REMOTE SOCIAL TOUCH: A FRAMEWORK TO COMMUNICATE PHYSICAL INTERACTION ACROSS LONG DISTANCES

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ABSTRACT

REMOTE SOCIAL TOUCH: A FRAMEWORK TO COMMUNICATE PHYSICAL INTERACTION ACROSS LONG DISTANCES

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In this day and age, there is a large group of people who have to live away from their loved ones due to various reasons such as work, study, or certain health-related concerns (e.g. infection diseases). Living away from their loved ones, certain negative emotions (e.g. stress, depression, and loneliness) may develop due to the loss of physical, mental, and emotional awareness about each other. From the various ways available that could enhance awareness and presence while communicating with a loved one, remote social touch (RST) is the main focus of this research. RST focuses on stimulating the sense of touch remotely. This is because social touch is very important in for human wellbeing and the absence of it could lead to the development of stress and jeopardize the development of relationships. The research is aiming to identify various dimensions of RST and to identify the process of communicating social touch remotely through a product. The results of this research are put in an early proposed remote social touch framework that consists of three elements and their dimensions, all together explain the process of RST communications through a product.

Keywords: Remote Social Touch, Haptics, Social Touch, Emotional Wellbeing

ÖZ

UZAKTAN SOSYAL TEMAS: UZUN MESAFELER ARASINDA FİZİKSEL ETKİLEŞİMİ İLETEBİLMEK İÇİN BİR ÇERÇEVE

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Çağımızda, okuma, çalışma veya sağlığa yönelik endişeler (örn. enfeksiyon hastalıkları) nedeniyle sevdiklerinden uzakta yaşamak zorunda kalan büyük bir insan grubu bulunmakta. Sevdiklerinden uzakta yaşamak, bazı olumsuz duygular (örn. stres, depresyon ve yalnızlık) ve insanların birbirlerine karşı fiziksel, zihinsel ve duygusal farkındalık kaybına dönüşebilir. Sevilen bir kişi ile iletişim kurarken farkındalığı ve bunun hissedilebilirliğini arttırabilecek çeşitli yollar olabilir, bunlardan 'uzak sosyal dokunuş' (USD) bu araştırmanın ana odak noktasını oluşturmaktadır. USD dokunma duyusunun 'uzaktan' uyarılmasına odaklanmaktadır. Bunun nedeni, sosyal dokunuşun insan sağlığı açısından çok önemli olması ve eksikliğinde stresin gelişmesine yol açması ve ilişkilerin gelişimini tehlikeye atmasıdır. Araştırma, USD'nin çeşitli boyutlarını belirlemeyi ve bir ürün aracılığıyla sosyal dokunma ile iletişim sürecini uzaktan tanımlamayı hedeflemektedir. Bu araştırmanın sonuçları, üç ana öğeden oluşan uzaktan sosyal dokunma çerçevesinde sunulmuştur, öğeler bir araya geldiklerinde bir ürün aracılığıyla USD ile iletişim sürecini açığa kavuşturmaktadır.

Anahtar Kelimeler: Uzaktan Sosyal Temas, Dokunsal, Sosyal Temas, Duygusal İyi-oluş

To my parents

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LIST OF ABBREVIATIONS

ABBREVIATIONS

AI:	Artificial Intelligence
EWB:	Emotional Wellbeing
F2F:	Face-to-Face
HCI:	Human Computer Interaction
NVBP:	Non-Vulnerable Body Parts
PI/PIs:	Physical Interaction(s)
PAM:	Pick-A-Mood
RST:	Remote Social Touch
ST:	Social Touch
SWB:	Subjective Wellbeing
TAM:	Technology Acceptance Model
VBP:	Vulnerable Body Parts

CHAPTER 1

INTRODUCTION

1.1 Introduction

The motivation behind the PhD research is the observation of the ill mental states that people may have such as depression, sadness, or anxiety due to living separately from their loved ones for a long period of time. There are in fact a large group of people, who have to live away from their loved ones due to, for example, work, study, or certain health-related problems such as illness or infection diseases (e.g. COVID-19 which became a pandemic during this PhD research). As individuals living away from their loved ones, certain negative emotions may develop due to: i) the separation triggering the lack of physical, mental, and emotional awareness of the other person, ii) poor evaluation of an event because of misinterpretation, or iii) certain resources not accessible to better interpret the event. Another factor that paves the way for negative emotions (e.g. stress, depression, and anxiety) is the absence of face-to-face (F2F) experiences (e.g. sharing activities, seeking social support). Additionally, the current communication media are not rich enough to give the presence feeling about the loved ones living away. Thus, from time-to-time people fall under an episode of depression, stress, or just a negative mood overall. This catalyst the PhD research to find ways that design can help reducing or relieving the level of ill mental states for people living remotely away from their loved ones.

In literature related to design and human-computer interaction, efforts can be found that have investigated various ways to create an emotion-link to regain the awareness missing between the individuals. Researchers looked at making certain information

possible to be communicated to cause an emotional change (Affective/Affect[1] communication) such as:

- Communicating physiological data, for example, sending one's breathing pattern to another person's wrist using "WearBREATH" by Min and Nam (2014, p. 7)
- Presence awareness, for example, displaying a loved one breathing pattern on an inflatable frame by J. Kim et al. (2015)
- Remote social touch, for example, sending a hug from one person to another such as "Huggy Pajama" by Teh et al. (2008).

This is because being social increases positive affect (Fredrickson, 2008), increase well-being (Ryff & Singer, 2000); and seeking social support from loved ones can impact one's physical and mental wellbeing (Goldsmith, 2004). Additionally, based on the "broaden-and-build" theory providing positive emotion not only makes one feels good at that moment, but when accumulated, may also lead to upward spirals enhancing emotional wellbeing and increase the odds to feel good in the future. It would also help as a coping mechanism for future events (Fredrickson & Joiner, 2002), and would will help decreasing the lingering negative emotions and fuel psychological resiliency (Fredrickson, 2001).

This research focuses on a sense that is underutilized in current communication media: "the sense of touch" (i.e. physically touching or being touched by someone or something). It also focusses on the action of physically touching among individuals which is the definition of "social touch". Social touch is very important in human development and it is a human need (Tiffany Field, 2014). Touch is important for emotional development for infants, adults, and it positively influences the elderly's wellbeing (Bush, 2001). Touch communicates intimate emotion easier

[1] To clarify the term "Affective/Affect", the author define it as Gohm and Clore (2000) describe it: which is general category that includes value (bad or good), preferences, emotions or moods.

than other verbal communication (Register & Henley, 1992). The absence of social touch among loved ones may contribute to the developing of stress and impact the health (Cocksedge et al., 2013; Ditzen et al., 2007), and jeopardize the development of the relationships (Jewitt et al., 2020).

Being away reduces social touch experience and replaces it with verbal and/or visual communication, which leads to an accumulation of negative affect that results in the aforementioned distress. Utilizing the touch sense digitally for the application of social touch is what identify as Remote Social Touch (RST). Allowing the transmitting of physical touch such as a hug among separately loved ones can help in reducing negative moods (Wang & Quek, 2010). Moreover, enabling physical touch while using current communication media can encourage more interaction and improve social connectedness (Chang et al., 2002; Park et al., 2013). Enabling social touch remotely among separately loved ones can impact emotional wellbeing positively, increases social awareness, and help with communicating discrete emotions such as love or valance emotions such as positively arouse emotions (Eid & Al Osman, 2016; Huisman, 2017). Thus, transmitting social touch among individual remotely through digital means is the main focus of this PhD research.

1.2 Research Opportunity

Building on the literature that social touch can impact emotional wellbeing, this research aims to focus on the application of remote social touch (RST) and the process of transmitting physical touch among remotely living individuals for its connectedness value. However, this research is not focusing on the study of the impact that RST has on the individuals' emotional wellbeing. The argument is that RST influences emotional wellbeing positively when providing positive emotion (Chapter 2 will discuss this further). Missing social touch can result in accumulating negative affect, which can then result in developing depression by empowering these negative feelings. On the other hand, positive emotions not only make one feels good at that moment, but also its accumulation leads to enhancing emotional wellbeing

and increases the odds to feel good in the future (Fredrickson & Joiner, 2002). Accordingly, Figure 1.1 illustrates the process for the problem formulation for PhD research.

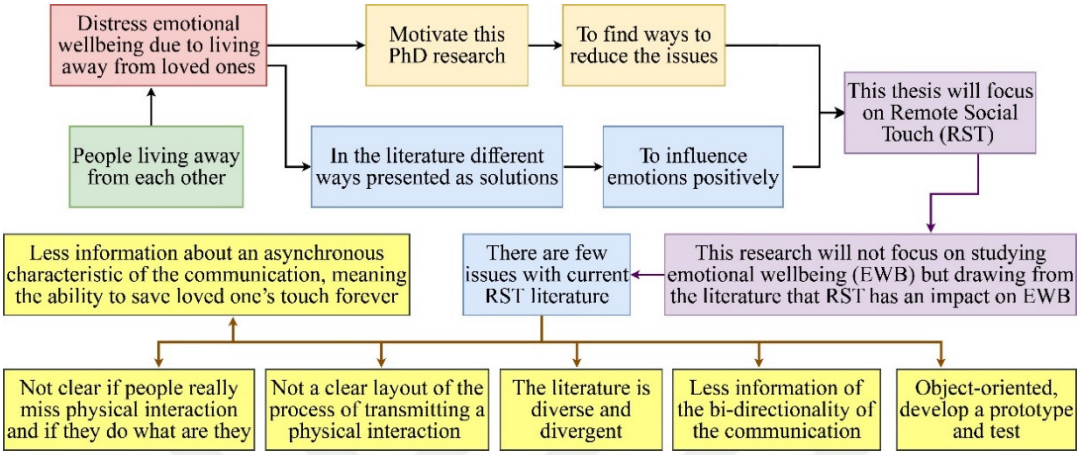


Figure 1.1. Problem formulation within the PhD research

Due to the importance of social touch, there is vast amount of research on delivering the social touch remotely, however, design for and research in remote social touch (RST) is a very complex endeavor. The main problem with RST literature is that it is divergent and diverse, it includes many directions in various fields one needs to look into to have a basic understanding of the many considerations impacting RST. Therefore, a designer or a design researcher may get lost in all the technical issues related to technology, communication, and psychology. This issue made the researcher deviate the research from studying the emotional impact of something ready which is RST, to first put forward a clear understanding of RST and easy path one can take to design or research RST in other fields including design.

Moreover, after surveying RST literature following issues also stood out.

1. Whether people do miss physical interactions (PIs), and if they do, then what kinds of PIs (e.g. hug, kiss, etc.).

2. There was not a clear layout of the process of transmitting a physical interaction (translating PIs from the human to the machine and back to the human).

3. The typical RST research is done with a predefined prototype and physical interaction, or making a prototype then finding what gesture can be applied on it to transmit it to the loved ones, such utilization of prototype and predefined scenario to research with could limit the research findings and the imagination of the participants of the research.

4. The common theme for RST research is that a person(s) trying to send something to another person(s) in one direction without looking into the communication as bidirectional as a typical face-to-face communication.

5. RST has the ability to offer asynchronous communication, which means a social touch can be saved, however the literature lacks information about such a feature.

From all these issues, RST literature leaves an underexplored area unnoticeable by RST researchers and designers concerning physical interactions, and various RST characteristics. This research aims to explore some of these issues by focusing on RST as a cycle communication (i.e. bi-directional) that is able to send messages that stimulate the touch sense synchronously and asynchronously. Moreover, the issues are going to be explored without the limitation of predefined prototypes or scenarios to allow previously unnoticed information to surface.

1.3 Aims of the Research and Research Questions

This PhD research aims to investigate ways to communicate social touch physical interaction remotely through a product. Additionally, it is important to understand the process for such communication, thus this research aims to put forth a scheme of the communication process of remote social touch. The research is going to take into consideration various aspect that impact such a concept and the target user group. In this direction, this PhD research aims to find answers to the following questions:

- How can a product facilitate delivering 'social touch' between people who are geographically apart?
    - What is the importance of social touch? and What are the most missed physical interactions while living-away from loved ones?
    - How can these interactions be substituted with a technological product?
        - What are the characteristics of the technologies that enable communicating physical interactions between individuals?
        - What are the characteristics of a product to facilitate Remote Social Touch?
            - How would the user interact with the product?
            - Where the wearable product should be located on the body?

1.4 Scope of the Research

Many fields contribute to literature related to remote social touch (RST), such as psychology, human-computer interaction, product design, and interpersonal communication. The present research covers literature focusing on social touch, mediated social touch, remote social touch, the touch sense, interpersonal communication, affective awareness, and emotional wellbeing (Figure 1.2). However, following aspects are outside the scope of this research and therefore, will not be discussed in detail: the psychology of touch, anatomy of touch, physiology related to the touch sense, and the technical detail and engineering of stimulating the touch sense remotely. The research also looks into how people imagine new ways of communicating the RST in future.

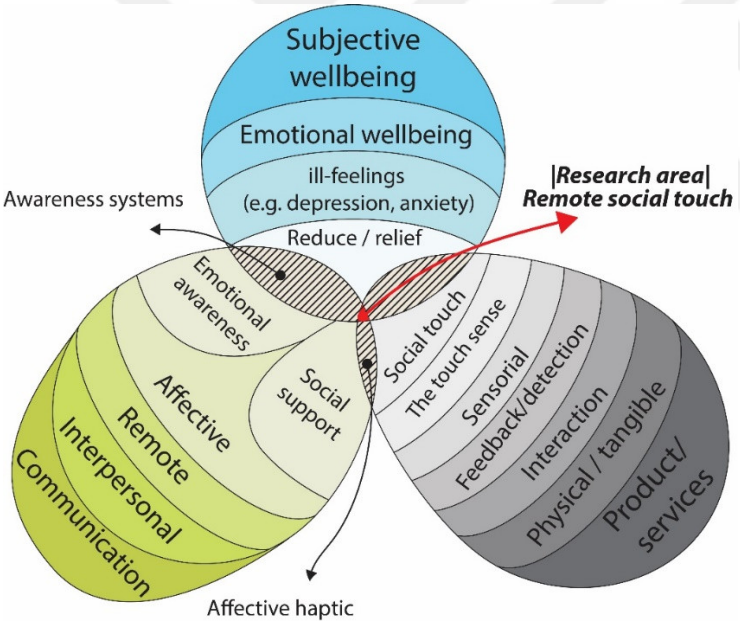


Figure 1.2. Scope of the research identified from the relevant literature

Initially, the direction of this research was a similar approach to the common direction with RST research which is to build a prototype then test/study the phenomenon. The idea behind this approach is to study the impact that RST has on emotional wellbeing. However, as the researcher gathered information related to

RST it became more apparent that there are few shortcomings in literature first needed to be attained before exploring a phenomenon based on a prototype.

Following points are also relevant to highlight for the scope of the PhD research.

- In this research, the human body is not going to be investigated as an instrument for delivering and feeling the social touch, instead, an artefact "an object" is going to be investigated as the instrument for receiving/delivering social touch remotely.

- New communication technologies offer a new ways for social relations and cultures to develop and shape, and the technologies are shaped and developed by how the societies use them (Jewitt et al., 2020). However, this research is not going to focus on the sociology of RST, and the impact of RST on cultures.

- The cultural dimension of social touch among individuals is also not the focus of this research. This PhD research acknowledges the fact that cultures can plays a big role in physical interaction (e.g. whether physical interaction is more acceptable in one culture than another during communication), but the acceptance (levels) of touch, and the kinds of touch-based on a certain culture is outside the scope of this research.

- Social touch in face-to-face communication incorporates verbal and non-verbal interaction with the touch, and social touch is a multisensorial experience, however, this research is not going to discuss in detail the multisensorial side of social touch and how it will be replicated in remote social touch. Acknowledging the other sensory modalities, this research is going to focus on the touch sense in relation to social touch.

- Social touch in face-to-face interaction is a spatial experience, individuals experiencing each other's body at the same time at the same location, however, this research focuses on remote social touch as a way to increase the sense of connectedness among geography separated individuals instead of spatially replicate the existence of a person in a different location.

- There are various ways to stimulate the touch sense remotely. In this research as a way to explore the concept of remote social touch, it focuses on how to translate the social touch (e.g. a hug) remotely through certain technology to stimulate the touch sense instead of abstractly stimulate the touch sense and letting the person feeling the stimuli interpreted the meaning.

- This research specifically focuses on 'intimate' social touch, a social touch that is engaged within a close relationship circle, such as family and friends.

- This research investigates the concept and the process of RST, however, the end motivation is to assist the research and design activities for RST. In RST, to send or to receive social touch messages individuals can interact with a physical artefact or with a digital application beyond a physical property. In both cases, a designer can be responsible to bring the artefact to life. This research is going to explore the product characteristics of RST artefacts.

1.5 Research Audience

The research outcomes are targeted towards two main groups. This first group is the researchers in any field interested in remote social touch (RST) as a research topic either as a whole or partially looking into one characteristic of RST. This research paves the way to expose many available dimensions of RST that is lacking in the literature. This research is going to shed light on future research directions researchers can explore. The second group is designers in the field of product industrial design, human-computer interaction design and other fields focusing on designing RST products. This research will allow them to understand the concept and the process of remote social touch (RST) communication and its various considerations that impacting RST design

1.6 Structure of the Thesis

This thesis is comprising of six chapters. Chapter 1 is the introduction to the research including, research opportunity, aim, and questions. Chapter 2 is the literature review sections including an introduction to various areas related to remote social touch, presenting previous works in this area. Chapter 3 is the methodology that explains the process for fieldwork and the initial formulation of a remote social touch framework. Chapter 4 is the result and analysis of the fieldwork. Chapter 5 present the early proposed remote social touch framework. Chapter 6 is the concluding chapter that includes answers to the research questions contributions, research limitations, and future research areas. Figure 1.3 explains the content of each chapter and the related research questions they are directed at.

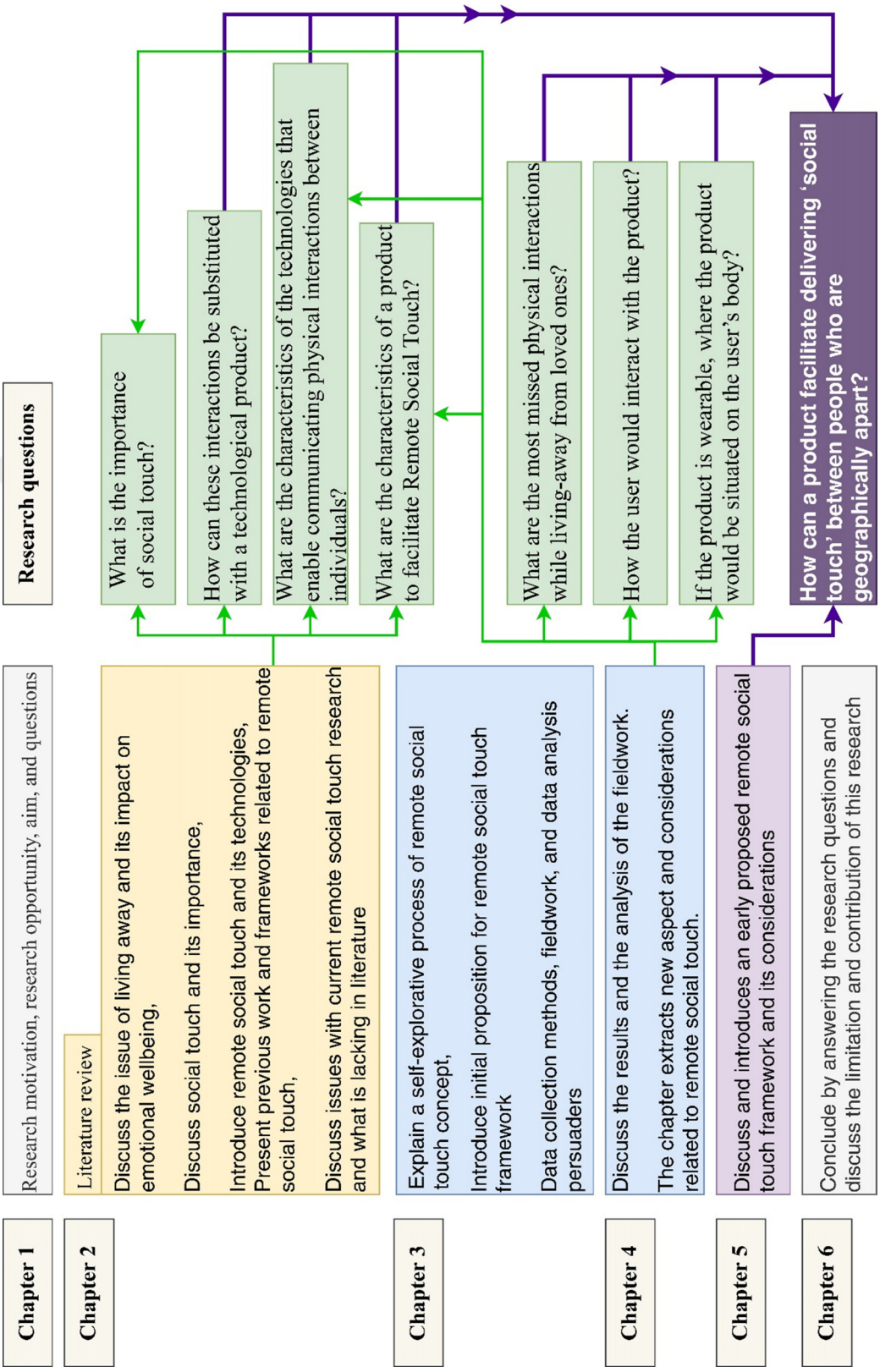


Figure 1.3. Structure of the thesis

CHAPTER 2

BEING AWAY AND TOUCH

2.1 Living Away from Loved Ones

2.1.1 Issues Related to Living Away from Loved Ones

Especially nowadays more individuals have been living away from their loved ones. For example, loved ones need to live away from each other for the purpose of work or study, or due to certain health-related problems such as illness or infection diseases such as COVID-19 which became a pandemic during this PhD research. In such a pandemic, where touch avoidance is enforced as a measure to reduce spreading the disease, can result in touch deprivation which impacted mood states negatively, and resulted in sleep disturbances and posttraumatic stress symptoms (Tiffany Field et al., 2020). Individuals who live in such situations can develop ill-emotional feelings such as stress and depression. This is because certain experiences will be missed out such as carrying out through a certain activity together (e.g. drinking tea sitting around the same table), the awareness about each other's wellbeing (this can happen by understanding verbal or nonverbal cues including touch, facial expressions, or face-to-face 'F2F' interaction), or physical interaction (e.g. shaking hand, hug or tap on the shoulder).

For instance, students studying away from their loved ones such as family or friends. Being away from loved ones and getting disconnected geographically could impose a higher chance of depression through the feeling of loneliness, and socially disconnecting from their usual social environment, especially for fresher students (Rich & Scovel, 1987). A study completed in the United States shows that many factors can affect the wellbeing of international students, such as homesickness,

isolation, and loneliness which lead to distress and depression, and some students feel hesitant to seek assistance even while experiencing mental health issues (Mclachlan & Justice, 2009). Depression seeps into college students through loneliness and the feeling of isolation (Rich & Scovel, 1987). Accumulated depression could lead to downward spirals of negative emotions (Fredrickson & Joiner, 2002). Other factors could lead to loneliness such as losing the sense of belongingness, lack of social support, and not being able to emotional self-disclosure which have negative effects on mental and physical health, and social life (Wei et al., 2005). Homesickness and home attachment could also lead to depression, anxiety, and withdrawal from activities such as school. These can be prevented by allowing enough time to adapt to being 'away-from-home' and maintain communication with home through the available communication media (Thurber & Walton, 2012).

Additionally, being away from loved ones can induce stress especially to the individuals lacking self-esteem and emotional support that has a higher chance to have a negative effect on the mood and health (DeLongis et al., 1988). Suppressing stressful situations can result in depression and anxiety which can also affect wellbeing (Gross & John, 2003) and result in unhappiness (Cacioppo et al., 2008). Not being able to access social support from loved ones while ill can impact one's physical and mental wellbeing, the recovery of illness, and coping with the situation (Goldsmith, 2004).

Nevertheless, seeking social support can impact health and wellbeing positively by reducing the negative effects (Duggan, 2006). Communication with family (and/or loved ones) does not only support people socially but also increases the positive effect generally by being socially active or by just being social (Fredrickson, 2008). Moreover, feeling connected to others and feeling cared reinforce positive feelings and can help in recovery from a depressed mood (Fredrickson, 2000). This is to show that having a connection that allows social support, emotional discloser or just to

stay aware and in touch (literally and figuratively) with loved ones while being away could reduce the chances of loneliness, depression, mental and physical distress.

2.1.2 Emotional Wellbeing (EWB)

Even though this research will not focus on studying the emotional wellbeing of individuals, yet since the issue is directly having an impact on the emotional wellbeing of individuals, it important to offer some background to know possible directions to take. As described earlier "being away" has impacts on mental health and wellbeing of oneself. The way we live a day and interact with our surrounding environment can be influenced by our state of mind. Similarly, feelings, emotions, and moods can influence our state of mind, and these are related to our subjective wellbeing (SWB).

