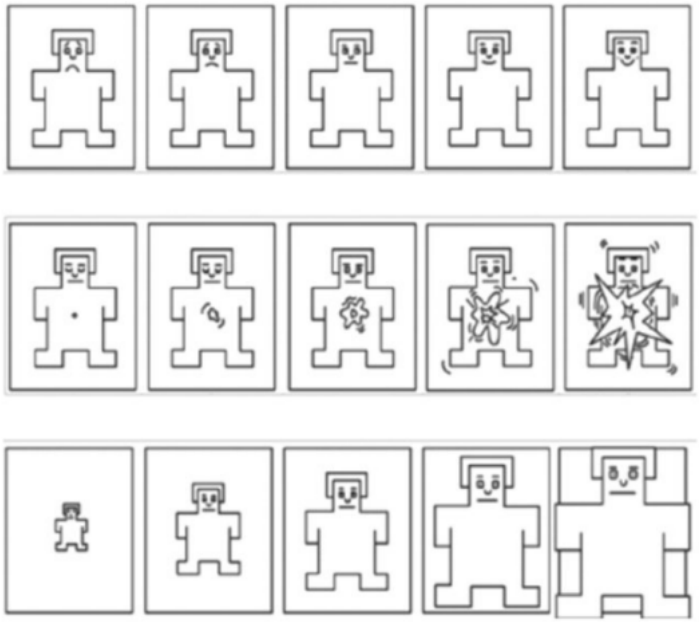
7 ◯

strongly disagree

The Self-Assessment Manikins (SAM). SAM scale is used in the experiment to capture participants' emotional reactions on three dimensions: (from the top row to the bottom row) the manikin representations are to express values of Valence (top), Arousal (mid), and Dominance (bottom). Valence describes the extent to which an emotion is positive or negative. Arousal is a state of heightened physiological activity. Dominance ranges from submission to feeling in control.

This session needs to be filled before you design any hug patterns

14. Choose the manikin that can present what you feel now. The manikin representations are to express values of Valence (top), Arousal (mid), and Dominance (bottom).



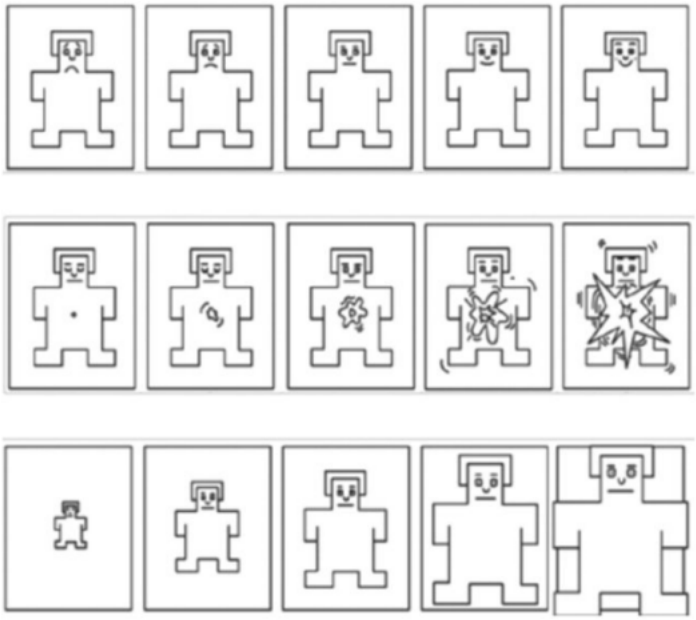
Tick all that apply.

1 2 3 4 5

Valence

Sender report emotions during designing

15. After designing the happy scenario, choose the manikin that can present what you feel now. The manikin representations to express values of Valence (top), Arousal (mid), and Dominance (bottom).