Subjective wellbeing is defined as "a person's cognitive and affective evaluations of his or her life" (Deiner et al., 2002, p. 63). Other factors such as the emotional reaction to events and positive or negative emotional experiences can also have an impact on our SWB (Diener, 2009). Subjective wellbeing can be divided into four main components: pleasant emotions, unpleasant emotions, global life satisfaction, and domain satisfaction. Each of these components can be subdivided, which can be used to gain additional information about one's SWB (see Figure 2.1).

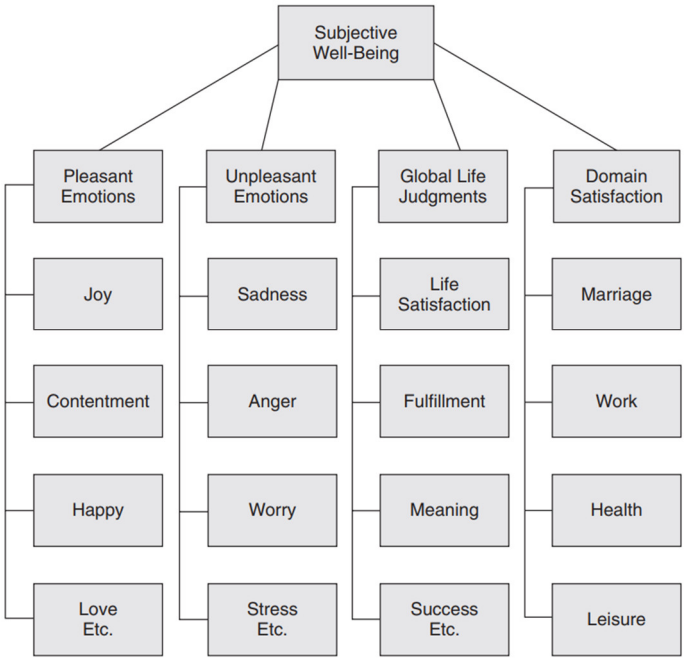


Figure 2.1. A hierarchical model of happiness, by Diener et al. (2009, p. 71)

Larsen and Prizmic (2008) identify emotional wellbeing (EWB) as a ratio between positive affect and negative affect over time. This means, increasing positive affect over time helps positively with EWB, and increasing negative affect over time impacts negatively with EWB. Positive affect is associated with arousal and pleasant and negative affect is associated with arousal and unpleasantness (Diener et al., 2009).

Feelings, emotions, and moods are usually mentioned together with emotional wellbeing. However, an "emotion" is a reaction to an event or stimuli; and a "mood" is a diffuse feeling that may not be connected to an event but it can correlate to emotion and last longer (Diener et al., 2009). Hacker (2004) divides feelings that are not bodily feelings such as pain or hunger into emotions, agitations, and moods which they called affections (Figure 2.2). Emotions such as love, hate, fear, etc., agitations things fall under short term states such as being excited, shocked, etc., and moods are short- or long-term state of mind such as depression. Moods are tied more with emotions than objects, one may feel depressed without being directed toward

an object but one may feel love toward someone or something. Moods are linked to manners of behavior rather than international actions (Hacker, 2004).

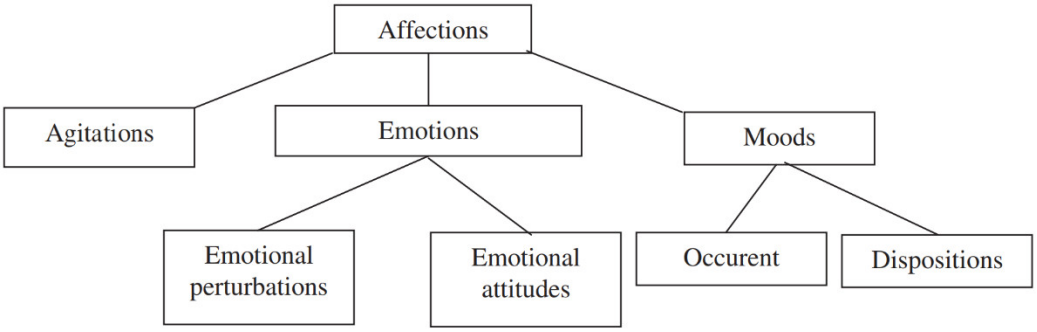


Figure 2.2. Types of affection, by Hacker (2004, p. 201)

One of the ways to evaluate emotions is the dimensional approach. In this approach, emotions, and moods interrelated both between the individual and the same individual over time. For example, if someone is experiencing a high level of depression also will experience other negative emotions such as anxiety. Usually, in SWB research the dimensional approach is in focus due to the fact over time certain emotions of the same valence are often correlated. Additionally, positive and negative effects are correlated and may or may not happen at the same time however one could experience a high level of positive emotion and a high level of negative emotion over time (Diener et al., 2009). Based on the broaden-and-build theory providing positive emotion not only make one feels good at the moment but it is accumulated which lead to upward spirals enhancing emotional wellbeing and increase the odds to feel good in the future, also it will help with a coping mechanism for future events (Fredrickson & Joiner, 2002). Additionally, it will help to decrease lingering negative emotions and fuel psychological resiliency (Fredrickson, 2001).

Another aspect of emotions that can impact wellbeing is the intensity and frequency, however, frequency has more impact than intensity (Diener et al., 2009). The frequency a person experiences pleasant emotions is associated with judgments of happiness (Lucas et al., 2009). Diener et al. (2009) describe the temporal sequence and stages of emotions through his model (Figure 2.3). The model explains each

stage of emotion and what happens to it through time. When an event occurs, it has less chance to influence global wellbeing unless it is translated to other stages. Events have more chance to influence online emotional reactions such as daily events (e.g. social interaction), which influence daily mood. The impact of such events will depend on people's attention, perception, and interpretation "appraisals". The impact can cause an emotional reaction which can appear through physiological, behavioral, verbal, or nonverbal reaction. These online emotional reactions get encoded in memory through emotional information, rumination, and reminiscing. This will impact the degree of recalling the emotional reaction of an event. At this point, memory influence the global judgment of SWB and a behavior choice toward an event (Diener et al., 2009).

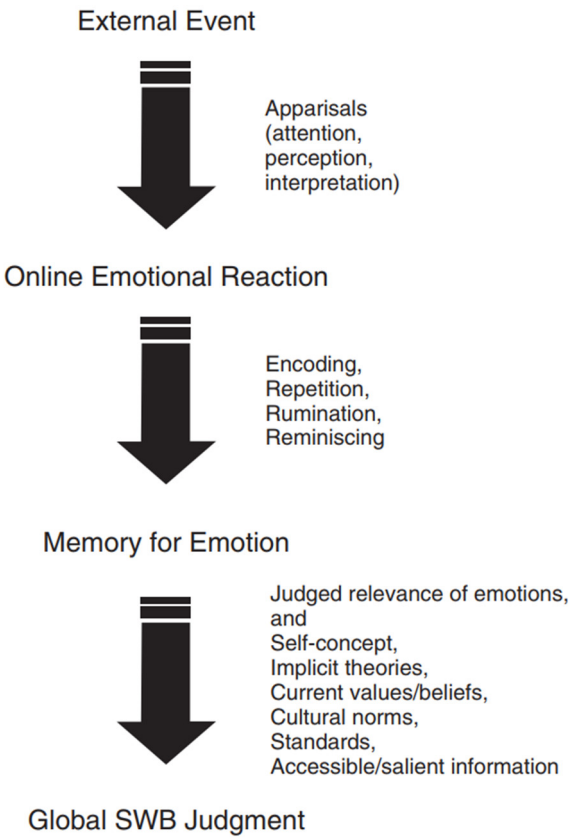


Figure 2.3. A temporal stage model of subjective well-being, by Diener et al. (2009, p. 80)

2.1.3 Ways to Support Emotional Wellbeing While Living Away

To cope with certain bad feelings (e.g. negative mood), one would seek face-to-face (F2F) social comfort from close individuals (e.g. loved ones, family members). When living away from loved ones such comfort may not be accessible, which may impact one's feelings, emotions, and mood. For this reason, professionals like product/industrial designers, engineers, as well as researchers in relevant areas have been investigating ways to facilitate communication for individuals who live away from their loved ones. They proposed design suggestions or research output that are focusing on enhancing interpersonal communication which is being affected by living away from a loved one, such as Huggy Pajama by Teh et al. (2008) (Figure 2.4), which is made to explore the parent-child relationship through a hug communication over distance.

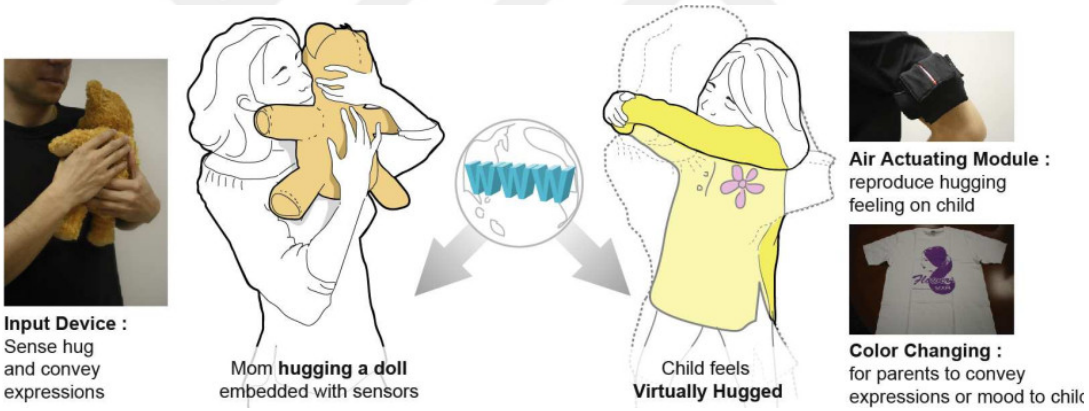


Figure 2.4. "Huggy Pajama" by Teh et al. (2008, p. 251)

Researchers in the areas of human commuter interaction and product design explored possibilities to bring back some of the F2F communication characteristics to the way individuals interact remotely. F2F interaction usually includes certain characteristics such as observing body language, observing facial expressions, speaking and listening, surrounded by a similar environment, and physiological arousal (Kock, 2005). For example, F2F communication is multi-sensorial in nature, thus researchers explored ways to provide multi-sensorial communication experience, such as "The Bed" (Figure 2.5) which allows bi-directional communication at the

same time with the feeling of presence through visual, touch, and temperature (Dodge, 1997).

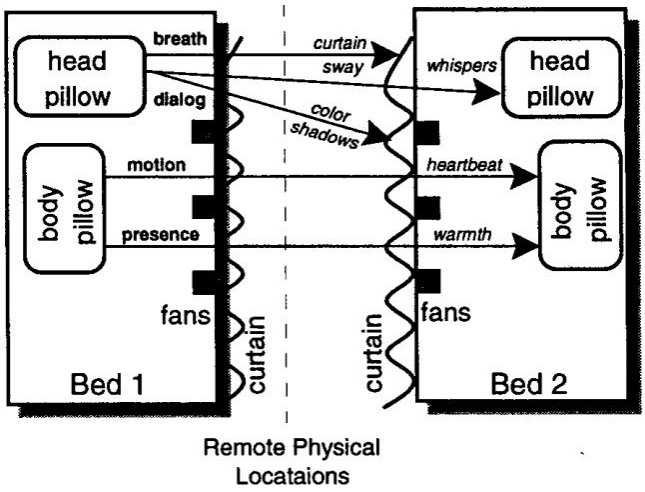


Figure 2.5. "The Bed" by (Dodge, 1997)

Moreover, researchers explored mediated nonverbal cues similar to F2F interaction such as allowing the exchange of stroking gestures over distance (Eichhorn et al., 2008) (Figure 2.6). Nonverbal cues can include touch, facial expression, voice, space, time, and the use of objects. The lack of nonverbal cues could result in confusion and disorder over the conversation (Rhoads, 2010). Nonverbal cues help individuals to understand the intended emotional message from the interaction better and form emotions and attitudes toward the people involved (App et al., 2011).

Figure 2.6. Stroking device by (Eichhorn et al., 2008)

Part of F2F commination is to feel the presence of the other person, literature in presence awareness is an example of this. For example, J. Kim et al. (2015) visually present the breathing action of the other person on a digital photo frame to raise awareness of the other remote person (Figure 2.7). Finally, an important part of F2F interaction is touch, people touching each other in various ways while meeting and talking (i.e., social touch). This is missing while being away from loved ones, thus some literature studied ways to bring touch back through something called remote social touch (e.g. sending a hug, such as Huggy Pajama by Teh et al. (2008)), which is going to be this research the main focus.

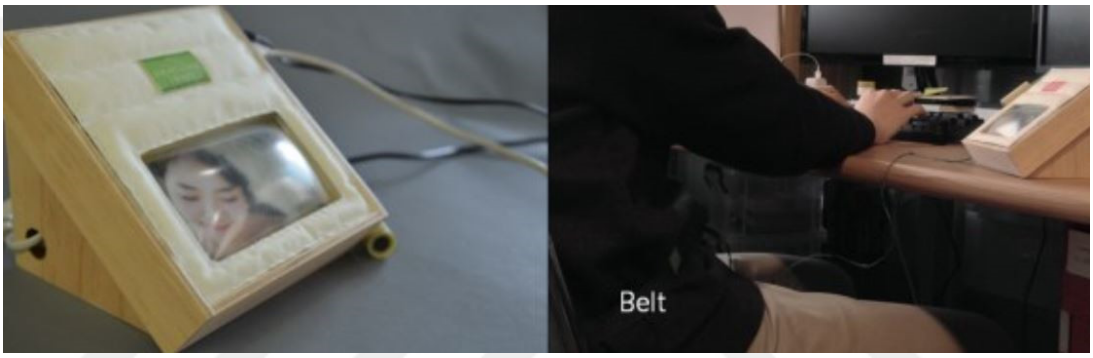


Figure 2.7. "BreathingFrame" by J. Kim et al. (2015)

All these can fall under the term "Affective/Affect[2] communication", that is communication not for directly mimicking F2F interactions, but for encouraging basic emotion exchange (e.g. happy, angry, etc) and/or arousing abstract emotion between the individuals involved in the communication (Broekens, 2010). For example, a wearable system concept 'WearBREATH' by Min and Nam (2014) meant to deliver one's breathing pattern to another user's wrist through the touch sense to support affective connectedness (Figure 2.8a). 'LumiTouch' by Chang et al. (2001) is another research output concept for Affective communication, one's picture frame light up when another frame is touched by another person (Figure

[2] To clarify the term "Affective/Affect", the author define it as Gohm and Clore (2000) describe it: which is general category that includes value (bad or good), preferences, emotions or moods.

2.8b). The common approach for most of these studies is to influence daily mood and thus help increase the positive impact on EWB. Most of these studies explored ways to exchange or alter the basic emotions (e.g. happiness, anger, etc.) or simply influence abstract feelings or emotions (e.g. sharing empty moments[3] by Lottridge et al. (2009)).

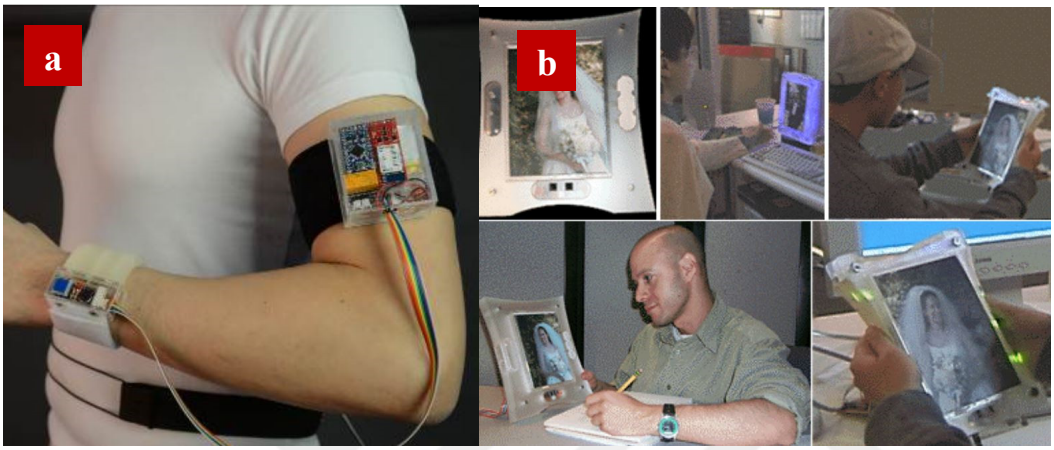


Figure 2.8. 'WearBREATH' by Min and Nam (2014), and b. 'LumiTouch' by Chang et al. (2001)

The present research will focus on one of the ways that can have an impact on the emotional wellbeing, that is "Remote Social Touch (RST)". Since the touch sense plays a primary role in RST, the next section is going to discuss the touch sense, social touch, and its importance. Then afterward a detailed explanation of RST and haptic technologies.

[3] Lottridge et al. (2009) define empty moment as: is the need to feel one's presence when not available for communicating.

2.2 Social Touch (ST) and Its Importance

2.2.1 The 'Touch' Sense

The touch sense is the use of skin, muscles, and joints to explore and obtain information about the material world around us (Révész, 1950) such as the forms and surface textures (Figure 2.9). The somatic sensation is another term coin to the touch sense, "soma", the Greek word for the body (A. G. Brown, 2020), which can be divided into four main modalities: tactile, thermal, pain, or pruritic (itching feeling) (McGlone, Vallbo, Olausson, Loken, & Wessberg, 2007). Researchers also refer to the term "haptic" for the sense of touch (Lederman & Klatzky, 2009). Haptic is driven from the Greek word "haptesthai" and it means to touch, refer to sensing and manipulating by touch (Varalakshmi et al., 2012). Based on Van Erp et al. (2010) "haptic" comprises of two main categories, Cutaneous which includes stimuli that provoke the skin such as thermal stimuli, and kinaesthetic which is the feeling produced by stimuli that impact the body limps and joint such as force (Figure 2.10).

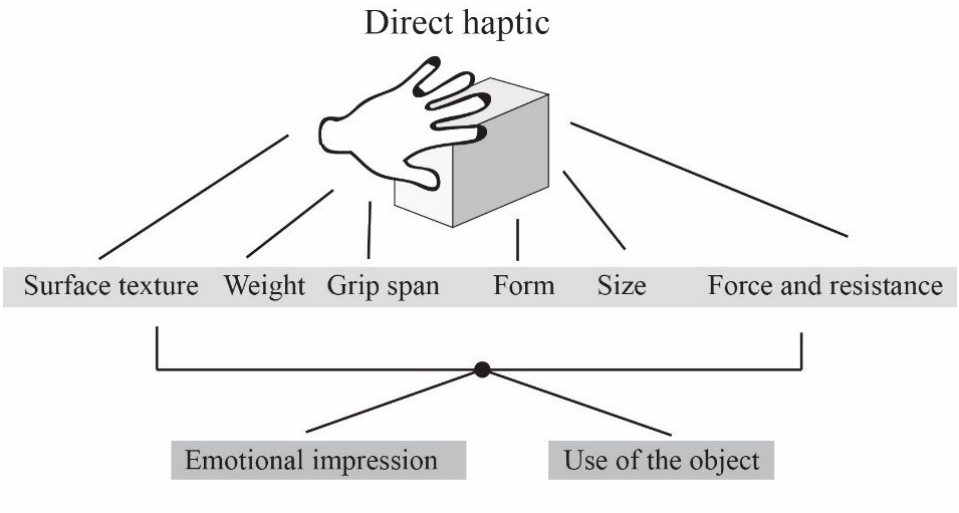


Figure 2.9. Touch in direct contact, illustrated by the author based on Isaksson (2004)

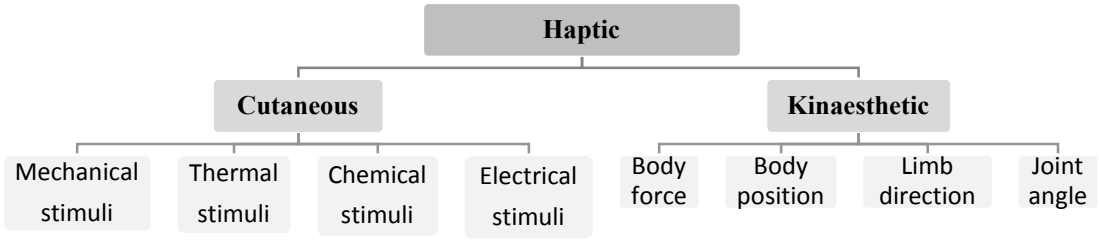


Figure 2.10. The components of haptics, reproduced based on Van Erp et al. (2010, p. 355)

Research in haptic encompasses various disciplines, including biomechanics, psychology, neurophysiology, engineering, and computer science (Eid & Al Osman, 2016). The haptic system perception encompasses most of the human body (F. Davis, 2017). It is denoted as a way to develop social interaction and offer a sense of pleasure while touching and feeling certain objects. It is bidirectional that provides intimate and personal feedback. Based on MacLean et al. (2015) touch has certain characteristics such as bidirectional and multi-parametered, and people touch for many reasons such as assessing an object and building a mental model of it, Figure 2.11 expands on what is touch and why we touch based on MacLean (2000) description.

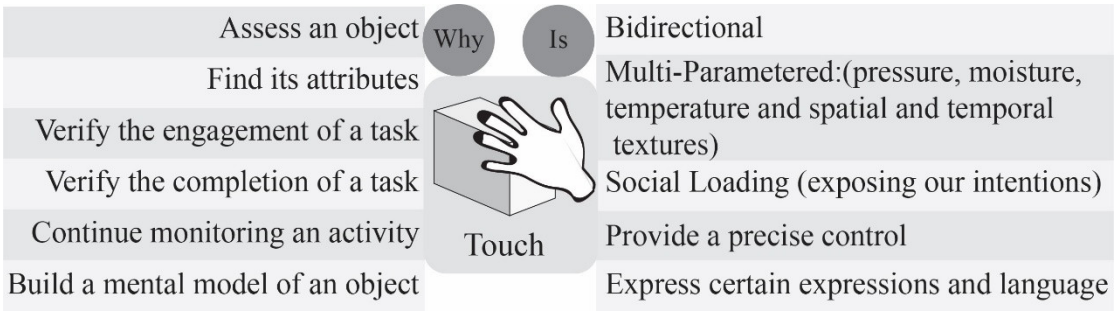


Figure 2.11. What is touch and why we touch, illustrated by the author based on MacLean (2000)'s description

Touch is essential for the development of human social skills and it is the earliest sensory system to develop (T. Field & Hernandez-Reif, 2008). It contains various meanings including welcoming, threatening, or persuasive. We touch because we

want to communicate or learn something, or we may choose to avoid touch because of personal preference or even cultural reasons (MacLean, 2000).

Touch perception can be divided into three: cutaneous sense, kinesthesis sense, and proprioceptive (which is a mix of the first two). Touch is embodied in everyday experience (Paterson, 2007). Individual differences in touch vary in sensitivity, motivation to touch, and personal preferences (Peck & Childers, 2013). The sense of touch can also be divided into two according to the type of touch: discriminative, or emotional. Discriminative touch is used to give information about an object while manipulating it, such as texture and pressure. Emotional touch is responsible for the affect and pleasure of the touch (McGlone et al., 2007). Following are some common terms used for the touch sense with their descriptions.

Cutaneous: It is a sense related to getting information from the skin surface (Lederman & Klatzky, 1987). The skin which dominates most of the human body is a primary sensory organ, it contains thermoreceptors for sensing temperatures, mechanoreceptors for sensing vibration, distortion, and stretching, and nocioreceptors that sense pain (Haans & IJsselsteijn, 2006; MacLean, 2008b). The skin obtains two-dimensional pressure feedback patterns (Lederman & Klatzky, 1987). The skin has a higher chance to sense certain patterns in the denser area (Vallgårda et al., 2017).

Tactile: The feedback that only arouses the cutaneous part of the touch sense is called tactile feedback such as vibration, temperature, texture, or material properties. It can be called to a specific technology such as vibrotactile feedback (MacLean et al., 2017).

Kinesthetic: It is the motor system that used to manipulate the material world around and feel the force, it is obtaining static and dynamic information of the position and spatial awareness of the head, torso, limbs, and effectors used in touching, (Lederman & Klatzky, 1987; Loomis & Lederman, 1984). With it, one can understand the limb movement, position, and orientation. It can help to recognize the

size and weight of objects (Haans & IJsselsteijn, 2006; Hatzfeld & Kern, 2014). Two types of receptors receive kinesthetic feedback: force sensors, and position/motion sensors (MacLean, 2008b).

Proprioceptive: It is a mix of cutaneous and kinesthetic perception. It is the sense responsible for knowing the space of one's body parts relative to each other. The receptors in joints, muscles, tendons, and skin stretching feedback are combined to provide for proprioceptive sense (Dijkerman, 2016).

Passive/ Active touch: The main difference between them: passive is receiving the touch information, active is creating touch impressions, or applying the touch (Richardson et al., 1981) (Figure 2.12). With passive touch one can perceive touch, pressure, heat, pain, and receive information about the shape been applied on, one can understand textures and hardness in this way (Varalakshmi et al., 2012). With active exploration, because of kinesthetic tasks, it might induce more cognitive processes than passive (Richardson et al., 1981). However, it has the advantage of being free to control the sensing procedure (Loomis & Lederman, 1984). With Active exploration each hand movement pattern considers an exploration procedure (EP) and it has its own characteristics (Lederman & Klatzky, 1987) (Figure 2.13).

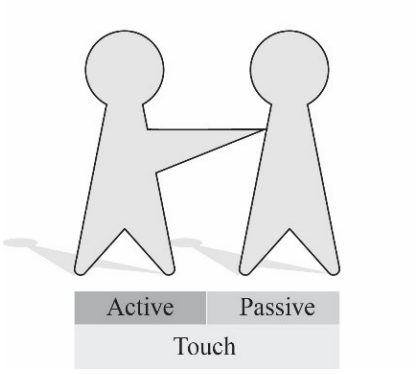


Figure 2.12. Active/Passive touch

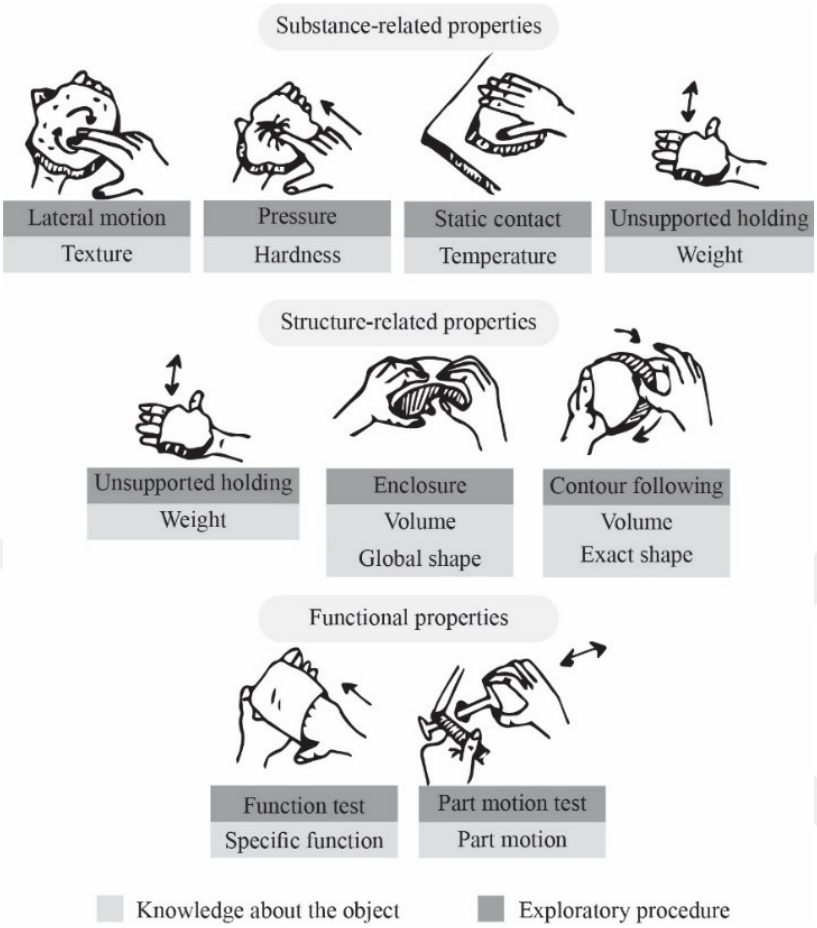


Figure 2.13. Active exploration: knowledge about the object and exploratory procedure (reproduced based on Lederman and Klatzky (1987, p. 346))

2.2.2 Social Touch and Its Importance

"Without tactile communication, interpersonal relations would be bare and largely meaningless," (Frank, 1957, p. 242)

"**Social touch**" is defined in this research as any kind of physical interaction (e.g. a hug or shaking hand) happening among individuals in a co-located space for any kind of reasons such as greeting (Huisman, 2017). The touch sense plays a primary role in interpersonal communication (Thayer, 1986). Social touch is used in our daily life communication with other individuals, it can be in form of greeting (e.g. shaking

hand), showing intimate affection (e.g. cuddling), or habit-forming (e.g. light hit for stopping an unwanted behavior). Even if individuals are not able to observe each other, they can still feel each other's presence through 'touch'. Touching in such communication contributes to assessing the desirability of communication and improving the quality of the experience (Takahashi et al., 2012). Social touch is a need, it plays an important role in human development and helps to shape human memory Touch deprivation in infants and children leads to cognitive and neurodevelopmental delays. There is a higher chance for young children, who do not receive enough touch affections from their parents, to show aggression in their childhood (Tiffany Field, 2014). Autism (Mammen et al., 2015) and over sensitivity (Wilbarger et al., 2010) can be named as two of the potential results of infant social touch deprivation. Touch for parents is also beneficial, it increases oxytocin (love hormone) level (Feldman et al., 2010).

Touching between people has an impact on emotional and mental wellbeing. One might perceive this as a positive or negative emotion depending on, for example, the context, gender, and cultural background (Gallace & Spence, 2010). An online study by a team of psychologists led by Prof Michael Banissy at Goldsmiths University of London in collaboration with the BBC where 40000 people from 112 different countries took part in it, showed that higher level of well-being and low level of loneliness associated with positive attitudes towards touch (BBCNews, 2020). Touch is important for emotional development not only for the infant but adults and it will positively influence the elderly's wellbeing (Bush, 2001). Touch communicates intimate emotions easier than verbal communication (Register & Henley, 1992) and it is generally the preferred way (App et al., 2011). Specific emotions such as anger, love, sympathy can be communicated through touch, e.g. patting on someone with sympathy or pushing someone with anger (Nardelli et al., 2018). Touch can reduce or relieve stress (Ditzen et al., 2007) and physical discomfort (Huisman, 2017), and have an impact on the healing process (Cocksedge et al., 2013). Communication through touch shows that the person has high self-esteem (Silverman et al., 1973).

Touching brings intention, one will touch someone only to be involved with somehow - unless it is an accidental touch (Jones & Yarbrough, 1985). Touch is vital in a social setting, it is the bond to maintain and develop relationships, it has rules to follow within the social norm as such allowing who may touch our body and where (Jewitt et al., 2020). Social touch can lead to better evaluations of the toucher (Erceau & Guéguen, 2007); persuasion (Crusco & Wetzel, 1984); increase relationship satisfaction (Gulledge et al., 2003), and reassure safety and pleasure (Ackerman, 1991). Social touch, such as a hug, can decrease cortisol (stress hormone) and increase oxytocin (the love hormone) which can help to strengthen a social bond. Individuals in the same location might use touch to convey subtle social messages (e.g. hostility, level of intimacy). The touch can be direct touch such as shaking hands or indirectly such as carry an object together (Smith & MacLean, 2007). The touch between people carries various meanings and intents depending on various factors, Figure 2.14 shows, in summary, these factors.

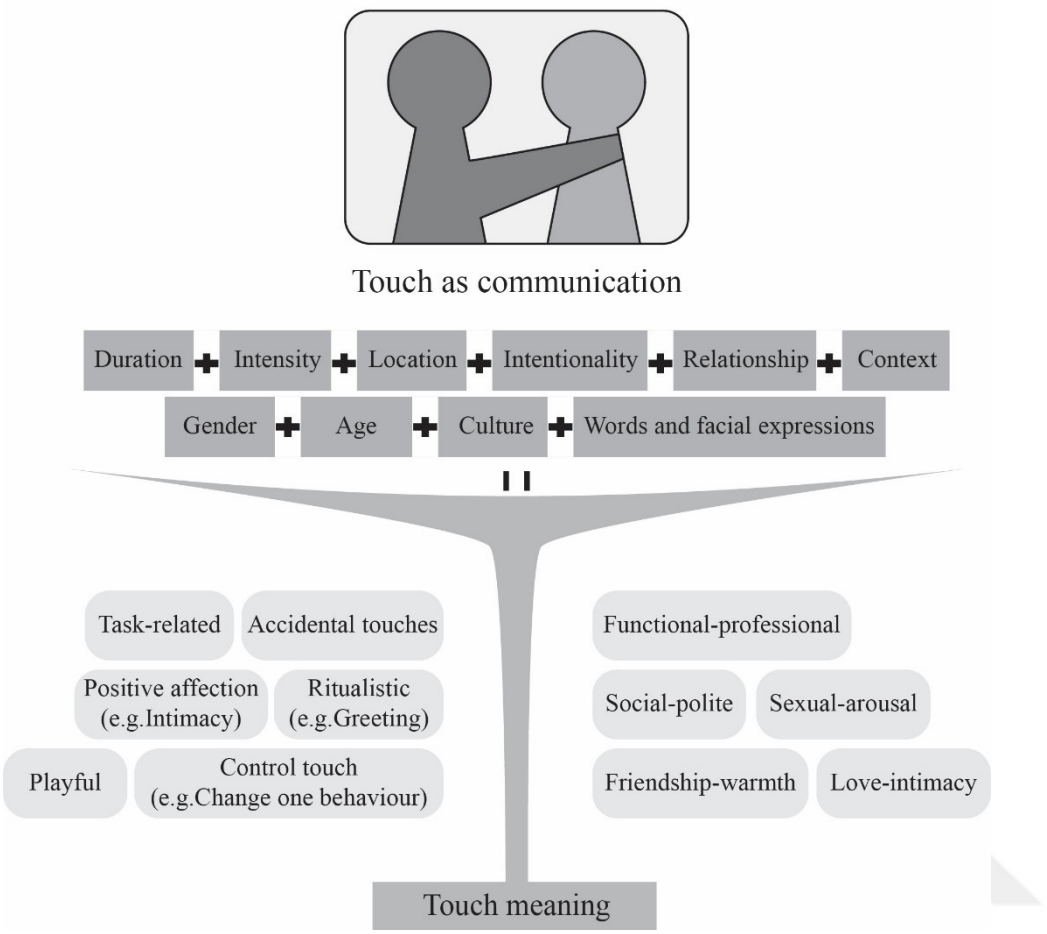


Figure 2.14. The attribute that affects the meaning of the touch, illustrated by the author based on Jones and Yarbrough (1985), Major (1981, p. 16), Wang and Quek (2010, p. 14), and Hans and Hans (2015, p. 48)

The location of the touch on one's body is very important to understand the meaning of the touch and to add value to the touch. The touch may violate someone which arouses negative affect or it may increase the positive affect depending on location. Jones and Yarbrough (1985) explain that there are two distinct body areas with a different meaning in one-to-one interaction: non-vulnerable body parts (NVBP), and vulnerable body parts (VBP) (see Figure 2.15). For example, a touch to NVBP could mean support, appreciation, or affection, however, the same touch applied onto VBP or NVBP can mean compliance touch. NVBP can accept touches from strangers however VBP can only accept touches from the ones in close relationships.

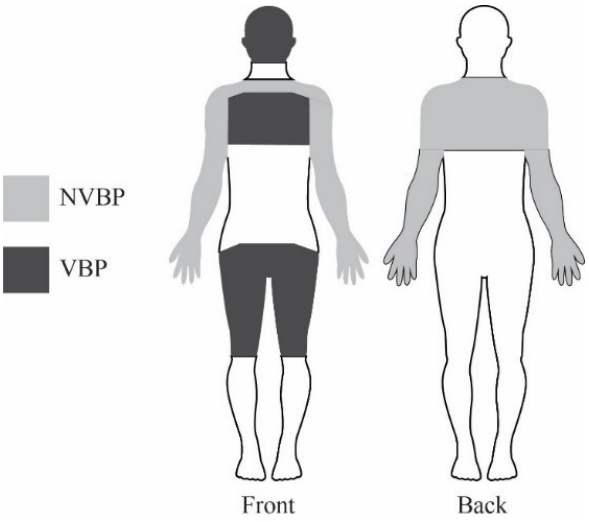


Figure 2.15. Non-vulnerable body parts (NVBP) and vulnerable body parts (VBP), illustrated by the author based on Jones and Yarbrough (1985)

Social touch is not acceptable by everyone, some might choose to avoid it or feel negatively, for example, people present with autism or ADHD (attention deficit hyperactivity disorder) cases (Tiffany Field, 2010). Some individuals might feel unpleasant or disgusted by touch (touch avoiders) for many reasons including feeling insecure about initiate the touch or sharing an emotion through it (Lenselink, 2016). Thus, context, relationship, age, gender, and culture play a big role (Andersen, 2005). The negative effects of touch in communication context is another interesting subject, but there are relatively fewer studies carried out in this direction (Gallace & Spence, 2010), and the present research will not specifically focus on this issue.

2.3 Remote Social Touch (RST)

Today's culture of always-on and pervasive connectivity allows new ways to connect geographically separate families (Madianou, 2016). The current means of communication however focuses on either verbal or visual communication (e.g. video and audio chat and text messaging) while communicating touch is underutilized. Thus, it leads to the missing of nonverbal cues carried through touch - an important sense in carrying emotional meaning. However, social touch or interpersonal touch can be realized (to a degree) through a digital means, such as through computers or similar technologies that can (digitally) deliver the sense of touch through haptic technologies and stimulate touch sense over a distance. This concept will be referred to as "Remote social touch" (RST), Figure 2.16 illustrates the basic principle of RST.

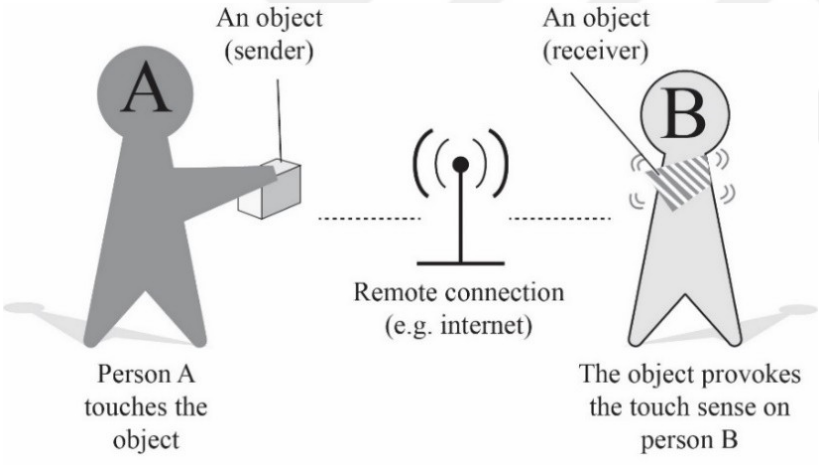


Figure 2.16. Remote social touch, illustrated by the author

Nowadays, remotely communicating touch can be possible with the current haptic technologies (refer to Section 2.4), availability of networking (internet and telecommunication technologies), and ubiquity of computing devices (MacLean, 2008b; Yoo, 2010). Touch can be transmitted and felt without the physical interaction with the main subject and that is "remote touch" (Seo, 2015). Another term coined for remote social touch is "digital touch" to identify touch over the digital medium (Jewitt et al., 2020). Simulated haptic can be used to describe when

the touch sense is stimulated through the help of certain tools. This can be a stick used to feel a texture or a teleoperator and devices used to transmit touch feeling remotely (Loomis & Lederman, 1984).

Figure 2.17 illustrates the concept of RST through one of the scenarios that RST can be utilized in, in this example one person (person A) trying to communicate a squeeze action to another person (person B). However, the "squeezing hand" action in RST will be converted from person-to-person physical interaction to person-to-object (the sender side) then object-to-person (the receiver side) interaction. Person A needs to have a sender object to send the physical interaction to person B which needs a receiver object to receive the physical interaction. In this example, person A squeezes the sender object which has certain sensors (refer to Section 2.4.4) that read the force amount applied onto it, here the physical interaction is converted to digital data, this is the person-to-object interaction side. Then the data transfer through communication technology (e.g. the internet) to the receiver object, this is the object-to-object interaction side. The receiver that person B has received the data from the sender object which then converted from digital data to touch feedback through the haptic technologies (refer to Section 2.4), this is the object-to-person side. In this example, the data will be converted to force applying onto person B's wrist to simulate the squeezing action by force actuators. This example can be applied to other physical interactions such as a hug or a shaking hand.

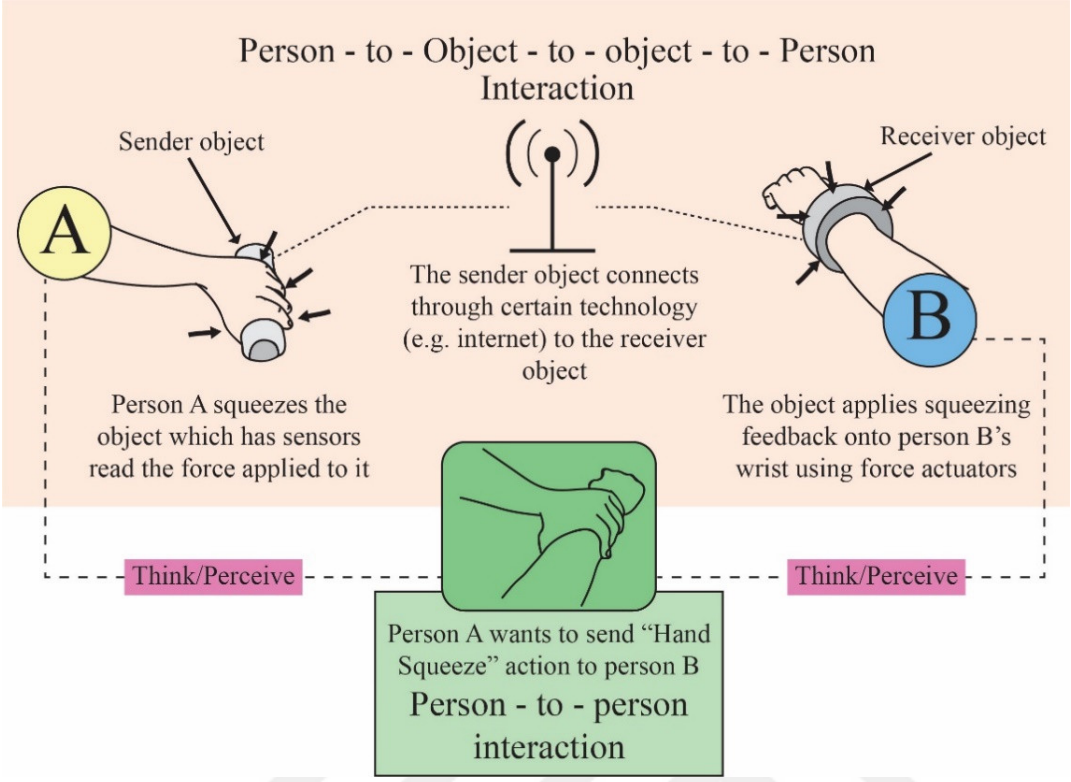


Figure 2.17. An example of sending squeezing action between two persons through remote social touch, illustrated by the author

Huisman (2017) states that remote social touch (RST) differs from social touch (ST) in a few ways.

- RST does not need to be reciprocal like a real touch: one can send a message without receiving any feedback from the second person but in real social touch, one will observe or feel some kind of feedback from the other person.
- RST provides various sensations to the sender and the receiver which do not need to be aligned with the actual feeling of the touch for example a hug can be translated to vibration (a symbolic way of messaging which is different in the real touch interaction.
- RST can be asynchronous communication which means a social touch can be saved and reproduced later or there can be a delay between

receiving and sending, which cannot be achieved by non-mediated social touch.

- RST can be less sensorially rich, it can be stripped from all other sensor modalities and only use the touch sense however a social touch in real life is multisensorial in nature.
- In RST one needs to act on something to initiate the connection, and the person feeling the haptic feedback needs to believe it was the sender's touch.
- Both ends, receive, and sender, one of them does not need to be a human being, a robot or artificial intelligence can substitute the human being. Such interaction between a human not non-human identifies as “touching virtual agents” which is outside the scope of this research, the focus will be only between humans.

2.3.1 The Benefits of Remote Social Touch

Enabling touch (interaction) in remote communication can bring several benefits. It can potentially: reduce sadness and negative moods and can help to encourage cheerfulness (Wang & Quek, 2010); can enrich the communication, mediate intimate and personal interactions in which common communication tools fail to do so; enhance the current communication tools by allowing nonverbal cues to pass through which can encourage more interaction, improve social connectedness, and help with evaluating the mood of the conversation better (Chang et al., 2002; Park et al., 2013).

Remote social touch can still have the benefits of interpersonal touch (Rantala et al., 2011), direct social touch (Cabibihan & Chauhan, 2017), or real touch (Haans et al., 2007). It can also bring out individuals' personalities and characteristics (McLaughlin et al., 2008). Using mediated touch as a communication medium able to transmit binary information such as yes-no or emotional content that is difficult to

communicate verbally such as desire. It can be used as a simple means to express sudden emotions and quickly act upon it (Heikkinen et al., 2009). RST can be private and ambiguous to an outsider however caries rich emotion (Mullenbach et al., 2014), sound recording can be heard by others in case they have it but touch does not carry meaning only to the right people. Additionally, the touch senses can be used to deliver nonverbal cues in communication. Nonverbal communications influence most of social meaning (Liu & Mougenot, 2016). It is crucial in communicating intimacy which can be better communicated through certain sensory modalities such as touch or visual (Register & Henley, 1992). Also, RST help with the feeling of presence, the feeling of the other person exist in the same time and space (Huisman, 2017).

Haptic technologies can also be used to detect and display emotions with and without the presence of other sensory modalities. Through haptic technologies, individuals can communicate discrete emotions such as anger, joy, or happiness, and arousal emotions such as positive or negative valence (Eid & Al Osman, 2016). For example, one can communicate stroking action to arose comfort or empathy, or squeezing action to express excitement or happiness (Rantala et al., 2011). Thermal altering can also communicate certain emotions, for instance, warm messages could express something positive, in contrast to the cold message that could express something negative (Suhonen, Müller, et al., 2012).

2.4 Mediating Touch Through Technology – The Haptic Technology

2.4.1 Uses of Haptics Technology

Haptic technologies (haptics) vary among different applications and research fields. Researchers used it in applications to support visually impaired individuals such as in displaying information by using pins array as input and output for graphical drawings (Bornschein et al., 2018) (Figure 2.18a) and using vibration feedback for wayfinding to keep walking straight and to reduce cognitive load (Kammoun et al., 2012). Haptics also used in entertainment such as allowing individuals to feel by touch what visually presented in a film (Danieau et al., 2014) (Figure 2.18b), enhancing the experience of online media such as YouTube by converting the visual image to tactile feeling (Rahman et al., 2010) (Figure 2.18c), to enhance digital games by using a haptic device that is able to provoke the touch sense through force feedback (Tokuyama et al., 2016) (Figure 2.18d), and in enhancing museum and exhibition experiences such as with the example of the "full stop" painting, visitor able to feel certain haptic feedback patterns using mid-air haptic technology while looking into the painting (Vi et al., 2017) (Figure 2.19a). Haptic technologies are also used to enhance smartphone experience by adding an additional layer to display information using tactual feedback (pin array) such as the example by Strasnick and Follmer (2016) (Figure 2.19b).