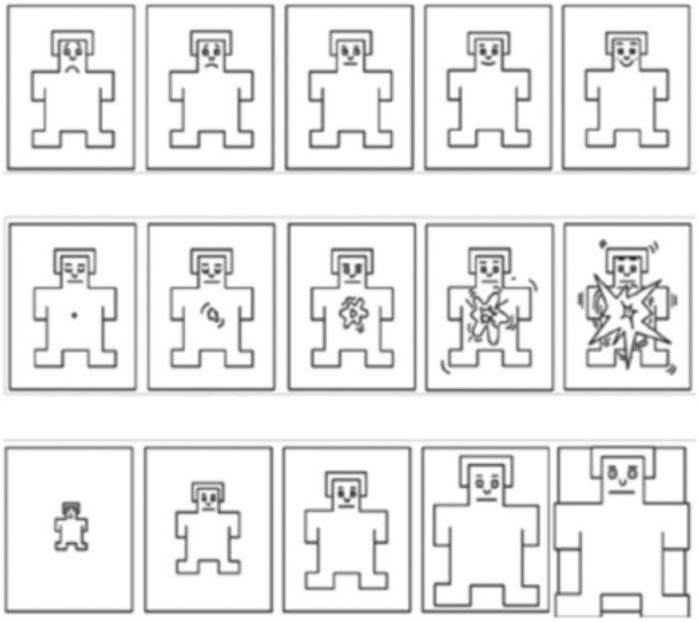
Tick all that apply.

1 2 3 4 5

Valence

Valence Valence	☐	☐	☐	☐	☐
Arousal Arousal	☐	☐	☐	☐	☐
Dominance Dominance	☐	☐	☐	☐	☐

16. After designing the comforting scenario, choose the manikin that can present what you feel now. The manikin representations to express values of Valence (top), Arousal (mid), and Dominance (bottom).



Tick all that apply.

1 2 3 4 5

Valence

Summary

Giving feedback about the experiment

17. Do you have any thoughts, remarks or ideas about the experiment?

The end

Thank for for participating, you can get the compensation from the researcher. Have a nice day!

Appendix C- Survey questionnaire experiment 3

Survey questions-experiments of validating hug patterns

You are invited to participate in a research study. The goal of this research study aims to collect and evaluate hug patterns in deliver emotions during mediated social interaction. This study is being conducted by Yizhen Jia (Joyce). The study was approved by the Ethics Committee Information and Computer Science under number 230201 if you want to discuss the study with an independent individual please email (ethics-create-itech@utwente.nl) You need to be more than 18 years old. When you complete the experiment, you will receive 5 euro as compensation. Thank you for joining!

* Indicates required question

1. I have read the information letter and gave the consent to the researcher to process the date I provide. *

Mark only one oval.

- ◯ No
- ◯ Yes
- ◯ Other: _____

2. My sex is

Mark only one oval.

- ◯ Female
- ◯ Male
- ◯ I prefer not to say

3. My gender is

4. My age is

5. My unique id number is *

Background information

6. 1. Do you consider yourself a social person?

Mark only one oval.

strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6 ◯

7 ◯

strongly disagree

7. 2. I can feel others' emotions during social interaction

Mark only one oval.

strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

strongly disagree

8. 3. Others can feel my emotions during social interaction

Mark only one oval.

1
2
3
4
5
6
7

9. 4. I consider myself to be a "touchy" person ("touchy" person means I think touch is a good way to express, transform, empathize and evoke emotions during social interactions with others, and considering both giving and receiving touches)

Mark only one oval.

strongly agree

1
2
3
4
5
6
7

strongly disagree

10. 5. When interact with people, I often use touch to make them feel my emotions

Mark only one oval.

strongly agree

1
2
3
4
5
6
7

strongly disagree

11. 6. I feel more comfortable initiating touch than most

Mark only one oval.

strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6 ◯

7 ◯

strongly disagree

12. 7. I do not mind if someone touches my shoulders and back

Mark only one oval.

strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6 ◯

7 ◯

strongly disagree

13. 8. During interaction with others, I don't mind if people touch me

Mark only one oval.