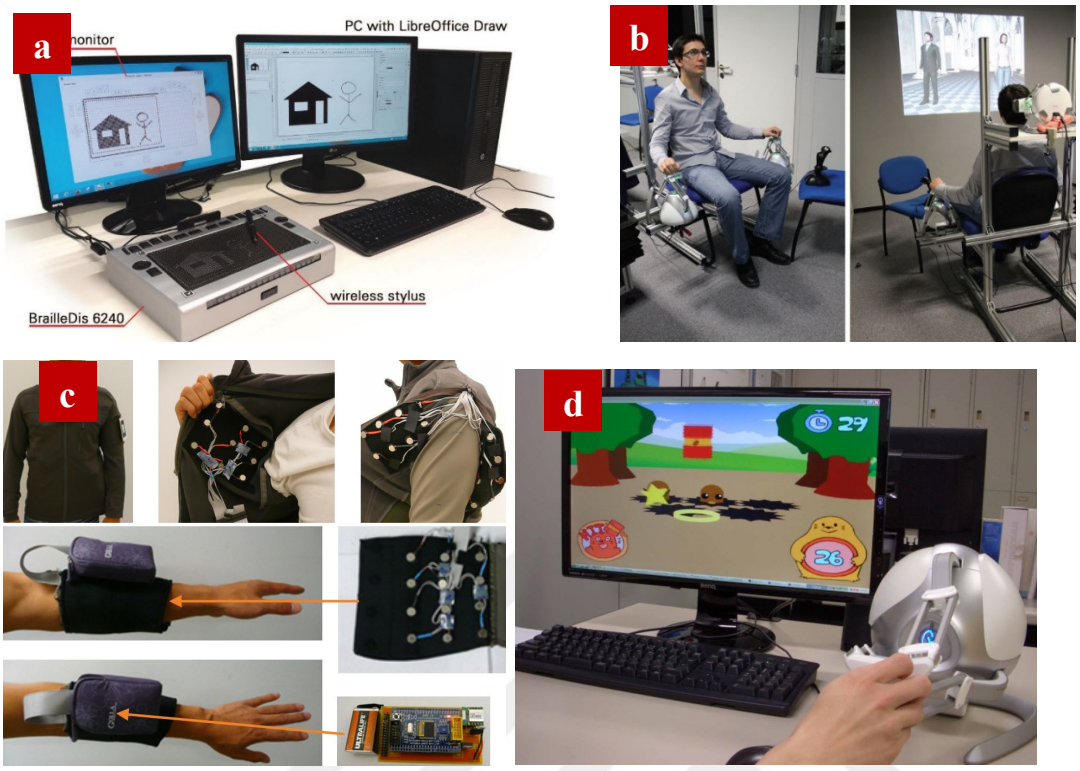


Figure 2.18. a. Pin array for graphical display by Bornschein et al. (2018), b. Experiences haptic effects while watching a video by Danieau et al. (2014, p. 18), c. Garment that provides tactile feeling to enhance YouTube experience (Rahman et al., 2010), and d. Enhancing digital games with haptic display (Tokuyama et al., 2016)

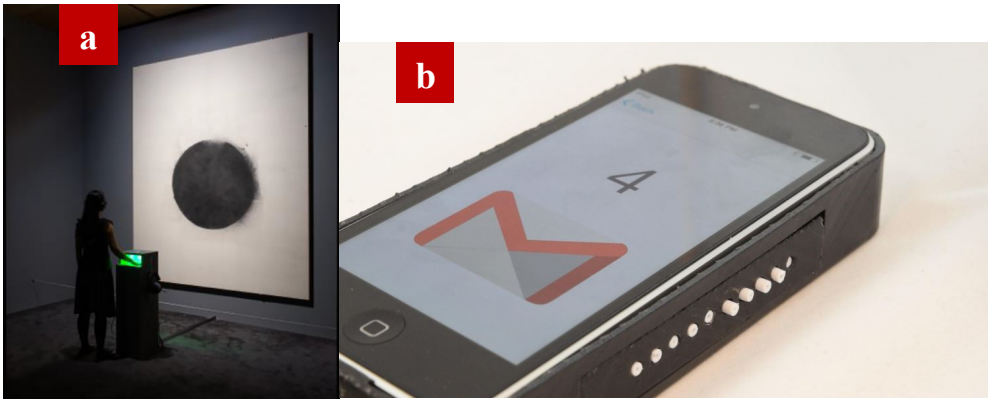


Figure 2.19. a. feeling art by Mid-air haptic (Vi et al., 2017), and b. Enhancing smartphone experience with tactual feedback (Strasnick & Follmer, 2016)

Haptic technologies are also used in safety applications, such as for car driving to provide assistance and warning, for example, by providing haptic feedback on the steering wheel (Gaffary & Lécuyer, 2018). Also, to support rehabilitation such as wrist rehabilitation after Stroke using a haptic device that provides force feedback while using a virtual application (López et al., 2018) (Figure 2.20a). Haptics also used to enhance learning experience such as learning handwriting a foreign alphabet with audio and visual accompanying with a haptic device to guide the writing with force feedback resampling a teacher guiding one's hand (Eid et al., 2007), also enhancing medical education such allowing one feel force feedback using a haptic device (e.g. PHANTOM Omni) while training for certain medical persuader (Ullrich & Kuhlen, 2012) (Figure 2.20b).

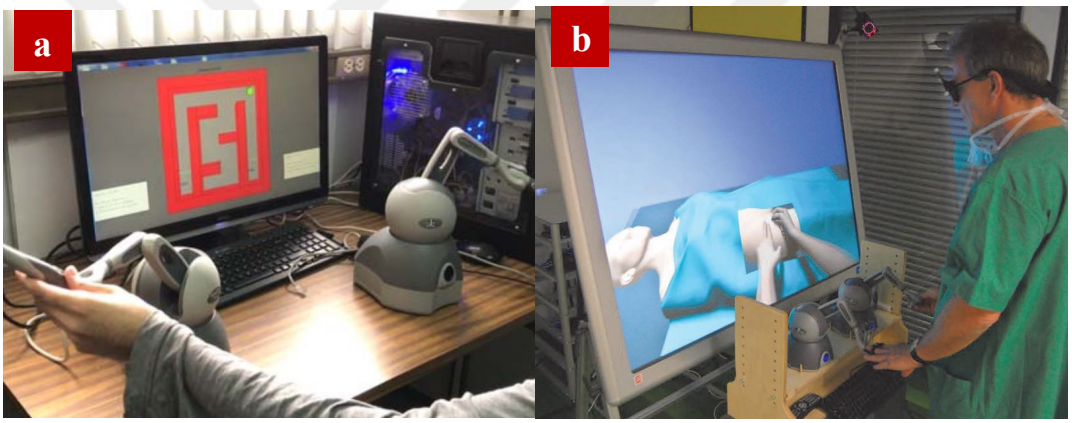


Figure 2.20. a. Wrist rehabilitation with a haptic device (López et al., 2018), and b. medical training simulator (Ullrich & Kuhlen, 2012)

It is also used to enhance remote collaboration by allowing sensing by touch remote objects in accompanying with the visual feedback (Tanabe et al., 2019) (Figure 2.21a), also supporting remotely located virtual reality collaborators to have the same physical feedback with the use of actuated robots to give the haptic feedback (He et al., 2017) (Figure 2.21b), or to enhance the virtual reality experience in general by helping users to feel the interaction with the surroundings and visual objects (Siu et al., 2018) (Figure 2.21c). Haptics also used to mediate social touch remotely by allowing sending a physical touch to a loved one such as the example of "Kiss

messaging" that allows individuals to exchange kisses remotely (Saadatian et al., 2014) (Figure 2.22).

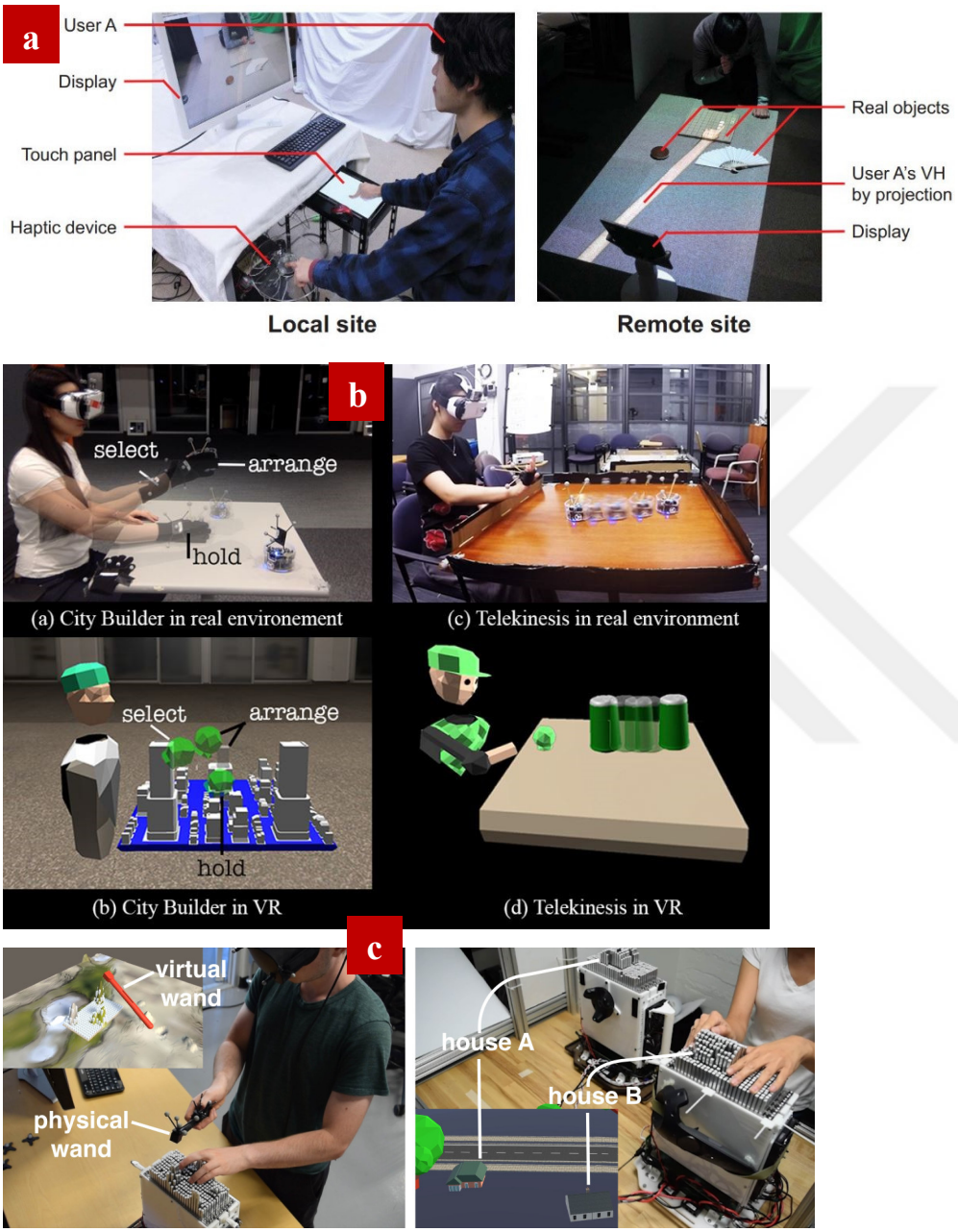


Figure 2.21. a. Remote collaboration with haptic and visual feedback (Tanabe et al., 2019), b. remote virtual reality collaboration with haptic feedback (He et al., 2017), and c. 'ShapeShift' enhancing VR experience by Siu et al. (2018), and

Figure 2.22. ‘Kiss messaging’ by Saadatian et al. (2014),

However, there are some medical conditions or physical problems that could cause impairment of touch, in such cases utilizing haptic technologies will not be a viable option. A few of such examples mentioned by Dijkerman (2016) are numbsense (unable to feel tactile sensation but still can move), finger agnosia (unable to distinguish the fingers but can use them), morphognosia (unable to distinguish macro-geometrical attribute of an object such as size (Figure 2.23)), and tactile apraxia (unable to accomplish exploratory movements with the hand and finger).

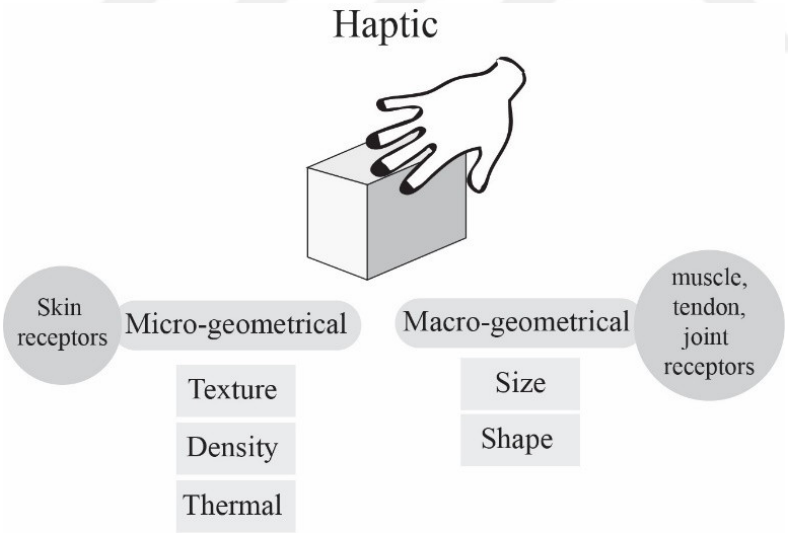


Figure 2.23. Haptic classification, illustrated by the author based on Dijkerman (2016)

2.4.2 The Benefits of Utilizing Haptic Technologies

The Touch Sense and Other Senses

The “touch sense” can additionally serve on some occasions especially, when visual and auditory channels fail due to, for example, sensory overload or visual and/or audio impairment. Sensory overload happens when one sense or few are exposed to high demand when interacting with a situation (e.g. manipulate a touch screen while driving a car) (Enriquez et al., 2006; Gaffary & Lécuyer, 2018). People with auditory and visual sensory loss have an increased risk of depression (Heine & Browning, 2014), therefore touch can in this case help with reducing the negative affect. It can be used to reduce sensory overload by distributing the information without disturbing the other senses (Enriquez et al., 2006) and reduce workload (Oakley et al., 2000).

The advantages of the touch sense have over other senses on some occasions (as discussed so far) make it a candidate to be utilized in remote communication applications. Stimulating the touch sense affects other sensory modalities' perceptual processes (Takahashi et al., 2012), other senses like visual and auditory refer to the sense of touch when trying to make sense of the material world around (Hatzfeld & Kern, 2014). Integrating the touch sense with other sensory modalities would potentially increase the effect on arousal and valence. In a user study by (Wilson & Brewster, 2017), where they combine various modalities (i.e. temperature, vibration, and abstract visual displays) as emotional feedback while messaging between individual, they found that combining modalities enhance the range of available emotions to express and to deliver.

learning shapes and assess forms incorporate visual and touch sensor modalities but sometimes visual sensor modality does dominant (Balaji et al., 2011). However, the touch sense can aid when the visual sensor modality is not available due to impairment or sensory overload. In eye-free interactions such as driving, heavy visual noise environment, or application for visual impairment users, utilizing the

touch sense leaves the user visual attention undisturbed which free the users to perform another task and reduce cognitive load (Oakley & Park, 2007).

Touch and emotion

Touch and human emotions are intertwined, this is supported by both physiological and behavioral data (Gallace & Spence, 2010). Many researchers have documented the link between touch sensation and emotion characteristics (Gatti et al., 2013). Touching a person, even if he or she was a stranger, will bring about a certain emotion (Hertenstein et al., 2006; Rantala et al., 2011). Emotions such as anger, fear, happiness, sadness, disgust, love, gratitude, and sympathy can be communicated through touch (Hertenstein et al., 2009). For example, a study carried out by Obrist et al. (2015) shows that stimulating regions on the hand can bring about either positive or negative emotions such as touching the thumb finger brings about positive emotions, and touching the pinky finger brings about negative emotion. Emotion can also be activated even if the touch is felt through haptic technologies such as vibration over distance (Rantala et al., 2011). Tactile and thermal sensation effect arousal and valence of the emotion (e.g. warmth may evoke a more pleasant feeling than cold) (Liu & Mougenot, 2016; Wilson & Brewster, 2017).

Additionally, utilizing haptic technologies for emotion-related reasons has its own research area, called "affective haptics" (Arafsha et al., 2012). Eid and Al Osman (2016) define it as: "the design of devices and systems that can detect, process, or display the emotional state of the human employing the sense of touch" (p. 27). In their study, they summarize the following uses of haptics: 1) to achieve emotional immersion haptics can be used, 2) haptics can successfully be used to communicating valence, arousal, and main emotions such as happiness and anger, 3) emotion detection through haptics still under study area however displaying emotion through haptic is well researched, 4) the context is the primary influencer to the haptics interpretation. Accordingly, the overall field is a combination of "affective computing", "haptic", and "user experience" (Eid & Al Osman, 2016). Affective computing deals with ways to detect, display, communicate, and influence emotions

through computing technology (Picard, 2000). That is combine with haptic technologies which are technologies that are able to detect and provoke the touch sense to provide bidirectional communication. Both of these fields combined within the user experience point of view to utilize the touch sense to enhance emotional and the overall quality of user experience (Eid & Al Osman, 2016).

2.4.3 Haptic Rendering

The process that stimulating the human's sense of touch is called haptic rendering (Salisbury et al., 2004), and what one's feels through the haptic technologies called haptic feedback. Current haptics technology made it possible to simulate cutaneous and kinaesthetic perception (Eid & Al Osman, 2016). Haptic technologies are subdivided into two main categories based on the feedback they provide: 1) tactile such as a display that acts on the skin, and 2) kinaesthetic (proprioception) such as for force feedback (Schneider et al., 2017). Utilizing haptic technologies is common in multisensory and multitasking environments (MacLean, 2008b). Figure 2.24 shows additional information about haptic feedback.

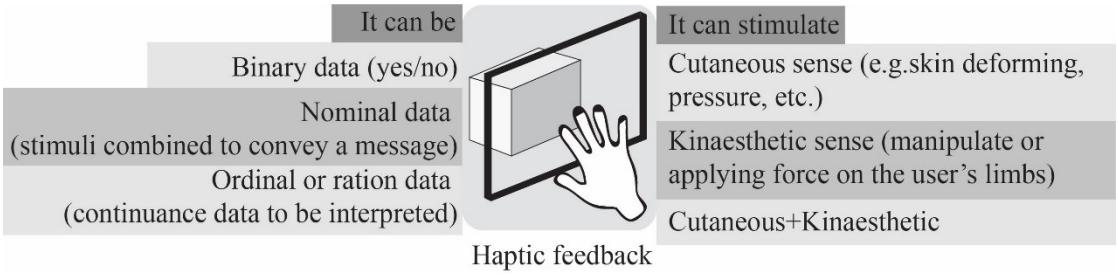


Figure 2.24. Haptic feedback, illustrated by the author based on Haans and IJsselsteijn (2006) and Tang et al. (2005)

There are various methods to render haptic feedback, the most common one is a vibration which is used broadly in applications for visually impaired people for

example for wayfinding: UltraCane[4] and MiniGuide[5] (Pawluk et al., 2015). Shakers can also provide a certain type of vibrotactile feedback such as the example of VR360HD which is a virtual reality player enhanced with haptic feedback (Israr et al., 2016) (Figure 2.25). Electrostatic technology is another method that can be used to render certain friction feedback (it may feel like vibration) which can be incorporated with screen devices (Osgouei, 2020).

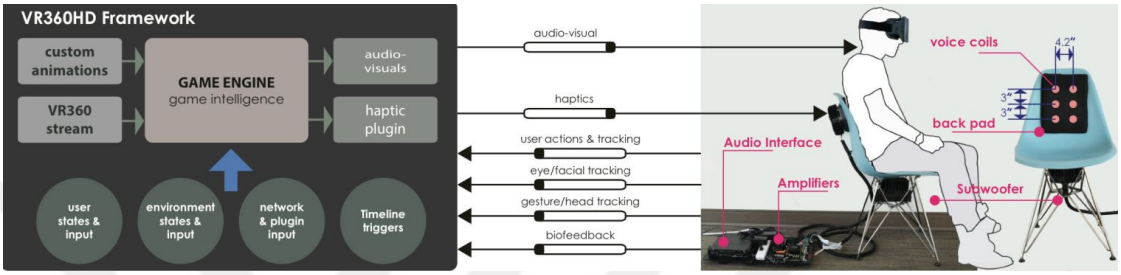


Figure 2.25. Virtual reality player with haptic feedback by Israr et al. (2016)

Other methods to render haptic feedback utilize certain actuators to deliver force feedback such as motors which have various type including a linear actuator (Figure 2.26a) and rotation actuator (Figure 2.26b), for example, Murakami et al. (2017) utilized miniature DC motors with a belt attached to them to simulate vertical and shearing forces to enhance interaction using augmented reality head-mounted display (Figure 2.27a). Exoskeletons can also give certain force haptic feedback to the user, they are used in various scenarios such as Exo-Jacket that supporting users while carrying a load (Ebrahimi, 2017) (Figure 2.27b). Another way to provide force feedback is using air pressure actuators for example "Force Jacket" by Delazio et al. (2018), they embed air pressure actuators in a jacket to deliver a hug-like experience (Figure 2.27c).

[4] http://www.ultracane.com
[5] http://www.gdp-research.com.au/minig_1.htm

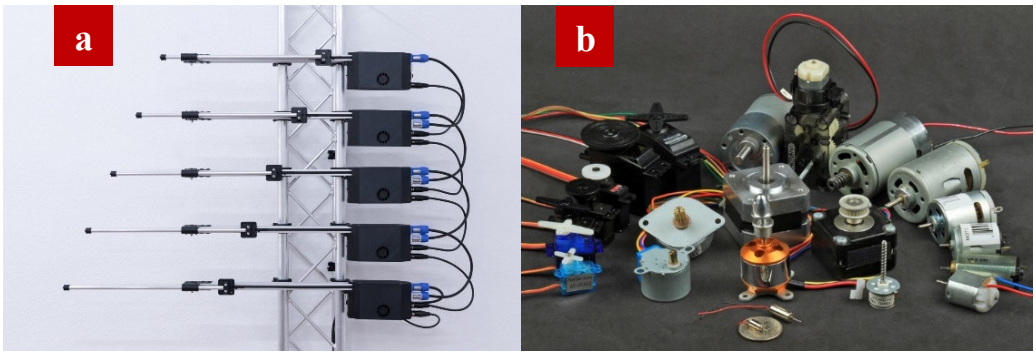


Figure 2.26. a "DMX linear actuator" an example of a linear actuator, reference (kasuga.is/work/dmx-linear-actuator), b. various type of motors available off the shelf to be used with Arduino for example, reference (learn.adafruit.com/adafruit-motor-selection-guide),

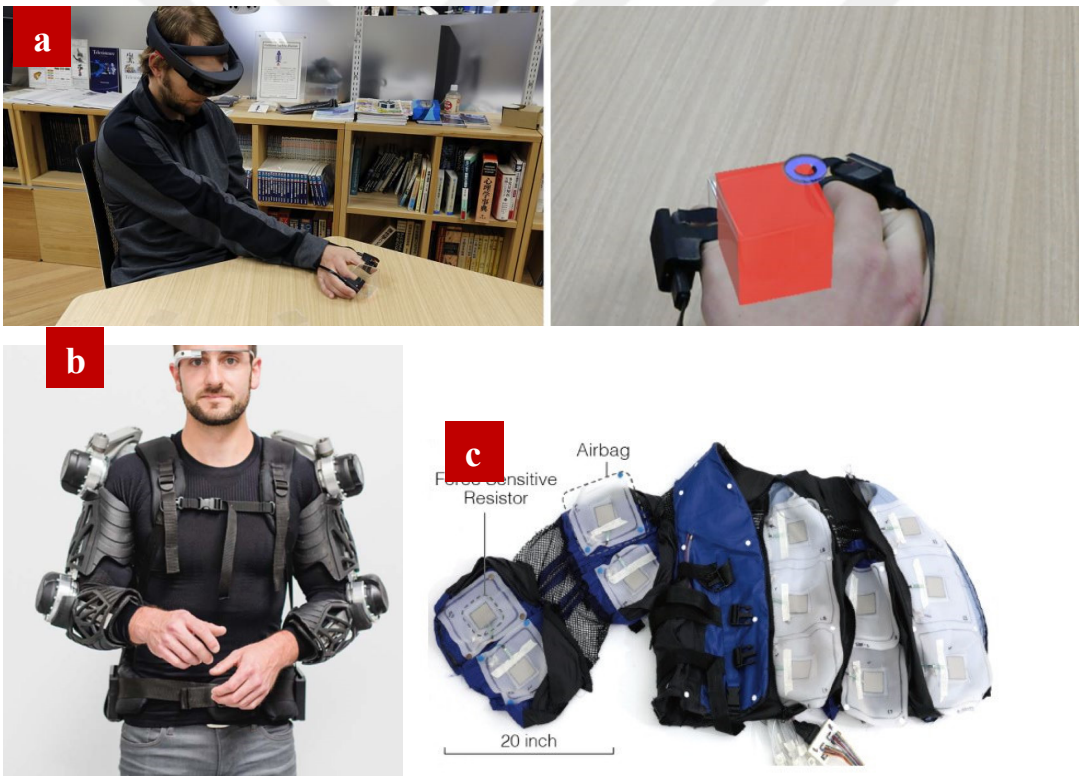


Figure 2.27. a. augmented Haptics Display by Murakami et al. (2017), b. "Exo-Jacket" by Ebrahimi (2017), and c. "Force Jacket" air back force feedback by Delazio et al. (2018)

Thermal feedback can also be provided by special displays used to give cold or warmth perception, for example, “ThermOn” by Akiyama et al. (2013) (Figure 2.28a) dynamically apply on the users either warmth or cold stimuli depending on the music. Moreover, robotics can be used to deliver certain haptic feedback, such as “SwarmHaptics” (Figure 2.28b) where a swarm of small-wheeled robots able to collaborate to deliver haptic patterns to the user’s hand, arm, or any other accessible body parts (L. H. Kim & Follmer, 2019). Shape changing materials include smart materials that are also used as technologies able to render haptic feedback, such as “milliMorph” (Lu et al., 2019) a thin film-like shape-changing material (Figure 2.28c).

Figure 2.28. a. “ThermOn” (Akiyama et al., 2013), b. “SwarmHaptics” (L. H. Kim & Follmer, 2019), and c. Shap changing material “milliMorph” (Lu et al., 2019)

Haptic rendering can be done either through direct contact or contactless. In contact haptics, the touch sense receptor will stimulate when in contact, the input and output coincide, thus mutual interactivity between the user and the interface is required (Saga, 2016). An example of that is by Stanley and Kuchenbecker (2011), who created a wearable haptic device that replicates tapping on, dragging across, squeezing, and twisting an individual's wrist feedback (Figure 2.29a). Contactless haptics simulates the touch sense without having direct contact with the body, an example for that is "Mid-air haptics" by Obrist et al. (2015) (Figure 2.29b) that uses ultrasound technology to generate a physical sensation in mid-air on any part of the body facing the direction of the device.

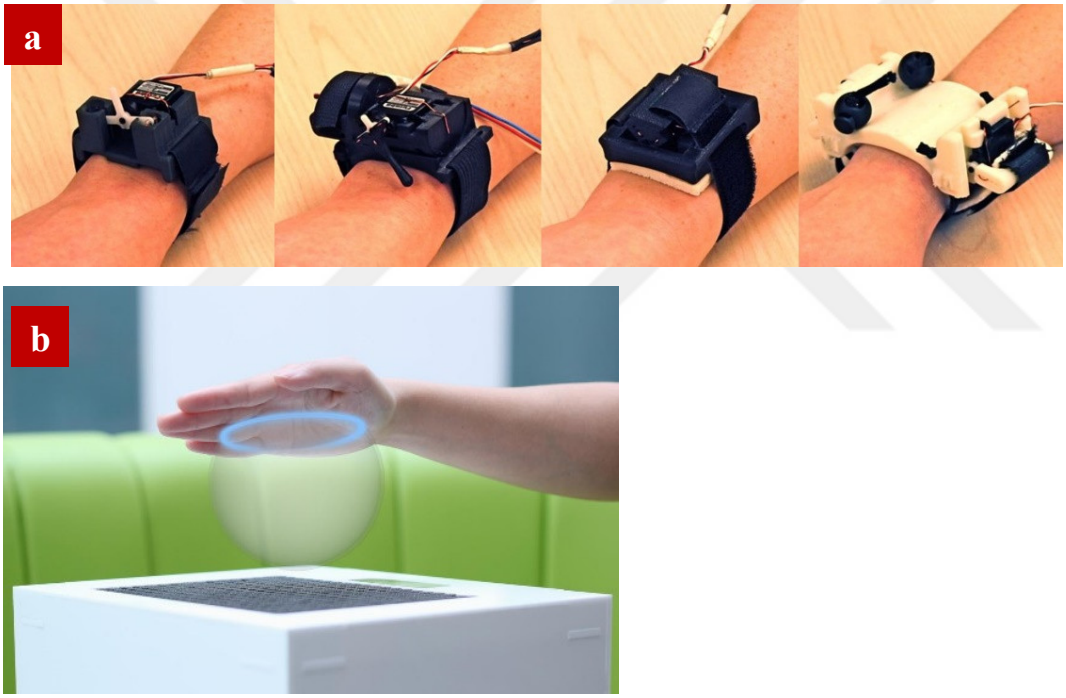


Figure 2.29. a. Tactile Actuators by Stanley and Kuchenbecker (2011), and b. "Mid-Air haptics" (Long et al., 2014)

Some products or devices utilize "haptic icons" to make their own haptic language which is easily learned by the users. Some other products allow the users to generate their own haptic language. "haptic icons" is a brief haptic stimulus that has a meaning for the user (Enriquez et al., 2006), it can be vibration, temperature, texture, or

anything that stimulates the touch sense. The haptic language can be communicated between the users and the machine or between different users (MacLean, 2000). It can help to reduce cognitive overload and ease the interaction (Haans & IJsselsteijn, 2006; Oakley et al., 2000). The most important factors can be listed as distinguishability, icon learnability, salience management, and recognizability in realistic conditions (MacLean, 2008a, p. 87).

Haptic rendering sometimes manifests a few issues as mentioned by Suhonen, Väänänen-Vainio-Mattila, et al. (2012). First, some individuals may feel haptic feedback differently than other individuals, for example, one may feel the haptic feedback as high intensity but another person may feel the same haptic feedback as low intensity. Second, some people may miss the starting, end, in-between sequence of the haptic feedback, for example, one-touch the product after the vibration feedback already started. Third, there could be a problem feeling the haptic feedback due to the user did not interact with the product correctly or other surrounding forces impede the feeling of the haptic feedback. One should consider such issues while designing various ways to render haptic feedback especially for the application of remote social touch.

2.4.4 Detecting Touch Through Technology

The touch sense when applied to an object can be detected through technology. Such technologies utilize sensors that can read touch location, duration, and intensity to understand the touch has been applied to it (Huisman, 2017). Many sensors can measure the user's force, grip, touch, and position. One example of this can be given from Silvera-Tawil et al. (2014) (Figure 2.30a), they created artificial touch-sensitive skin to detect location, duration, and intensity of touch. Processing this data with a special algorithm can result in a robot for example understand the emotions and the social messages of a human. Pourjafarian et al. (2019) (Figure 2.30b) and Kao et al. (2016) (Figure 2.30c) show few examples where a thin film-like material capable of detecting touch contact can be placed on human skin or objects. Another group of

sensors is fiber-like material which can measure starches and bending which can be integrated into clothing items such as Gioberto et al. (2013) (Figure 2.30d) which can detect joint angles and Strohmeier et al. (2018) (Figure 2.30e) which can detect touch and pressure.

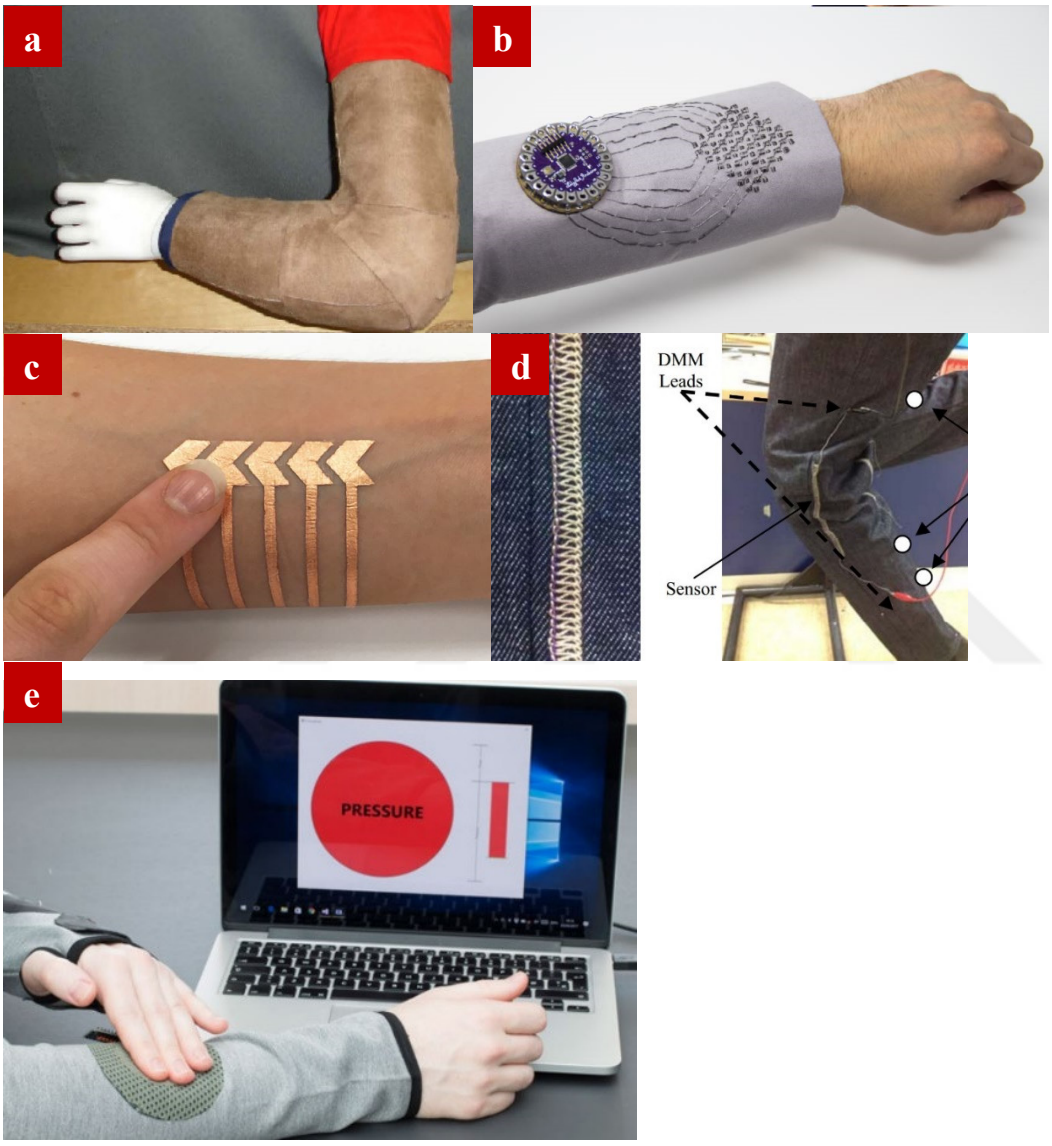


Figure 2.30. a. EIT-based Sensitive Skin by Silvera-Tawil et al. (2014), b. "Multi-Touch Kit" (Pourjafarian et al., 2019), c. "DuoSkin" (Kao et al., 2016), d. stitched Sensors by Gioberto et al. (2013), and e."zPatch" (Strohmeier et al., 2018)

2.5 Previous Work in Remote Social Touch

In literature, it is possible to come across examples of remote social touch (RST) prototypes and/or research output, a systematic review was carried out by the researcher considering following criteria.

- Database: The survey included Google Scholar search as well as the ACM Digital Library, IEEE Xplore Digital Library, Springer.
- Timeframe: The main review is carried out between January - December 2018, however results were updated prior to the submission of the PhD.

A few conditions are set to include or exclude the reviewed publications.

- Reasons for inclusion: 1) the publication should be related to communication over distance between humans, and 2) haptic feedback is one of the sensory used to receive message feedback.
- Reasons for exclusion: 1) pure engineering background of haptic feedback, 2) about human to non-human / one-side communication, and 3) communication without using haptic or the touch sense.
- Keywords: The following keywords are used in search: remote social touch, mediated social touch, remote interpersonal touch, mediated interpersonal touch, remote touch, and remote haptic interaction.

The resulted research outputs, and artefacts are put together in Table (Table 2.1 a, b, c). The Table made use of certain categories which shed the light on research outputs that are commonly stood out. These categories are as follow.

- The ‘Purpose’ behind creating the research output.
- ‘User-count’ includes one communicating to another person, one communicating to many people at once, or many people communicating to one person as one. It also includes the direction of sending and receiving, one

direction means only one side sends and the other side receives, two directions means both sides able to send and receive.

- ‘Gesture type’ shows the type of physical gesture the research output meant to communicate such as hug or kiss.
- ‘Haptic detection type’ is the technology behind sensing the touch applied to the research output.
- ‘Haptic rendering type’ is the technology behind rendering the haptic feedback.
- ‘Other sensor modalities’ are used besides the haptic feedback such as using light or audio notification.
- ‘Touch representation’ includes ‘simulated’, which means a person needs to simulate the real action to send the physical message (e.g. hug an object to send a hug message); and ‘symbolic’, which means substitute the real action with a symbol (e.g. one vibration means a kiss).
- ‘Message synchronization’ includes synchronous that happens at the same time, and asynchronous that can happen at a different time or recorded then played later.
- ‘Interaction type’ includes ‘implicit’ that happens without the user intervening as soon the connection opens one starts feeling the feedback; and ‘explicit’ meaning the need for the user to intervene after the connection opens (i.e. one needs to intervene to accept to start feeling the feedback).
- ‘Body location’ that the research output trying to impact, utilize or the object is live on, for example using the hand to send or to feel a message.
- ‘Artefact characteristics’ include wearable, embedded in the artefact, stand-alone, and decorative which can be entertainment or just look good.

The review of literature and putting forward the tabulated information (Table 2.1 a, b, c) helped to inform the knowledge about the current RST research paradigm, directions, and main trends. The main trend here means a common occurrence of research outputs in literature with certain similar features. Additionally, this list helped to clarify the framework for designing remote social touch products. Also, the analysis of these research outputs helped in building a card set used in interview sessions (see Chapter 3 Section 3.7.2) to elicit information about RST from the user's point of view. The list will be further explained in the next section by shedding the light on the main trends seen among these research outputs.

Table 2.1 (a) Examples of remote social touch [The purpose]

#	Name/ref	Purpose
1	Telephonic arm wrestling (White & Back, 1986) https://v2.nl/archive/works/telephonic-arm-wrestling	Physical entertainment over a distance
2	SHAKER (Strong & Gaver, 1996)	Create awareness, personal and expressive communication
3	Tele-Handshake (Hashimoto & Manoratkul, 1996)	Support handshaking over a distance
4	InTouch (Brave & Dahley, 1997)	Enrich current real-time communication
5	The bed (Dodge, 1997)	Allowing to feel the presence of the other for intimate communication
6	VibroBod (Dobson et al., 2001)	Enhancing current communication medium with touch to amplify the mood
7	The LoveBomb (Hansson & Skog, 2001)	Sending anonymous love/sad cues to surrounding individuals
8	ComTouch (Chang et al., 2002)	Enhance audio communication by sharing nonverbal cue through touch
9	The Hug (DiSalvo et al., 2003)	Facilitating intimate communication across distance
10	The sensing beds (Goodman & Misilim, 2003)	Support intimate telepresence
11	Hug Over a Distance (Vetere et al., 2005)	Mediating Intimacy over a distance
12	Hug over a distance (Mueller et al., 2005)	Support intimate communication over distance
13	ComSlipper (Chen et al., 2006)	Maintain a sense of connection with others
14	Lover's Cups (H. Chung et al., 2006)	Encourage sharing the drinking time
15	TapTap (Bonanni et al., 2006)	Emotional therapy
16	Huggy Pajama (Teh et al., 2008)	Encourage physical closeness between parents and children in distance situations by providing a hugging sensation

Table 2.1 (a) (continued)

17	(Eichhorn et al., 2008)	Support long-distance relationships by communicating nonverbal cues
18	Stress OutSourced (SOS) (K. Chung et al., 2009)	Crowdsourcing haptic therapy over the social network
19	Linked (Laschke et al., 2010)	communication device for teenage boys to squabble over a distance
20	(Wang et al., 2010)	Influence the sense of connectedness and enhancing audio communication
21	Thermal hug (Gooch & Watts, 2010)	Enabling being there a moment in emotional connectedness
22	CoupleVIBE (Bales et al., 2011)	Position tracking and notification from a mobile application
23	Gestural haptic interface (Rantala et al., 2011)	Investigating abstract feeling.
24	CheekTouch (Park et al., 2012)	Enhancing audio communication by adding a nonverbal and emotional haptic layer
25	KUSUGURI (Furukawa et al., 2012)	Facilitating playful nonverbal tactile interaction at a distance
26	YourGlove, HotHands and HotMits (Gooch & Watts, 2012)	Support lovers in long-distance relationships in form of hand-holding
27	Pressages (Hoggan et al., 2012)	Enhancing audio communication by adding a nonverbal and haptic layer
28	Feelybean (Kontaris et al., 2012)	Enhance video/audio communication by sharing intimate moments through touch
29	iFeel_IM! (Tsetserukou & Neviarouskaya, 2012)	Supporting emotional telepresence in online social interaction
30	TaSST (Huisman, Frederiks, Van Dijk, et al., 2013)	Synchronous mediated social touch
31	POKE (Park et al., 2013)	Enhance audio communication by sharing intimate moments through touch
32	Tug of War (Beelen et al., 2013)	Enhance current communication medium by supporting the feelings of social presence and enjoyment over a distance
33	kiss messaging (Saadatian et al., 2014)	Maintains intimacy in long-distance relationships by transmitting a kiss
34	Remote handshaking (Nakanishi et al., 2014)	To enrich mediated communication where video and audio channels are already available
35	(Blum & Cooperstock, 2016)	Support an implicit way to notify about remote activity
36	Flex-N-Feel (Singhal et al., 2017)	Enhance video/audio communication by sharing intimate moments through touch
37	The affective tele-touch system (Cabibihan & Chauhan, 2017)	Investigation on social touch versus mediate touch
38	bioSync (Nishida & Suzuki, 2017)	For combining the kinesthetic experiences of two persons
39	(Nunez et al., 2019)	Huggable Interface in Remote Communication effect on Social Connectedness and Stress Levels
40	(Chan, 2019)	For research: determine characteristics of synthetic touch necessary to convey supportive affect effectively

Table 2.1 (a) (continued)

	In market products	
41	TapTap [www.taptap.me]	A wristband to send touch messages between individuals
42	Feelhey [feelhey.com]	A wristband to send touch messages between individuals
43	iXu [www.joyhaptics.com]	huggable teddy bear which mirrors touch over distance mainly for caressing
44	The Hug Shirt™ [cutecircuit.com/the-hug-shirt]	A shirt that lets you send hugs over a distance
45	Frebble [vimeo.com/86103101]	Comminate holding hands over a distance

Table 2.2 (b) Examples of remote social touch [User Count*, Gesture type, Haptic detection type, Haptic rendering type, Other sensor modalities]

#	User Count*	Gesture type	Haptic detection type	Haptic rendering type	Other sensor modalities
1	One to one / 2D	Arm wrestling	Force detection	Force feedback	-
2	One to one / 2D	Shake	Force	shaking	-
3	One to one / 2D	Handshake	Force	force	-
4	One to one / 2D	Rolling	Movement detection	Movement	-
5	One to one / 2D	Contact	Contact sensing	Temperature / vibration	Visual
6	One to one / 2D	Grip	Force sensor	Temperature / vibration	-
7	One to many / 2D	Pressing	-	Vibration	-
8	One to one/ 2D	Pressing	Force	Vibration	-
9	One to one / 2D	Squeeze, stroke and hug	Motion sensing	Temperature / vibration	Audio / Visual: light
10	One to one / 2D	Contact	Pressure sensor	Temperature	-
11	One to one / 1D	Hug	-	Force: air pockets actuating	-
12	One to one / 1D	Hug	Touch-sensitive screen	Air inflatable force	-
13	One to one / 2D	Contact	Press / pressure	Temperature / vibration	Visual: LED
14	One to one / 2D	Shake	Force	Vibration	Visual: LED
15	One to one/ 1D	tap, press, stroke, and contact	Contact	Vibration	-
16	One to one / 1D	Hug	Pressure sensing	Temperature / Force: air pockets actuating	Visual: color
17	One to one / 2D	Stroke	Movement	Movement	-
18	Many to one / 1D	-	-	Vibration	-

Table 2.1 (b) (continued)

19	One to one / 2D	squabble	Force	Force	-
20	One to one / 1D	Squeeze	Pressure sensor	squeeze	-
21	One to one / 1D	Hug	-	Temperature	-
22	One to one /1D	-	-	Vibration	-
23	One to one / 2D	Squeeze, stroke, and movement	Gyroscopes, force-sensitive resistors, touchpad	vibration	-
24	One to one / 2D	Touch movement	touchscreen	vibration	-
25	One to one / 2D	Touch movement	touchscreen	vibration	-
26	One to one / 2D	Hand holding / contact	Contact	Temperature / force	-
27	One to one / 2D	Squeeze	Force	vibration	-
28	One to one / 1D	Abstract touch	Touch-sensitive pad	vibration	-
29	One to one / 1D	Hug - abstract	Text based	Temperature / vibration	-
30	One to one / 2D	Simple touch: Poke/ Protracted touch: pressing and Stroke	Conductive wool	Vibration	-
31	One to one / 2D	Poke	Force	Force - inflation and deflation	-
32	One to one / 2D	Pull	Force	Force	-
33	One to one / 2D	Kiss	Force sensor	force	-
34	One to one / 2D	Handshaking	Grip force / Warm	-	Video/ audio
35	One to one / 1D	-	Motion	vibration	-
36	One to one / 1D	Abstract	Flex sensors	Vibration	-
37	One to one / 1D	Grasp	Force, temperature, and flexion sensors	Temperature / vibration / tickle	-
38	One to one / 2D	Movement	electromyogram (EMG) measurement	electrical muscle stimulation (EMS)	-
39	One to one / 2D	Hug	Force	visual / vibration	-
40	One to one / 1D	Squeeze	Force	Force	-
41	One to one / 2D	Tap	-	Vibration	-
42	One to one / 2D	Touch	-	Gentle squeeze	-

Table 2.1 (b) (continued)

43	One to one / 2D	Movement	-	Movement	-
44	One to one /one to many 2D / 1D	Hug	-	-	-
45	One to one / 2D	Holding hands	-	Tap	-

* **User count**: Meaning the user count in one side to another / **2D**: two directions, both sides send and receive (both have the same artefact) or **1D**: one direction, one sends and one receive (each one has different artefact)

Table 2.3 (c) Examples of remote social touch [Touch representation *, Message synchronization **, Interaction type***, Body location, Artefact characteristics ****]

#	Touch representation *	Message synchronization **	Interaction type***	Body location	Artefact characteristics ****
1	S: Sim / R: Sim	Synchronous	Implicit	Arm	SA:
2	S: Sim / R: Sim	Synchronous	Implicit	Hand	SA: portable/ accessory
3	S: Sim / R: Sim	Synchronous	Implicit	Hand	SA:
4	S: Sy/ Sim R: Sy / Sim	Synchronous	Implicit	Hands	SA:
5	S: Sy/ Sim R: Sy / Sim	Synchronous	Implicit	Whole body	AP:
6	S: Sim / R: Sy	Synchronous	Implicit	Hand	SA: portable
7	S: Sy / R: Sy	Synchronous	Explicit	Hand	SA: portable
8	S: Sy / R: Sy	Synchronous	Implicit	Hand	AP:
9	S: Sy/ Sim R: Sy	Synchronous / Asynchronous	Explicit	Upper body	SA:
10	S: Sim / R: Sy	Synchronous	Implicit	Body	AP:
11	S: - / R: Sim	Asynchronous	Explicit	Upper body	SA: Wearable
12	S: Sy / R: Sim	Synchronous	Implicit	Upper body	SA: Wearable: Portable
13	S: Sy / R: Sy	Synchronous	Implicit	Feet	AP: Wearable: Portable
14	S: Sim / R: Sy	Synchronous	Implicit	Hand	SA: portable
15	S: Sim / R: Sy	Asynchronous	Explicit	Upper body / Everywhere	Wearable
16	S: Sim / R: Sim	Synchronous	Implicit	Upper body	SA: Wearable:
17	S: Sim / R: Sim	Synchronous	Implicit	Hand	SA: Portable
18	S: - / R: Sy	Synchronous	Explicit	Upper body	SA: Wearable:
19	S: Sim / R: Sim	Synchronous	Implicit	Everywhere	SA: Portable
20	S: Sim /R: Sim	Synchronous	Implicit	upper-arm	SA: AP: Wearable: portable
21	S: Sy / R: Sy	Synchronous	Implicit	lower back	SA: Wearable:

Table 2.1 (c) (continued)

22	S: Sy / R: Sy	Asynchronous	Implicit	-	
23	S: Sim / R: Sy	Synchronous	Explicit	Hand	SA: portable
24	S: Sy / R: Sy	Synchronous	Implicit	Hand / cheek	AP:
25	S: Sy/Sim R: Sy/Sim	Synchronous	Implicit	Hand	AP:
26	S: Sim / R: Sim	Synchronous	Implicit	Hand	SA:
27	S: Sim / R: Sy	Synchronous	Implicit	Hand	AP:
28	S: Sy / R: Sy	Synchronous	Implicit	Hand	SA:
29	S: Sy / R: Sy	Synchronous	Implicit	Upper body	SA: Wearable:
30	S: Sy/ Sim R: Sy	Synchronous	Implicit	Forearm	SA: Wearable: portable
31	S: Sim / R: Sim	Synchronous	Implicit	Cheek	SA: AP:
32	S: Sim / R: Sim	Synchronous	Implicit	Hand	SA: Decorative
33	S: Sim / R: Sim	Synchronous	Implicit	Lips	SA: Portable/ decorative
34	S: Sim / R: Sim	Synchronous	Implicit	Hand	SA
35	S: Sy / R: Sy	Asynchronous	Implicit	Ankle	SA: Wearable: Portable
36	S: Sy/ Sim R: Sy	Synchronous	Explicit	Hand	SA: Wearable: portable
37	S: Sim / R: Sy	Synchronous	Implicit	Forearm	SA: Wearable
38	S: Sim / R: Sim	Synchronous	Implicit	Arm	SA: Wearable: portable
39	S: Sim / R: Sy	Synchronous	Implicit	upper body	SA / portable
40	S: Sim / R: Sim	Synchronous	Implicit	upper arm	SA /Wearable / portable
41	S: Sy / R Sy	Synchronous	Implicit	Wrist	SA /Wearable
42	S: Sy / R Sy	Synchronous	Implicit	Wrist	SA /Wearable
43	S: Sim / R: Sim	Synchronous Asynchronous	Implicit	Anywhere	SA / portable
44	S: Sim / R: Sim	Synchronous Asynchronous	Implicit	Upper body	SA /Wearable
45	S: Sim / R: Sy	Synchronous	Implicit	Hand	SA / portable

* **Touch representation**: **S:** Sender / **R:** Receiver / **Sim:** Simulated: Simulating the real action / **Sy:** Symbolic: substitute the real action with a symbol

** **Message synchronization:** data sending timing**, synchronous**: happens at the same time, **Asynchronous**: can happen in a different time or recorded then played later

*** **Interaction type: Implicit**: without user intervening as soon the connection open one start feeling the feedback / **Explicit**: the need for user intervening after the connection open one need to intervene to accept the feedback feeling / If the paper does not mention which one I am interrupting that based on the working principle of the prototype

**** A**P**: embedded in an artefact / **SA**: stand-alone / Decorative can be entertainment or just look good

2.5.1 Trends in Remote Social Touch Literature

In this section, the main trends which are based on the categories presented in Table 2.1 (a, b, c) are further explained with examples. Here trends mean a common occurrence of research output's feature observed in the literature.