strongly agree

1 ◯

2 ◯

3 ◯

4 ◯

5 ◯

6 ◯

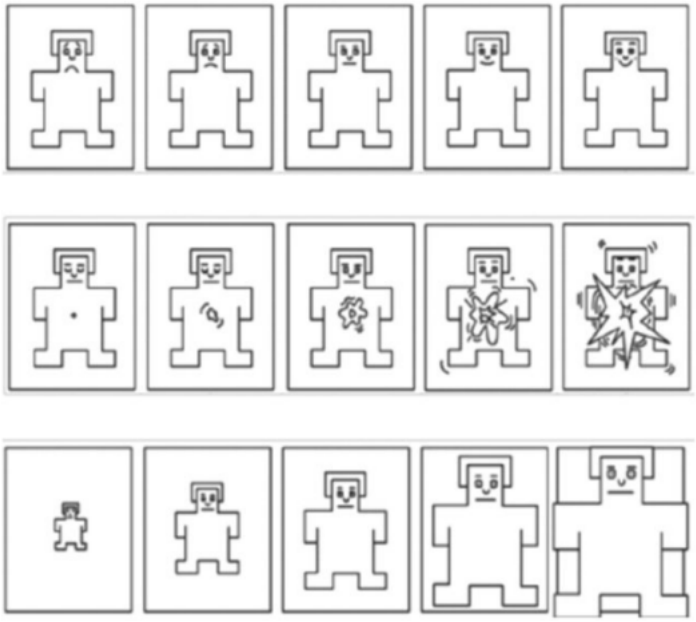
7 ◯

strongly disagree

The Self-Assessment Manikin (SAM). SAM scale used in the experiment to capture participants' emotional reactions on three dimensions: (from the top row to the bottom row) the manikin representations to express values of Valence (top), Arousal (mid), and Dominance (bottom).

This session needs to be filled before you receive any hug patterns

14. Choose the manikin that can present what you feel now. The manikin representations to express values of Valence (top), Arousal (mid), and Dominance (bottom).



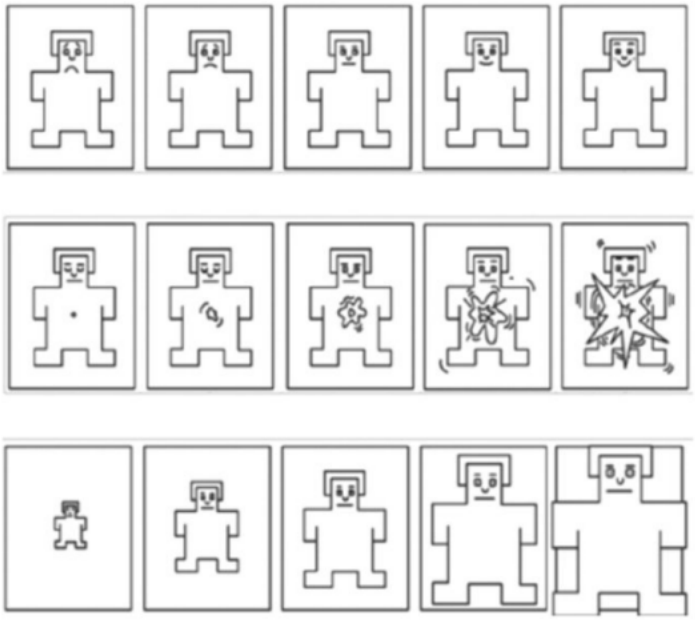
Tick all that apply.

1 2 3 4 5

Valence

Receiver evaluate different patterns 1

15. After receive pattern 1-1 Choose the manikin that can present what you feel now. The manikin representations to express values of Valence (top), Arousal (mid), and Dominance (bottom).



Tick all that apply.