The purpose behind the research outputs

There are many reasons why these research outputs were made, however, mostly the purposes are for enhancing or encouraging social interaction, and affective connectedness such as increase intimacy for remote relationships. The Sensing Beds (Goodman & Misilim, 2003) for example, allowed intimate couples to communicate presence to feel the existence of the other person remotely through the concept of 'Bed', where one feels the warmth from the bed if the other person is laying on the remote bed. This concept tracks one's bed behaviors such as movements during sleep and various bed-time behaviors that can be translated into warmth for the other (receiving) person. This ambiguous presence can still help with the feeling of connectedness by knowing that the other person is doing the same thing.

Some researchers investigated the enhancing of the current communication tools. Park et al. (2012) investigated simple touch addition while using a mobile phone to allow non-verbal and emotional communication. Their research output (Figure 2.31a) allowed translating touch-based gestures to vibrotactile display rendered on the receiver's cheek in real-time during a call. They stated that the research output helped to enrich emotions, allow comfort, and move the conversation in a positive way. Similarly, Park et al. (2013) (Figure 2.31b) investigated attaching a poke action to a phone conversation between long-distance couples, when the sender pokes a place on an object hold by the hand near the cheek an area on an object hold by the receiver hand near the cheek inflates. Their study found that participants used it for expressing emotions, replacing a word with touch, and feeling close to the partner,

however, their participants did not used it while fighting, fatigue, or serious situations.

Figure 2.31. a. Vibrotactile display on a mobile phone by Park et al. (2012), and b. POKE by Park et al. (2013)

User Count

Another observation about such prototypes is the trend to create one-to-one interaction over a distance. This is understandable as touch communication can provide a close and private way of communication. However, a few of them investigated 'many-to-one' (multiple individuals send to one person), and 'one-to-many' (one person sends to multiple individuals). Mostly the prototypes were made to allow both parties (i.e. sender and receiver) to send and receive haptic feedback (2D-2 directional) and allow one to feel the haptic feedback as well sending it through a certain gesture. Nunez et al. (2019)'s research output (Figure 2.32a) allows two individuals to connect through the gesture of a hug, where one hugs a billow-like object to translate it to the other person through vibration and colored light, the receiver of the hug can do the same. Their test participants stated that they felt as if

being touched by the other person. Such a concept can allow back and forth communication on nonverbal cues and it may also enhance social presence. Other examples offer a different kind of connection such as "Stress OutSourced (SOS)" (Figure 2.32b) which is a "many-to-one" connection for crowdsourcing haptic therapy over the social network where anonymous individuals can send massage like haptic feedback to the wearer.

Figure 2.32. a. Cushion-type communication interface by Nunez et al. (2019), and b. "Stress OutSourced (SOS)" (K. Chung et al., 2009)

Remote social touch communication characteristics

In the literature the RST communication has certain characteristics that be investigated depending on whether they are: i) simulated or symbolic, ii) synchronous or asynchronous, and iii) implicit or explicit.

i) 'Simulated and symbolic' is about sensing and rendering the action. For example, a 'hug'. It is about whether one has to perform the hug action to send it (digitally) and feel being hugged to receive the hug message (simulated), or the action is substituted with a code (symbolic) such as few squeezes to indicate a hug.

ii) 'Synchronous or asynchronous' is about whether communication is done in a live manner between the individuals or not. For example, a phone call is synchronous, however, when a message is sent (although it can be sent

immediately) it can also be recorded and saved then sent - it becomes an asynchronous way of communication.

iii) Depending on how the people interact with the communication medium (e.g. the research output in these cases) two ways can be observed. Implicit: the research output sends or receives the touch feedback directly, or explicit: one needs to intervene to start feeling the touch feedback. Most of the research outputs are assumed to be implicit if they stated it is live communication unless stated otherwise.

- "BioSync" by (Nishida & Suzuki, 2017) (Figure 2.33a) is an example of simulated, synchronous, and implicit RST, it allows kinesthetic experiences for two people. "BioSync" reads the muscle movement of one's hand and transmits it to another person's piece, where the muscle stimulator will reproduce the muscle movement performed by the sender.

- Another example offered by Bonanni et al. (2006) "TapTap" (Figure 2.33b) can be used for emotional therapy, where one records a symbolic message of tap, press, stroke, or contact on a wearable scarf, then it can be given to another person to wear it who can access the recorded messages asynchronously and explicitly when the person needs to feel the support of a loved one.

- "The Hug" by DiSalvo et al. (2003) (Figure 2.33c) allows an explicit way of interacting through which one can squeeze the object then say the name of the receiver to initiate the connection, then the receiver has to squeeze it and say 'hello' to accept the incoming hug. This can facilitate a more familiar way of communication similar to a phone call.

- "Feelhey" by (feelhey.com) (Figure 2.33d) a wristband product example of synchronous and symbolic way of messaging. It sends touch messages synchronously between individuals. The product is able to deliver a gentle squeeze to indicate the symbolic message sent by the other person.

Figure 2.33. a. “BioSync” (Nishida & Suzuki, 2017), b. “TapTap” (Bonanni et al., 2006), c. “The Hug” (DiSalvo et al., 2003), and d. “Feelhey” available product for remote social touch, reference: feelhey.com

Haptic technologies

RST literature investigated various haptic technologies for rendering and sensing. The most frequently used haptic feedback is 'vibration' due to the ease of its implementation within the application. It can also be arranged in a grid-like form (i.e. 9 x 9 or 9x3 grid or any kind of grid configuration) or used individually (each vibration motor used in a place not formed in a certain grid or layout). Other haptic feedback technologies, such as *force* feedback, *temperature* feedback, and *electrical muscle stimulation* are also utilized.

- "TaSST" (Tactile Sleeve for Social Touch) (Huisman, Frederiks, Van Dijk, et al., 2013) (Figure 2.34a) for example, utilizes vibration motors in a grid layout to achieve the touch sensation on the forearm, the research output translates various gestures such as a hit and a squeeze into vibration feedback.

- An example of combining force and temperature feedback is "Huggy Pajama" (Teh et al., 2008) (Figure 2.34b), it is made to explore the parent-child relationship through a hug communication over distance. The system consists of a doll with the parent to hug and a clothing item with the child to wear to feel the hug through air pocket force feedback and temperature change feedback.

- Another experimental research output is "bioSync" (Nishida & Suzuki, 2017) that focuses on muscle activity, it sends one's muscle movement to the receiver, who will then feel the muscle movement through electrical muscle stimulation pads. Such a concept can allow remotely living individuals to feel each other's physical activity and may also allow reproducing the activity from one person to another.

- "iXu" from (joyhaptics.com) (Figure 2.34c) is an example of an available product that utilizing movement to deliver haptic feedback for remote

social touch. The movement is made to resemble caressing the other person through a teddy bear object.

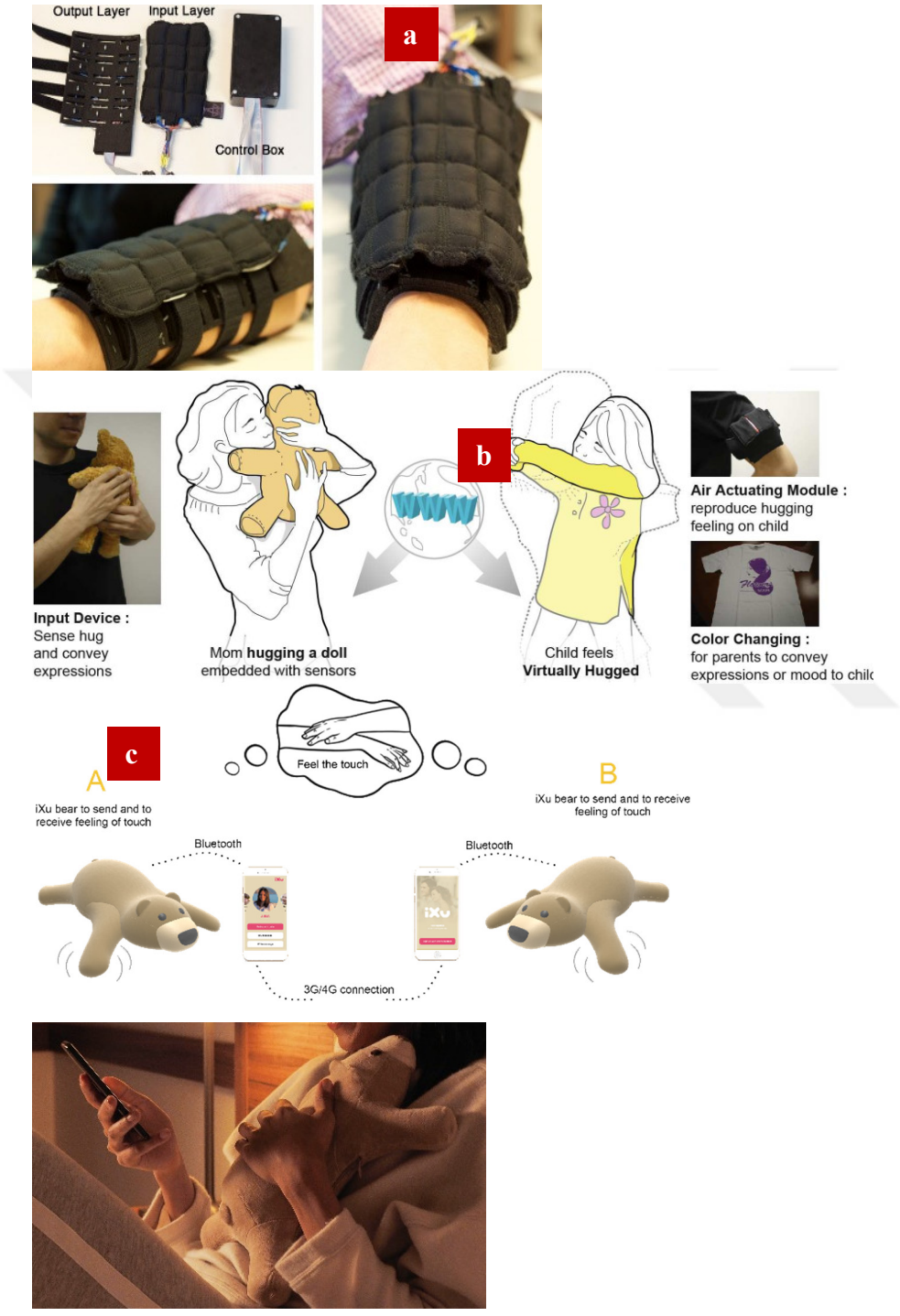


Figure 2.34. a. “TaSST” (Huisman, Frederiks, Van Dijk, et al., 2013), and b. “Huggy Pajam”a (Teh et al., 2008), and c. “iXu” (joyhaptics.com)

Location on the body

RST researchers explored various places on the body to apply the haptic feedbacks, however, the hands including the full-arm found to be the most commonly explored body part to receive the haptic feedback. Other explored body parts included the cheek, upper body, and lower back.

- "The Hug" (DiSalvo et al., 2003) for example, focuses on impacting the upper body area, where one will feel a vibration pattern when receiving a touch message.

- "ComSlipper" (Chen et al., 2006) explores the feet as a way to send and receive touch messages to maintain a sense of connection between individuals. A different area of the feet can be used to press on it to send certain feedback to the other person who will feel vibration or temperature feedback.

- Wang et al. (2010) (Figure 2.35) explore the upper arm as an area to feel the squeezing sensation, in which the sender squeezes an object for the receiver to feel it through armband tightening on the upper arm to replicate the squeeze.

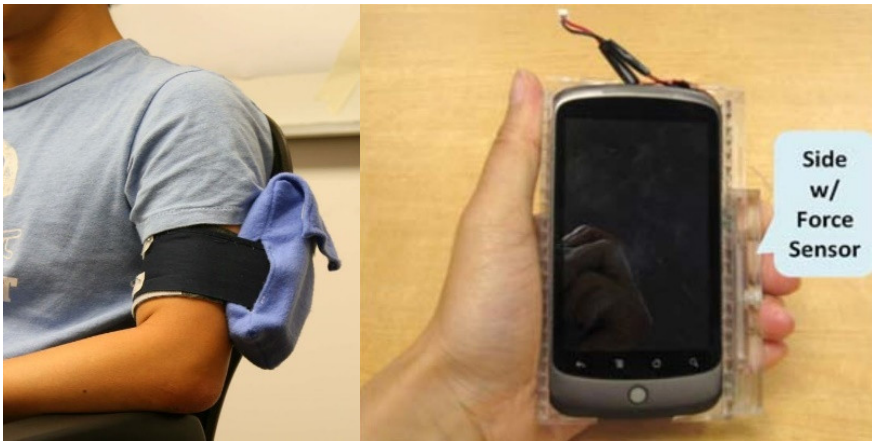


Figure 2.35. touch device using a motor actuator by Wang et al. (2010)

Haptic sensing methods

Force sensing and contact sensing are common haptic detection methods, because of the rapid availability of such sensors and their ease of implementation. Other sensors such as motion, and electromyogram (EMG) are also used.

- "ComTouch" (Chang et al., 2002) for example, uses force sensors to sense how strong one presses on an area on "ComTouch", which later will be translated to vibration feedback on the other side.

- "Pull Tug of War" (Beelen et al., 2013) (Figure 2.36) is another example of using force sensing for rope pulling game. It allows individuals to pull to control the on-screen game, the pulling from one side is also translated to force feedback to the other side joining in the same on-screen game. Such a research output helps to enhance social presence in an enjoyable collaborative digital game.

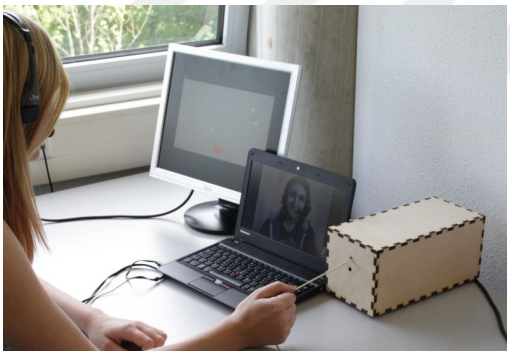


Figure 2.36. "Pull Tug of War" (Beelen et al., 2013),

Other researchers explored other ways of sensing, such as investigating the translating of text messages instead of sensing physical touch to produce the touch feedback.

- "iFeel_IM!" (Tsetserukou & Neviarouskaya, 2012) (Figure 2.37) is implemented with the digital platform "Second Life", where a user can write a message to the "iFeel_IM!" wearer to feel, for example, a hug.

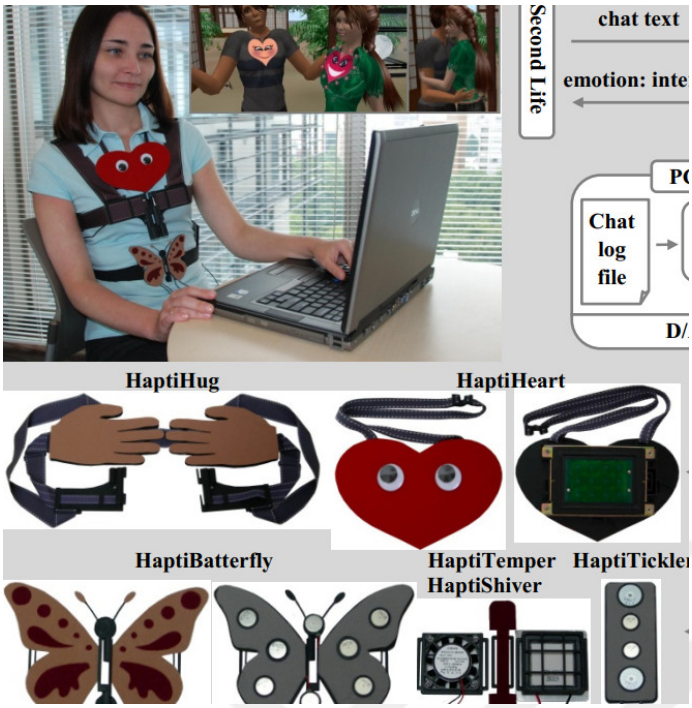


Figure 2.37. “iFeel_IM!” (Tsetserukou & Neviarouskaya, 2012)

Ways of interactions

There are various ways to interact with these research outputs to send a message, which are linked to the action one wants to send. RST researchers investigated various gestures and social touch actions to be communicated between individuals, such as hug action an example of that is “Thermal hug” by Gooch and Watts (2010) (Figure 2.38a), handshaking action Nakanishi et al. (2014) “remote handshaking” Figure 2.38b) illustrate that a grip action which is used in Dobson et al. (2001) research output “VibroBod”; the kiss is another action investigated to be communicated among long-distance relationships Saadatian et al. (2014) “kiss messaging” (Figure 2.38c) showcase that, squabble is another action explored by Laschke et al. (2010) (Figure 2.38d) among teenage boys, and various gestures and action also explored by Rantala et al. (2011) such as stroke, squeeze and abstract movements. The hug action is easier to find RST literature about this because it is commonly missed physical interaction while being away from loved ones (as this research uncovered).

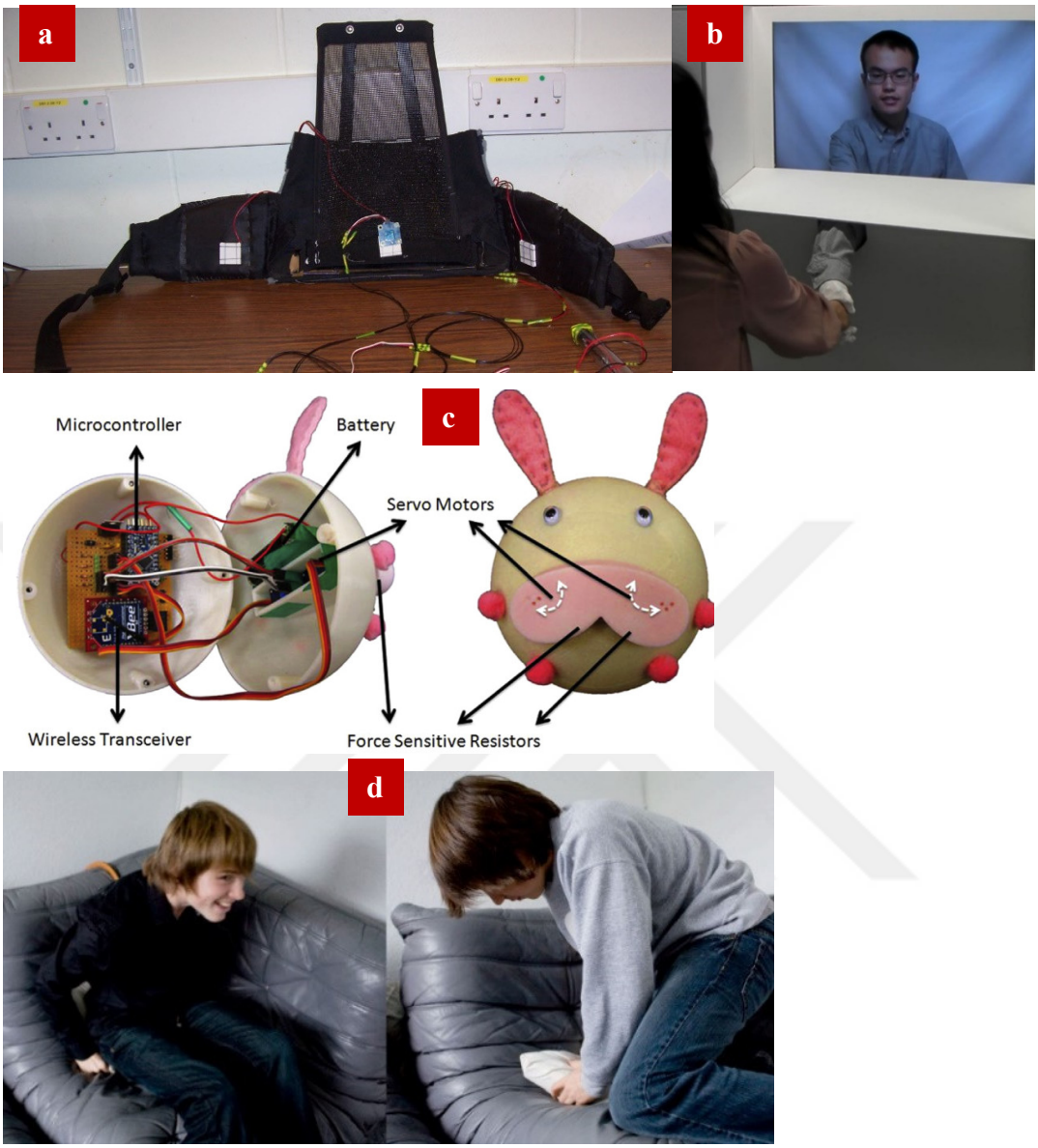


Figure 2.38. a. “Thermal Hugs” by Gooch and Watts (2010), b. “Remote handshaking” by Nakanishi et al. (2014), c. “Kiss messaging” (Saadatian et al., 2014), and d, “linked” by Laschke et al. (2010)

Artefact characteristics

Most of these research outputs are made with certain limitations of the technologies used and some are still in very low fidelity. However, it is still possible to extract a few artefact characteristics, such as being a stand-alone artefact, wearable, portable, or embedded in another artefact. Most of them are stand-alone made for RST, however, a large quantity of them are also made to be wearable in some way. Some examples are as follows.

- "Kiss messaging" (Saadatian et al., 2014) meant for sending and receiving kisses between remote living individuals. It is a small, portable, and standalone artefact that can also be decorative as it was made to look like a small doll toy with big lips.
- "TapTap" by Bonanni et al. (2006) is a wearable scarf that was made to be wrapped around the body and allow customization.

Such prototypes are familiar to the user and their functionality as RST artefact is hidden from other people to notice which is the nature of private intimate communication of touch. Some RST researchers explored embedding or attaching RST in an existing product such as electronic gadgets or furniture. Also attaching RST to a daily used object either to use it any time which coincide with the nature of touch (e.g. attaching it to a mobile phone), or attach RST to products used only in certain times (e.g. attaching it to a bed).

- "The bed" (Dodge, 1997) for example embed RST in a bed concept, Wang et al. (2010) attached the sending piece of RST to a mobile phone, and (Chen et al., 2006) attach RST to a slipper.

Utilization of other sensor modalities

There are not many other sensor modalities that were used alongside touch however, some RST researchers explored adding visual and audio sensor modalities. Visual is usually represented as changes in light colors and audio represented in melody

notification. ‘The Bed’ (Dodge, 1997) is an example of utilizing visuals in various ways with haptic feedback. In this system, the audio from one side (spoken word or noise) is translated to either colored shadow on curtains or movement of curtains, as an addition to feeling the pillow warming up with physical pulsing. ‘The Hug’ (DiSalvo et al., 2003) on the other hand, uses audio to represent incoming hugs with customizable melody notification to emphasize the personal nature of such a message.

2.6 Issues with Current Remote Social Touch and Implications for Current PhD Research

In literature, it was not possible to come across ways to use remote social touch (RST) to positivity enhance emotional wellbeing (EWB) that include all the various considerations involved within such communication despite the principle of RST was clear “one-touch a device for another person to feel it by another device”. This led the current research to be shifted away from looking into designing RST artefacts for impacting user’s emotional wellbeing. Instead, the research focuses on establishing a clear understanding of RST and the considerations involved in it. This is to enable a clear path for future RST products and RST research.

Additionally, the literature was not clear enough about what physical interactions (PIs) people miss while living away from their loved ones; do people miss physical interactions; and the way PIs are transmitted technically in a clear manner (translating PI from the human to the machine and back to the human). The existing investigations are generally carried out for predefined physical interactions (e.g. a hug); ways to send emotions with any gesture appliable to an artefact; or potential gestures that users can imagine applying on the artefact to send. This leaves a vast area underexplored and unnoticeable by RST researchers and designers. Moreover, there are some miss opportunities in RST literature that this research trying to uncover to influence future RST design and research practices. This research is neither a pure technical nor a pure psychology study but an initial step before

research deep in one of those paths, it can help researchers to develop the tools they need to either study RST for psychology purposes or develop new tools and technologies for haptic communication.

In RST literature may appear that some of these studies trying to transfer X from one person to another remote person. X can be nonverbal cues (e.g. gestures, touch), mood, physiological data (e.g. breathing cycle), or emotions. However, the final output intended from transferring X is communicating emotions or arousing them. This is to enable coping with negative emotions (e.g. stress, depression) as a result of living away from loved ones or providing a better way to interpreted certain situations. As stated previously emotional wellbeing is influenced by the memorability of an event, this can be caused by frequency or how one will re-evaluate an event over time. In F2F interaction there is also an acknowledgment of the emotion. when one reveals an emotion (through verbal on nonverbal cues) the opposite person will either acknowledge it or not. Yet most of these studies do not discuss the acknowledgment part neither the memorability of the emotion withing their working framework, for example, person A sends angry feedback to person B, person A will not know: 1) if person B received it or not, and 2) the emotional reaction from person B to the feedback.

Additionally, some RST literature is limited by the technology they build an object by focusing on the technical implementation then seek the practical implementations of the object. It is an object driven approach where sometimes a certain scenario chosen ahead for the object to achieve neglecting other scenarios may surface using the object. If a fantasy approach or open-minded approach “everything possible” used may help further explore a wide range of RST possibilities and various considerations related to elements involved in RST. Using this approach can elicit information for the user's point of view instead of providing a research output with set characteristics to see what the user perceives about RST.

Finally, another common trend not explored as one of RST features is the asynchronous way of communication. RST differs from F2F interaction is that it can

carry the physical interaction asynchronously and save it to be experience anytime. The individual who design or research RST may miss such an opportunity to focus on such feature if not aware of it. Thus, it should be made possible to easily noticeable with other RST features, characteristics, and attributes.

2.7 Existing Put Frameworks and Models

There are few frameworks mentioned in the literature that aid to understand RST as communication and some of the elements involved in the communication. These frameworks and models will be used alongside the RST literature previously mentioned in this chapter to establish an initial framework (stage one) which will be further researched by putting it in the research methodology of this research before finalizing it as a framework for designing RST for remotely separated loved ones.

Model for The Design of Feeling Communication and Entertainment Systems

The first model which can establish the initial link between two sides of communication meant for more than the verbal exchange, it is the model for the design of feeling communication and entertainment systems propose by Cheok and Zhang (2019) and (Cheok, 2009) (Figure 2.39). This was proposed to encounter the disconnectedness in physical social spaces that the communication over the internet has which provides weak connection among society. Their model consists of three components, Sensing, Actuation, and, Integration. Sensing is sender-media interaction, the media sense the multisensorial aspect of the senders and their environment. Actuation is receiver-media interaction, the media actuate sensory cues represent the sender's feelings or emotions. Integration is sender-receiver interaction, the integration of human emotion for the sender, and the receiver to understand the emotional state behind the message. Evaluation is the blurring of the real world with the virtual world that the new technologies may offer to connect both worlds.

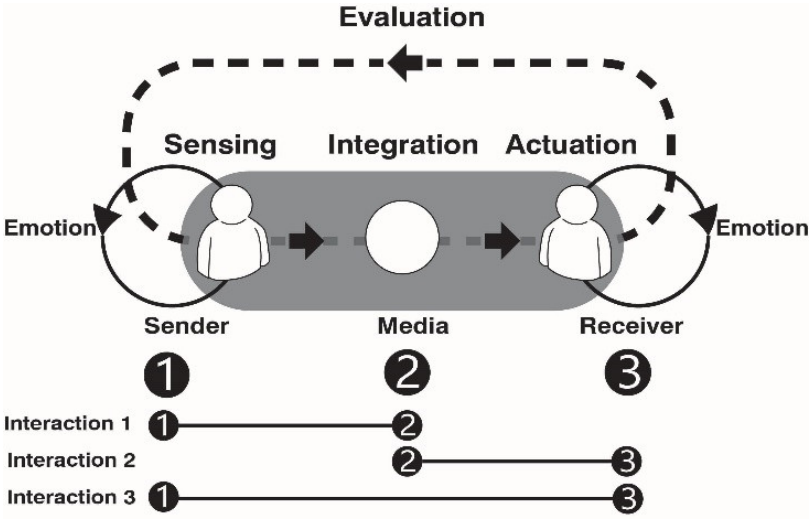


Figure 2.39. Model for the design of feeling communication and entertainment systems, reproduced based on Cheok (2009, p. 417)

As for RST, Cheok and Zhang (2019) model can aid in understanding the two sides of the interaction, However, a researcher or a designer for RST may miss a few factors involved in touch communication this model did not include. For example, elements related to user-product interaction which can evoke certain emotion or memory while a user interacting with the product (touching the product or gesturing a certain physical interaction to send it). Not only interacting with a product may evoke emotion but the product itself may evoke some emotions. Pieter Desmet (2012, p. 8) states six ways emotions evoked by a product "(1) the object, (2) the meaning of the object, (3) the interaction with the object, (4) the activity that is facilitated by this interaction, (5) ourselves, and (6) others involved in the interaction". Another point that can be added is communication qualities such as synchronous and asynchronous communication, implicit and explicit communication, and whether one trying to send direct emotion e.g. anger) or impact general valance emotion (e.g. positive or negative mood). Overall, this model was not meant specifically for RST but for communication that helps with impacting emotions.

Model of Tactile Communication

Another model proposed by Hertenstein (2002), a Model of Tactile Communication, which explains the direct touch between an infant and a caregiver (Figure 2.40). In this model, the caregiver provides the touch while the infant is receiving the touch, however the infant also plays an active role in the communication process, it is an intersection between the two. In the model, the left column refers to the qualities or touch: action, intensity, velocity, abruptness, and temperature; and parameters of touch: location, frequency, duration, and the surface area touched. Both the qualities and parameters create one structure, the stimulus array, which refers to the context the infant will be surrounded in that it will give meaning to the touch. Hertenstein (2002) continues to explain that other modalities used by the caregiver contextualize the touch such as vocal displays. In the middle of the model is mechanisms of meaning, which are direct perception, learning, and cognitive processes. These mechanisms and the context result in variant communicative effects of touch, the right side of the model which are valence emotion (positive or negative), discrete emotions (e.g. fear, love, anger), and specific information.

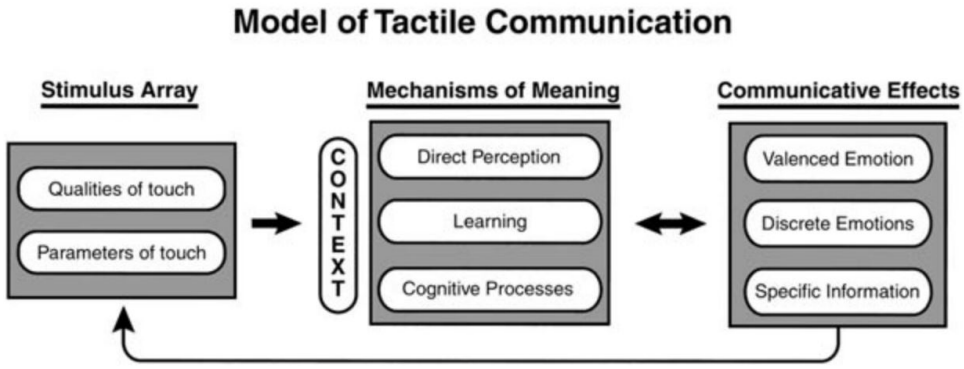


Figure 2.40. Model of Tactile Communication, by Hertenstein (2002, p. 89)

Hertenstein (2002) model is bi-directional however it means that what the infant express after the touch will feedback to the qualities and parameters of touch that will impact future touch the infant will likely experience. For example, if the desired manner is achieved by certain touch, the caregiver will continue using the same touch

else the touch will be changed. This model closer to touch communication by explaining the element of touch between two individuals (even if it was between caregiver and infant), this still applies to the subject under study in this research, remote touch in general between individuals. However, in this model acknowledgment of touch is seen as a behavior that impacts how future touch will be applied, since this model for caregiver-infant only relationship (power over a weaker) there is still a hint of unbalanced relationship give and take within the communication. Yet, this model exposes an important aspect of touch that is important for future RST applications such as the quality and parameter of touch, context, and the effect of touch (valence emotion, discrete emotions, and specific information).

Research and Design Framework for Digital Touch Communication

Research and Design Framework for Digital Touch Communication is a framework proposed by Jewitt et al. (2020) (Figure 2.41). It can be used for designing the experience, the device, or the system for digital touch communication. It offers a view of various design stages and iterative process for evaluation. One can use this framework to focus on specific research, design, or analysis concerning a specific user group and social encounter, or focus on a specific dimension of touch. This is a holistic way to explore certain topics related to digital touch communication, how a certain cell in the framework can shape the experience. Jewitt et al. (2020) state that this framework can be used to develop a method for research on specific topics or key aspects related to digital touch communication such as social encounters, technology, temporality, or sensorial experience. It helps to reflect on the ethical issues raised, and gains and losses from meditating touch digitally. At this stage, this framework is intended to be a facilitator for future development and conceptualization. It brings analytical attention to the different modes and models available for given digital touch communication encounters such as multisensorial experience, and how its interexchange with the user to create the meaning. This framework brings to the attention certain dimensions to the touch: agency and power

(who or what touches), social norms, social categories (e.g. gender), social relations, materiality, and temporality. These dimensions are entangled with the body, the technology, and the environment which provide another parallel to investigate various considerations to emphasize a specific aspect of digital touch for research or design. Through this framework, touch communication is explained with the sensorial experience as a part and a result of social encounters (human-human, human-object/robots) in social sensorial and materialistic environments.

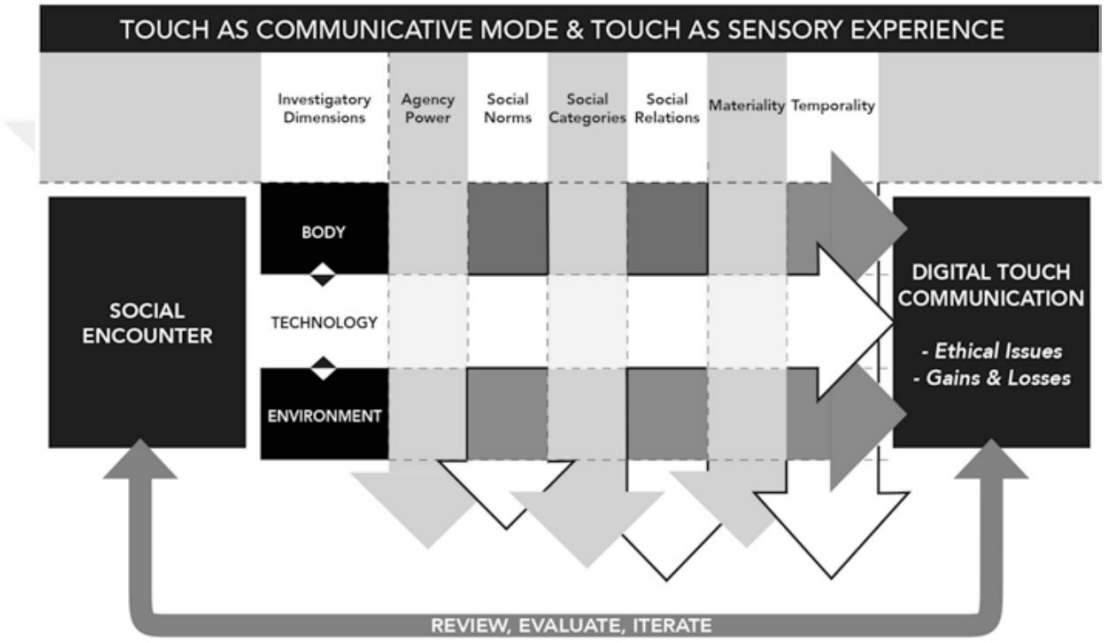


Figure 2.41. Research and Design Framework for Digital Touch Communication, by Jewitt et al. (2020, p. 129)

Jewitt et al. (2020) framework can be used alongside other previously mentioned frameworks in this section. Since this framework is explaining digital touch which another term for remote social touch, it consists of important factors impacting communication. It brought to the attention few elements otherwise were not in focus such as ethic of touch, and gain/loss of mediating touch. Yet this still did not bring the emotional aspect of touch into focus, it seems that is more focused on the general experience and the elements involved in the touch such as the social, and the

technical aspects. Remote social touch has an emotional aspect which future framework should be able to explain.

Framework for Designing Wearable Technology for Tactile Communication of Emotions

Bordegoni et al. (2012) proposes 'Designing Wearable Technology for Tactile Communication of Emotions' framework (Figure 2.42) based on Nguyen et al. (1976)'s Model of Tactile Communication. Bordegoni et al. (2012) framework explains each stage of tactile interaction between individuals and starts with the tactile stimulus applied by the sender. Bordegoni et al. (2012) put forward qualities (i.e. action, intensity, velocity, abruptness, temperature) and parameters (i.e. location, frequency, duration, and extent of the surface) for the tactile stimulus that one needs to considers. To measure these qualities and parameters one can utilize certain sensors such as touch or pressure sensors that read these data then send it to the other person's device. The connection can happen between the two devices (the sender device and the receiver device) through a wireless connection. When the receiver device receives the data, certain tactile displays such as vibration motors will render the emotional message sent by the sender. The emotional message can be perceived as an emotion, perceived as a new emotional tactile behavior, or can recall a past memory that evokes an emotional response. In this framework, they address the response as another cycle that starts the same process again from the beginning. According to Bordegoni et al. (2012), a designer of a wearable device needs to consider these components of the framework as a whole to establish an efficient loop. For example, the designer needs to consider the materials as it affects the tactile qualities or the kind of tactile display as it effects the tactile perception.

Even though Bordegoni et al. (2012) framework is meant for designing a wearable device for the reason of RST, it still can be used for nonwearable RST devices. This framework did address the cycle of communication, the main component of RST, and brought the attention to the emotional side of RST. However, this framework lacks mentioning the communication characteristics of RST such as synchronous

/asynchronous communication, implicit /explicit communication, and saving the messages and their impact. Additionally, tactile interaction among individuals is multi-sensorial experience however in this framework was solely focusing on tactile interactions in its technical form describing the tactile detection and rendering sides.

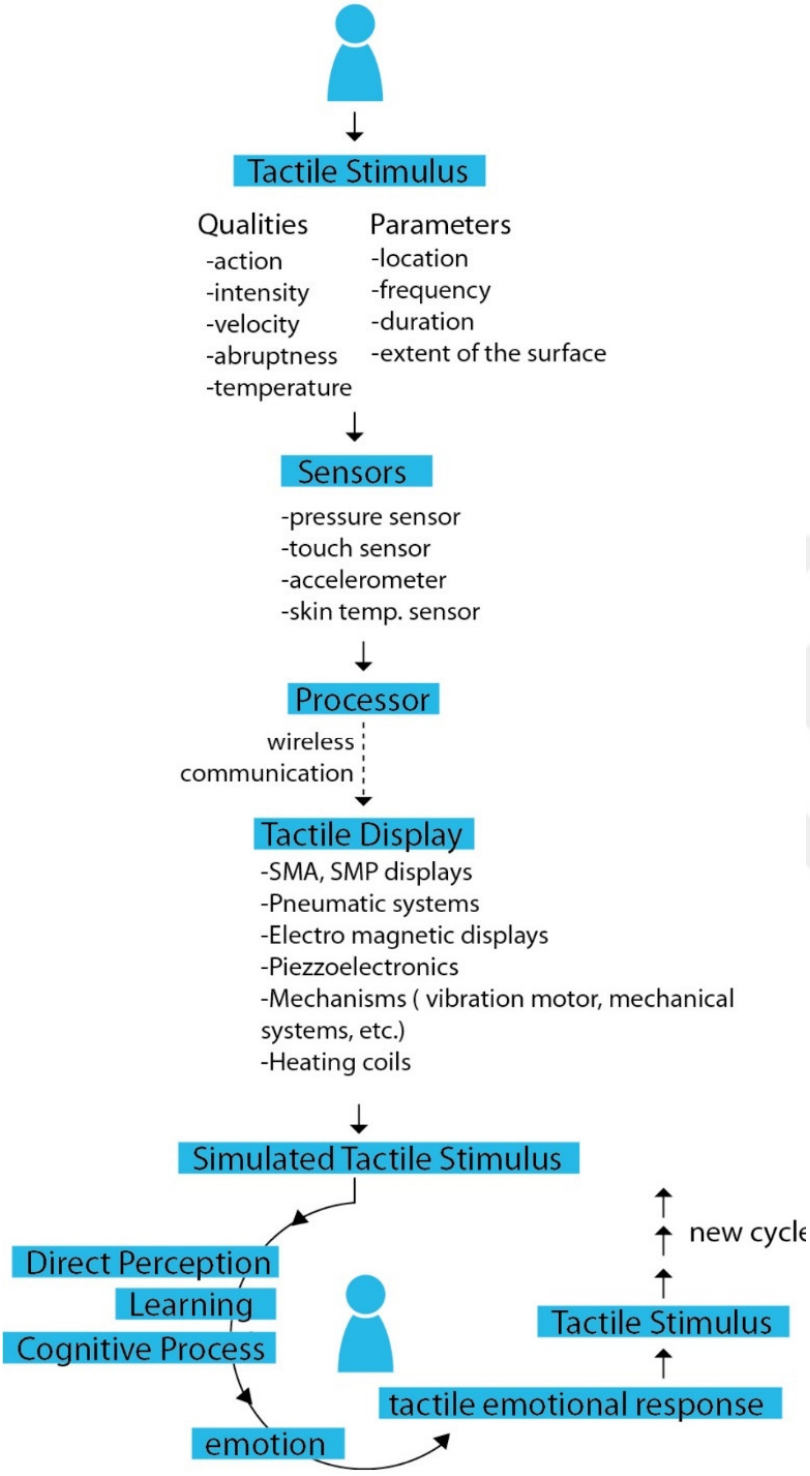


Figure 2.42. Framework for Designing Wearable Technology for Tactile Communication of Emotions, by Bordegoni et al. (2012, p. 4)

2.8 Remote Social Touch in its Relation to Theories from Human-Computer Interaction and Product Design Fields

There are few theories in Human-computer interaction (HCI) and product design fields that can link remote social touch (RST) to the users of such technologies. Researchers and designers can use these theories to establish the basis to explain how this technology might propagate among target users. In this section three main theories are discussed in relation to RST: i) technology acceptance model, ii) embodiment theory, and iii) innovation diffusion theory. However, the researcher believes that a researcher or a designer working in the fields of design and/or HCI should also investigate other relevant theories that could enhance the understanding of RST concerning the target users.

i) RST and Technology Acceptance Model (TAM)

While designing for RST artefacts, theoretical background related to new technologies can also provide useful insights, such as the technology acceptance model TAM (F. D. Davis, 1985). The technology acceptance model (Figure 2.43) can help to describe an individual's motivation to accept a technology, for example in the context of the present research the RST product of the future. The model was introduced by F. D. Davis (1985) to explain the user's intention to use technological innovation. The model relates user's motivation towards technology by means of two main factors:

- Perceived ease of use: the degree to which the individual believes that the effort requires to use technology is minimum.
- Perceived usefulness: the degree to which the individual believes the technology helps to achieve a job better.

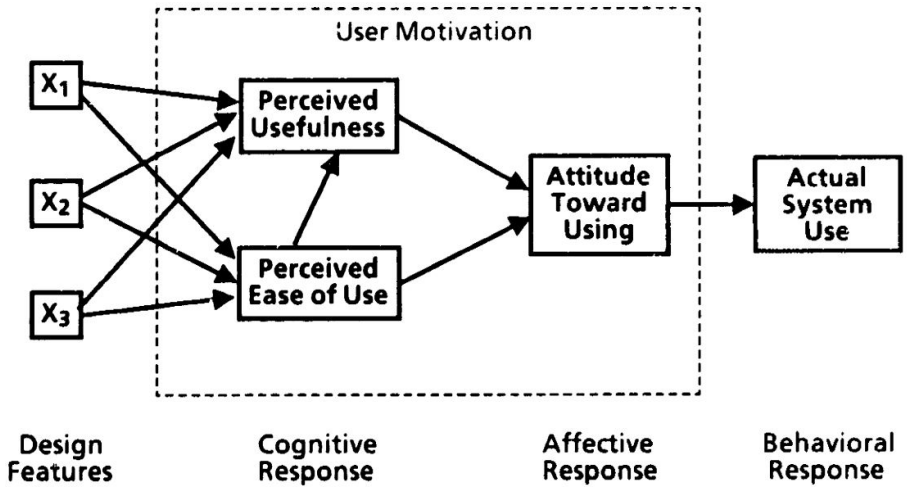


Figure 2.43. Original technology acceptance model proposed by F. D. Davis (1985, p. 24)

While designing for RST, technology acceptance model can help to manipulate the external "design features" (Figure 2.43) to impact the user's attituded (interest in/ motivation to use) toward the acceptance of such technology with the help of TAM measurement questionnaire proposed by F. D. Davis (1985). A further investigation can be done to check how to adopt this model within the design of RST products.

ii) RST and Embodiment Theory

RST products can be tangible artefacts that individuals physically interact to establish and/or receive the communication, these interactions can be bound by our sensory and bodily characteristics. Such interactions can be further explained by the "embodiment theory". The "embodiment" of the interaction with RST product can be interpreted as: i) the RST product is attached to our body, ii) the RST product can read our bodily movement, and iii) the RST product can move with our body that creates a local context for the product to interact with (Van Dijk, 2018). The interaction with RST product can take a similar meaning as explained by Merleau-Ponty (1962)'s description of 'embodiment' that the interaction with a RST product could take us away from our "embodied being". While interacting with a RST product we are taken out from our embodied being-in-the-world and asked to interpreted the actions in our "mind", we are not intended to interact with the product

but we use our body as the extension of or mind thinking of what we initially wanted to do. For example, we might be thinking about hugging the loved one in our mind but we may interacting with a tangible artefact with our body. While interacting with RST artefacts, based on Merleau-Ponty theory, our body and mind are considered as one and over time these artefacts could be incorporated into our habits (Merleau-Ponty, 1962). This is another theory that designers involved in RST should consider. This is because, while interacting with a RST artefact we are not only interacting physically with an artefact, but also our mind imagines something else while the body physically manipulates something different.

iii) RST and Innovation Diffusion Theory

The adaptation of a RST product may vary among the individuals, which can be explained better by the innovation diffusion theory. The theory focuses on the *why*, *how*, and *what rate* technologies propagate among people (Everett M. Rogers, 1962). In relation to this theory Fichman (2000) explains "Diffusion" as the process of a technology or an idea propagate over time across the population. Concerning RST, the diffusion process can be thought of early on while developing RST to avid obstacles preventing a future RST product propagate among the relevant users. To better help with that, one could understand the four elements that Sahin (2006) introduced as categories of this theory, these are:

- Innovations: the idea that is perceived by individuals as new. In this elements, RST researcher or designer can focus on the part that can be perceived as new to the targeted user group by explaining or introducing the "New" part of RST clearly to the user.
- Communication Systems: the channels used to communicate the new idea to individuals and among themselves. In the previous element, after identifying the "New" in RST that could be interested by the user, it is important to find the right channels to clearly deliver the information. Also, the researcher or the designer should also think about how the information will be propagated

among the individuals themselves, will it be some misunderstanding? Is the information will be clear enough?

- Time: the time that a new idea takes to cease. This is important for artefacts that are based on technology. If a technology took too long to propagate a new technology may come replacing the old one which means the process of propagating could reset and start again. Concerning RST, does the time needed to propagate may impact the technology used?
- Social System: people that make up the social system that the new idea is introduced to. Concerning RST different social could approach differently, a researcher or designer should keep in mind this point and investigate it while developing a RST.

Additionally, one can further understand how RST will propagate within the user group one is developing RST to by understanding their willingness to adopt a new innovative technology. Within innovation diffusion theory Everett M. Rogers (1995) divided the social system into five sections, innovators, early adopters, early majority, late majority, and laggards (Figure 2.44). knowing these sections within the targeted user group one can develop the right information, tools, and ways to introduce RST to and which sections one needs to focus on more.

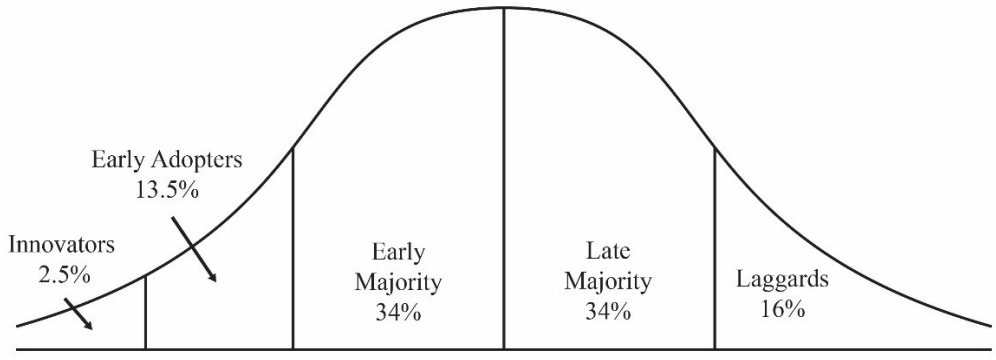


Figure 2.44. Adopter categorization on the basis of innovativeness, reproduced based on Everett M. Rogers (1983, p. 247)

Whilst designing for RST Everett Mitchell Rogers and Shoemaker (1971)'s five attributes that influence the adaptation of an innovation should also be considered:

- Relative advantage: individuals adopt a product if perceived better option than what they have. Concerning RST, a designer can think about how to make a RST an artefact that adds value to the users' life.
- Observability: how easy the knowledge about the product is communicated to the individuals. Concerning RST, a designer can think about how to arrange the right information and methods to communicate easily to the targeted user group.
- Trialability: the degree of possibility to test a product by the individuals. Concerning RST, a designer can provide a method to allow the future user of a RST to test and understand RST.
- Compatibility: the product perceived by the individuals as compatible with their needs, value, and beliefs. Concerning RST, a designer should first investigate the future user of RST and find out their need and expectations for RST.
- Complexity: how simple or complex the product is perceived to understand or use by the individuals. Concerning RST, a designer could use product trials to test how complex the RST is and what is needed to make it similar to the target group to use and understand.