1 2 3 4 5

Valence

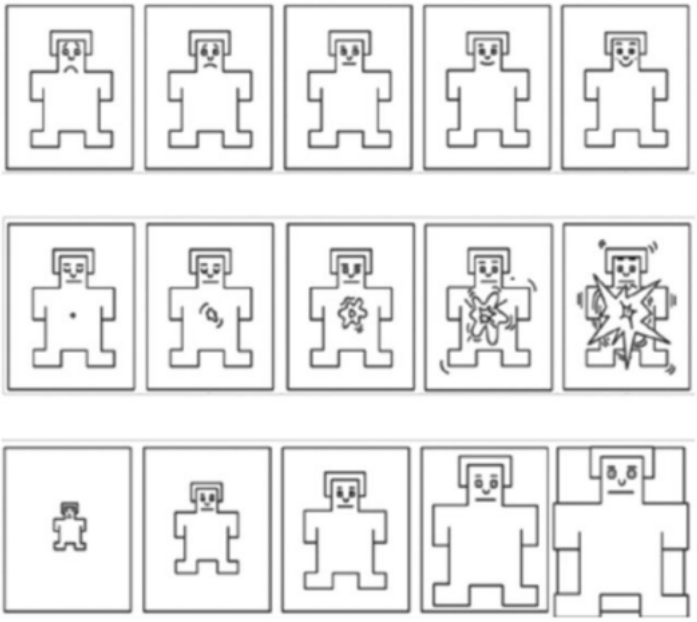
Valence	☐	☐	☐	☐	☐
Arousal	☐	☐	☐	☐	☐
Dominance	☐	☐	☐	☐	☐

16. After receive pattern 1-1, I perceive the pattern expressed

Mark only one oval.

- ◯ Happiness
- ◯ Comforting
- ◯ I don't feel any of these

17. After receive pattern 1-2 Choose the manikin that can present what you feel now. The manikin representations to express values of Valence (top), Arousal (mid), and Dominance (bottom).



Tick all that apply.

	1	2	3	4	5
Valence					

Valence					
Arousal					
Dominance					

18. After receive pattern 1-2, I perceive the pattern expressed

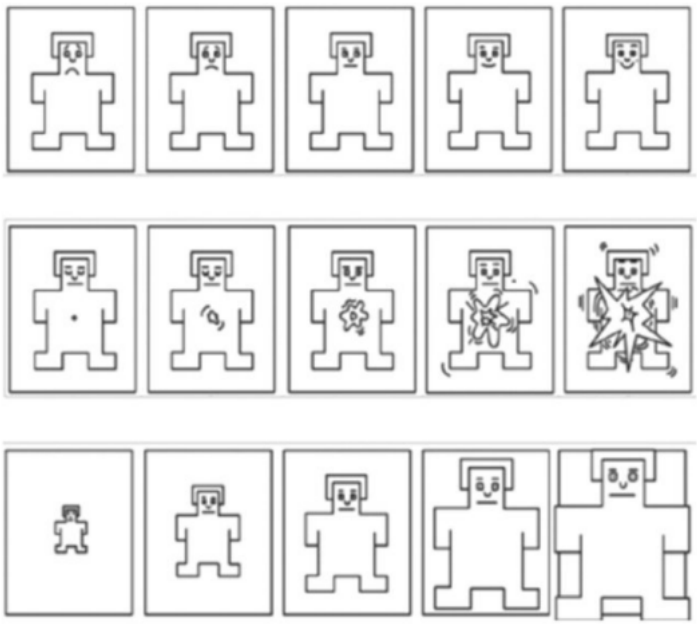
Mark only one oval.

- Happiness
- Comforting
- I don't feel any of these

Receiver evaluate different patterns 2

Repeat the multiple choice questions until pattern 10-2 as below:

53. After receive pattern 10-2 Choose the manikin that can present what you feel now. The manikin representations to express values of Valence (top), Arousal (mid), and Dominance (bottom).



Tick all that apply.

1 2 3 4 5

Valence

Valence					
Arousal					
Dominance					

54. After receive pattern 10-2, I perceive the pattern expressed

Mark only one oval.

- Happiness
- Comforting
- I don't feel any of these

Summary

Giving feedback about the experiment

55. Do you have any thoughts, remarks or ideas about the experiment?

The end

Thank for for participating, you can get the compensation from the researcher. Have a nice day!