These attributes are useful not only at the designing stage, but also when promoting and introducing a new technology to target user groups. Further research is required to establish a better link between technologies accompanying to RST, and its acceptance level among the individuals.

2.9 Literate Review - Discussion and Conclusions

Individuals living away from their loved ones could miss various interactions they used to engage in while being around their loved ones, one of these interactions is social touch. In this research social touch is defined as any intimate physical interaction exchange among individuals such hug. Missing physical touch could result in touch deprivation which impacted mood states negatively which could result in posttraumatic stress symptoms, stress, and depression (Tiffany Field et al., 2020). The accumulation of depression could lead to downward spirals of negative emotions (Fredrickson & Joiner, 2002). Such negative emotions could impact one's physical and mental wellbeing (Goldsmith, 2004). To prevent or to recover from such a negative state of emotional wellbeing, one should feel connected to others and feel cared for (Fredrickson, 2000). However, due to being geographically or forcefully being separated from loved ones, a person cannot access the social physical interaction a person may need on daily basis. Individuals surrounded by friends for example may still have access to some physical interaction but one my still keen on engaging physically with remote loved ones.

To solve this issue or to present to a degree a solution remote social touch was proposed by various researchers and by this PhD researcher. Due to the importance of touch among individuals as it plays a primary role in interpersonal communication (Thayer, 1986), this research was interested to understand how physical interaction can be communicated among geographically separated individuals. The researcher of this PhD research agrees with what Frank (1957, p. 242) stated: *"Without tactile communication, interpersonal relations would be bare and largely meaningless,"*. Thus, remote social touch is seen by this PhD researcher as a way to bring back meaning to remote interpersonal communication among separated individuals. There are few reasons that motivate the researcher of this PhD to pick touch among individuals as the focus. First, Touch is important for emotional development not only for the infant but adults and it will positively influence the elderly's wellbeing (Bush, 2001). Second, Touch can reduce or relieve stress (Ditzen et al., 2007) and

physical discomfort (Huisman, 2017), and have an impact on the healing process (Cocksedge et al., 2013). Third, specific emotions such as anger, love, sympathy can be communicated through touch, e.g. patting on someone with sympathy or pushing someone with anger (Nardelli et al., 2018). Fourth, touch is vital in a social setting, it is the bond to maintain and develop relationships, it has rules to follow within the social norm as such allowing who may touch our body and where (Jewitt et al., 2020). Thus, the idea of enabling the transmitting of touch remotely for its intimate and physical properties seemed to the researcher as one of the ways to impact the emotional wellbeing positively for those in need.

Similar to current PhD motivation, various researchers have explored RST in different settings. Various research outputs were produced to stimulate touch remotely. In order to form the bases of initial framework intended to be proposed by this PhD, a systematic literature review is carried out, and the researcher observed some common themes and trends among the available RST outputs. These themes and trends are as follows.

- These research outputs mostly tend to be for the purpose of enhancing or encouraging social interaction, and affective connectedness such as increase intimacy for remote relationships. Another purpose is to enhance the current communication tools such as video and audio calling.

- They tend to be created for one-to-one interaction over a distance. This is understandable as touch communication can provide a close and private way of communication. However, a few of them investigated ‘many-to-one’ (multiple individuals send to one person), and ‘one-to-many’ (one person sends to multiple individuals).

- Most of these research outputs were made to allow both parties (i.e. sender and receiver) to send and receive haptic feedback (2D-2 directional) and allow one to feel the haptic feedback as well as sending it through a certain gesture.

- Certain characteristics can be extracted from such research outputs, these are simulated or symbolic, synchronous or asynchronous, and implicit or explicit.

- These research outputs use various haptic technologies for rendering the touch sense but the most frequently used haptic feedback is “vibration” due to the ease of its implementation.

- RST researchers explored various places on the body to apply the haptic feedbacks, however, the hands including the full-arm tend to be the most commonly explored body part to receive the haptic feedback. Other explored body parts included the cheek, upper body, and lower back.

- Force sensing and contact sensing are common haptic detection methods, because of the rapid availability of such sensors and their ease of implementation.

- There are various ways to interact with these research outputs to send a message, which are linked to the action one wants to send. For example, stroking or hugging.

- RST researchers investigated various gestures and social touch actions to be communicated between individuals, such as hug, handshaking, kiss, stroke, squeeze, and abstract movements.

- Few artefact characteristics were extracted for these research outputs, such as being a stand-alone artefact, wearable, portable, or embedded in another artefact. Mostly these tend to be stand-alone and made to be wearable in some way.

- There are not many other sensor modalities that were used alongside touch however, some RST researchers explored adding visual and audio sensor modalities. Visual is usually represented as changes in light colors and audio represented in melody notification.

There are some issues with the research direction in the literature related to remote social touch and in these research outputs such as i) not clear and scattered considerations, ii) not clear why certain physical interactions were investigated over others, and what kind of physical interaction people do miss when they are away from their loved ones, iii) technical and technology-driven investigation with limitation on the technology utilized in the research, iv) researchers do not discuss the acknowledgment part neither the memorability of the emotion withing their working framework, v) Asynchronous communication was not explored as a way to provide a frequency of event to impact the emotional wellbeing.

For those issues in literature, the researcher of this PhD research intended to collect and compose an initial remote social touch framework then used it in this research to general the early proposed remote social touch framework. However, there are some already existing frameworks and models that can be used for understanding and designing remote social touch. On the other hand, there are few lacking aspects of remote social touch not explained or missed out by these frameworks. One aspect is the "user-product interaction" interacting with a product can evoke certain emotions or memory (touching a product or gesturing a certain physical interaction). Not only interacting with a product may evoke emotion but the product itself may evoke some emotions Pieter Desmet (2012, p. 8). Another aspect missed out is communication qualities such as synchronous and asynchronous communication, implicit and explicit communication, and whether one trying to send direct emotion e.g. anger) or impact general valance emotion (e.g. positive or negative mood). Additionally, in some frameworks, the general experience and the elements involved in the touch could be in focus but they do not explain the emotional aspect of touch. Moreover, tactile interaction among individuals is a multi-sensorial experience however some frameworks solely focusing on tactile interactions. Thus, the researcher of this PhD research intends to overcome these issues by proposing a remote social touch framework.

Additionally, researching or designing for RST can explore not only RST frameworks but few theories in Human-computer interaction (HCI) and product design fields that can link remote social touch (RST) to the users of such technologies. Some of these theories are:

- Technology acceptance model TAM (F. D. Davis, 1985) can explain an individual's motivation to accept a technology such as RST product in the future. by two main factors (perceived ease of use and perceived usefulness) which in result both shapes the attuite toward using technology. These factors are also shaped by the technology characteristics that can be manipulated by the designer.

- The interaction with the physical product can be explained further by the "embodiment" theory mentioned by various researchers in the relation of our body with the outside world. The "embodiment" of the interaction with RST product can be interpreted to i) the RST product is attached to our body, ii) the RST product read our bodily movement, and iii) the RST product move with our body which creates a local context for the product to interact with. We are not intended to interact with the product but we use our body as an extension of our mind thinking of what we initially wanted to do, e.g. we are thinking about hugging the loved one in our mind but we are interacting with a tangible product with our body. This is allowing RST researchers and designers to think not only about the physical tangible manifestation of remote social touch but how it is linked to our minds.

- Another theory to explain the adaptation of RST among individuals is the innovation diffusion theory. This theory focuses on the why, how, and what rate technologies propagate among the people (Everett M. Rogers, 1962). Additionally, it divided the user group into five sections, innovators, early adopters, early majority, late majority, and laggards (Everett M. Rogers, 1995). This is to target each section with specific information to help with the adaptation.

Researchers and designers can use these theories to establish some bases to explain how this technology might propagate among target users. However, there might be other theories that might be relevant to other cases of research or design as well.

CHAPTER 3

RESEARCH METHODOLOGY AND FIELDWORK SET-UP

3.1 Introduction

This chapter describes the methodological framework carried out in this research. It is divided into few sections: the first section reminds about this research aim and questions. The second section briefly describes the research process and stages meant to answer this research questions. In the third section, description about self-exploration stage. The fourth section is the description of the initial proposed remote social touch framework put together after surveying the literature. The fifth section discusses the research direction for implementing the proposed Remote Social Touch (RST) framework. The sixth section elaborates on the materials used for data collection for the fieldwork. The seventh section explains the fieldwork set-up carried out in this research, explaining its various stages and the changes that happened due to COVID-19 restrictions. The last section describes the proposed data analysis procedure.

3.2 Aims of the Research and Research Questions

Chapter one introduces the aim of this PhD research which is to investigate ways to communicate social touch physical interaction remotely through a product. Additionally, it is important to understand the process for such communication, thus this research aims to put forth a scheme of the communication process of remote social touch. The research is going to take into consideration the various aspect that impacts such a concept and the target user group. In this direction, this PhD research aims to find answers to the following questions and supporting questions:

- How can a product facilitate delivering ‘social touch’ between people who are geographically apart?
    - What is the importance of social touch? And What are the most missed physical interactions while living-away from loved ones?
    - How can these interactions be substituted with a technological product?
        - What are the characteristics of the technologies that enable communicating physical interactions between individuals?
        - What are the characteristics of a product to facilitate Remote Social Touch?
            - How would the user interact with the product?
            - Where the wearable product should be located on the body?

3.3 The Research Process in Brief

The process of the PhD research is illustrated in Figure 3.1, further details about the stages are as follows.

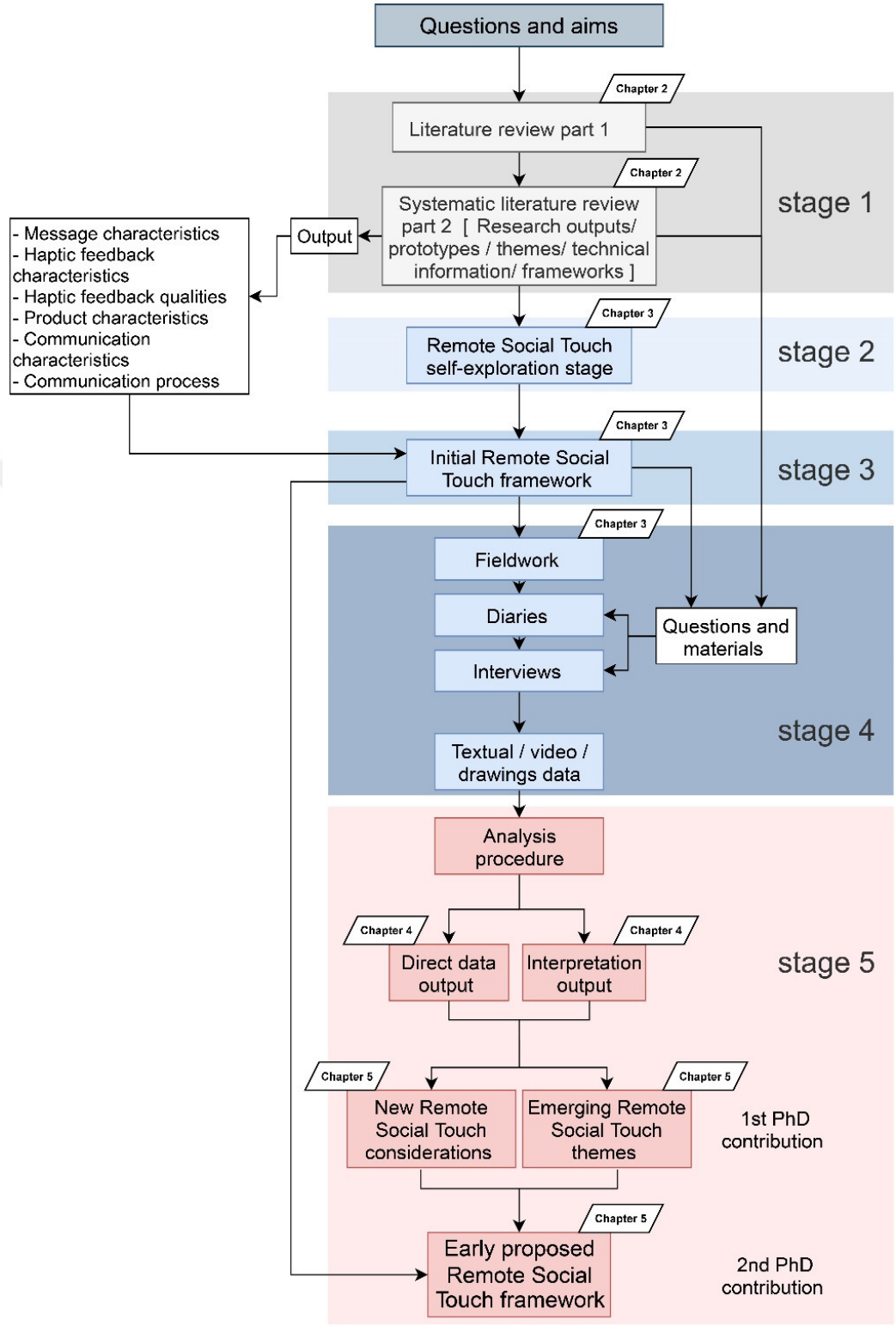


Figure 3.1. The PhD research process

Stage 1

First, a literature review is carried out in a few related fields and subjects to understand more about this issue. The initial literature search was about the issues that resulted from being separated geographically from loved ones. Consequently, this led to literature related to emotional wellbeing to understand more about the emotional state when being away and its related terms. After identifying the issues related to emotional wellbeing, another search was done to find how other researchers manage to tackle such an issue. Researchers in various fields such as psychology, human-computer interaction, interpersonal communication, and product design were interested in the emotional outcome from living away from a loved one. They introduce various ways to tackle this issue including allowing multisensorial experience, awareness systems, enhancing the presence feeling, enhancing other communication media, and allowing to communicate nonverbal cues such as physical touch. The researcher of this PhD research is interested in investigating the physical touch further. This is because physical touch is underutilized in current communication media and it was utilized in literature as one of the ways to aid with emotional wellbeing for geographically separated individuals.

Literature review is carried out including the areas related to the sense of touch, social touch, mediated social touch, remote social touch (see Chapter 2 for details of the literature forming initial information of RST). The review resulted in identifying the gaps in the literature and establishing a direction for the present PhD research. Additionally, a detailed RST literature review was carried out looking into research outputs, prototypes, themes, technical information, and frameworks. The resulted information was put in categories that helped in forming the initial RST framework. The categories included: message characteristics, haptic feedback characteristics, haptic feedback qualities, product characteristics, communication characteristics, and the process.

Stage 2

After Stage 1, a self-exploration of RST through a prototyping stage is carried out by the researcher. The reason for the exploration was to understand the technical details of RST, to experience RST personally, and to develop a tool for future RST designers to test out RST concept. From this stage a rough prototype extracted as a tool to explain the principle of RST to the participants of this research. This stage also helped the researcher level of understanding of how the RST could be implemented in an artefact and how RST can be achieved with the use of simple on the shelf materials.

Stage 3

Analyzing and organizing the information from the literature resulted in an initial framework (see Section 3.5) that encompasses the RST process with the focus on physical interactions and bidirectionality of the communication. This initial framework was made for two reasons: i) to serve as a guide in this research fieldwork and its related analysis, and ii) as a base for the early remote social touch framework proposed by this research. The initial framework also covered some of the gaps missed out by the earlier frameworks in literature related to social touch and remote social touch mentioned in Chapter 2 Section 2.7.

Stage 4

In the present PhD research, to establish process and data collection materials to answers the research questions the initial RST framework is used. This was the first step to validate and investigate the framework concerning eliciting information related to RST. The RST framework was accompanied by a qualitative research approach to gain information about social touch and remote social touch subjectively from the user's point of view. The proposed initial RST framework was put forth to be utilized in RST research thus it was crucial to test the framework in a research activity related to RST. In this PhD research, there are few questions related to RST needed to be answered: how physical interaction can substitute with technology? and

what are the characteristics of a product to facilitate Remote Social Touch? These two questions partially can be answered from literature, however, a critical part of it is the target user of this technology which seems their input missing in the literature.

In the present research in order to validate the proposed framework of RST and check whether the elements were sensible, involving users was an important source of information, and their input can help with enhancing the knowledge about the subject. User's input can also be used as a source of inspiration for future RST designers and researchers (Sanders, 2002). Additionally, the input from the involved targeted users of this research provides a chance to impact the technologies and products that later will impact the user's life. This is done by exposing the users to technologies even through rough mock-ups (Schuler & Namioka, 1993). In the case of this research, this is done through expose the user to remote social touch principles and technologies through a rough prototype and RST technology video (see section 3.7). The aim to get users feedback on i) their needs and whether they would be interested in such a technology, and ii) whether the framework was able to elicit information based on uses' point of view concerning remote social touch's characteristics.

This is where the proposed initial RST framework can contribute by building the research layout based on all the different considerations related to RST while involving the targeted users. A common method to involve the users is self-reported ways such as interviews, online diary, cultural probes (Simonsen & Robertson, 2012). However, social touch is a very personal and intimate subject for that certain methods utilized by the researcher can elicit information from the users and yet do not disturb the personality of the touch. In this PhD research, as part of the fieldwork two methods used online diary and the interview (see Section 3.7 for further details). These methods and their accompanying materials and tools made one set for the fieldwork needed to answer the research questions. From this stage, the resulted information can be categorized into i) textual data, ii) video footage data, and iii) and, drawings data.

Stage 5

To analyses the data collected in the fieldwork a qualitative analysis approach is going to be used, this is because the study is carried out using qualitative methods that gain mostly subjective data from the participants. The findings from analyzing the data from the fieldwork are not only meant to answer the research questions but i) to act as the first validation process related to the proposed RST framework, and ii) to use the information from the users to update the framework about any missing consideration related to remote social touch missed out by the literature.

After analyzing the data (see Chapter 4), two main results were achieved. First the findings of certain new considerations related to remote social touch, and secondly is emerging RST themes. These two outputs are used to develop a second iteration of the proposed RST framework. The second iteration will highlight the main considerations related to remote social touch by adding the ones mention in literature and add new consideration found through this PhD research (see chapter 5 for further details).

3.4 Remote Social Touch Self-Exploration Prototyping

3.4.1 Reasons Behind the Self-Exploration

To understand the technical detail

The researcher was not fully aware of the technical details that are required to develop a working RST prototype. Thus, the researcher decided to undergo a self-exploration experience where it is possible to learn the technical details to create a communication device for the reason for transmitting touch feedback and stimulating the touch sense. Investigating the literature resulted to gain two kinds of information,

i) Technical information about communication (i.e. how the communication should be made). The information is related to the tangible parts needed for the communication, the principles for transmitting information from one side to another, and the simplest framework for communication touch.

ii) Technical information about detecting the touch sense. In literature, one can find from very technical information to simple off-the-shelf solutions able to deliver the main principle for detecting touch. After understanding this point an internet search underwent to find accessible off-the-shelf material to serve this point.

iii) Rendering haptic feedback to stimulate the touch sense. Similarly, in literature, one can find from very technical information to a simple off-the-shelf solution able to stimulate the touch sense. Additionally, there are various ways to render haptic feedback thus the reassures needed to understand each type and the availability of the type of haptic feedback to be reproduced from accessible off-the-shelf materials. After understanding this point an internet search underwent to find accessible off-the-shelf material to serve this point.

To personally experience remote social touch

Until the point where a prototype was developed by the researcher, the idea of remote social touch (RST) was only understood by text and visuals, the researcher did not experience RST yet before. For that one motivation to develop the prototype is to self-explore and self-learn about the main essence of RST and to feel the haptic feedback. The researcher working by hand trying to achieve certain haptic feedback to experience it through a remote touch communication prototype helped the researcher to form a solid understanding of the content of the literature related to remote touch better.

To understand the characteristics of remote social touch

Developing the prototype helped to understand some remote social touch characteristics that are related to communication and haptic feedback. Concerning the communication, working on the prototype helped to form an understating of symbolic communication, synchronous communication, and implicit interaction. In relation to haptic feedback, the prototype helped to form an understating of force feedback, tactile texture feedback, and active/passive feedback. Additionally, working on the prototype made it possible to see how one (a designer, a researcher, or a user) can customize these characteristics to suit a certain need. For example, customizing the haptic feedback to feel a certain way, or one kind of haptic feedback can be accompanied by another, each can be stimulating a certain area of the human body.

To extract a simpler version (an early-stage low fidelity working prototype of haptic communicator)

Another aim to develop the prototype was to extract a simpler version for the participant of this research to try especially for the one-to-one interviews. The simpler version aims to illustrate the principles of remote social touch for the participants for them to understand, and to feel the haptic feedback instead of imagining it. The simpler version should look like a tool without any indication of a final product so it will not limit participants' scope to judge a final product instead of discussing the concept of RST. Refer to Section 3.7.2 for detailed information about the simpler version.

To develop a tool to test RST

The intended reason for developing this prototype is to have the technical side of RST investigated by the researcher. However, it was not meant to resemble a complete product, it was rather an early prototype. The technical exploration aimed to establish an open-source material for future RST designers and researchers. This was to allow them: to use off-the-shelf material with the instructions created in this

research; and to build their own RST tool/prototype to test their hypothesis; and to experiment with various considerations related to RST.

3.4.2 The Process for Building the Prototype and the Technical Details

The process of building the prototype followed the stages illustrated in Figure 3.2, following the explanation of each part of the process.

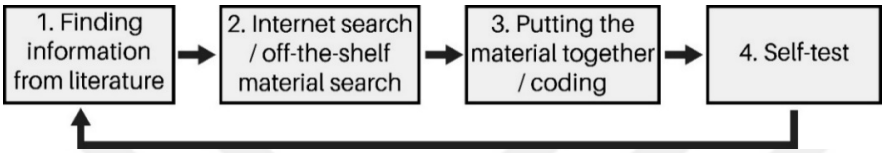


Figure 3.2. Developing the prototype process

1. The process started with collecting enough information from the literature to start developing the prototype. Additionally, few available prototypes/ research outputs/ tools are used as a base to develop this research prototype. For example, Huisman, Frederiks, and Heylen (2013) for their research they developed a wearable prototype (warn on the forearm) (Figure 3.3). Their prototype able to sense touch and render haptic feedback, they utilized vibration motors in a grid-based layout (3X4). In this PhD research, the researcher sought to build a similar prototype however with two changes, i) utilizing force feedback instead of vibration feedback as this research trying to test other kinds of haptic feedback than vibration, and ii) separate the receiver from the sending for easy understanding the various RST considerations on each side of the communication.

Figure 3.3. Huisman, Frederiks, and Heylen (2013) prototype

After collecting the necessary information from the literature a list of criteria was put to guide the prototype building process. General criteria included the following:

- The prototype should be constructed in two parts: the sender and the receiver.
- It should be wearable, so it is possible to test various locations on the body.
- The communications should be achieved wirelessly so that it is possible to miniplate the sender and the receiver parts without having need to handle any cables.
- The communication should be done in a live manner if one sends a message then the other person should feel the message directly without any delay.

Criteria for haptic feedback:

- In the literature, it is common to use vibration as a way to render the haptic feedback however to explore other types of haptic feedback force feedback should be used to render the haptic feedback.
- The feedback can be coded by the users (a symbolic way of sending a message) which means that one may assign meaning to the feedback.

2. An initial technical list of materials needed to develop the prototype was generated, then an internet search underwent to find off-the-shelf materials. Table 3.1 and Figure 3.4 show the final list of the material used in the prototype.

The heart of the prototype is the ESP32 Arduino board this is because i) it has a wireless capability for communication between the two boards, ii) small enough to be easily handled around and be integrated into a wearable application, and iii) it has capacitive touch inputs to map the touch sensor on. For touch sensing, a conductive fabric used this is because it can easily integrate into a wearable application and able to sense the touch contact. For rendering the haptic feedback, a mini servo motor to create deformation able to generate light pressure on one's skin.

Table 3.1. List of materials used in the prototype making

Quantity	Part	Comments
2	ESP32 / LOLIN32 Lite	It is an Arduino board that has wireless capability and has enough inputs.
1	16-Channel Servo Driver / PCA9685	To manage and easily control the various servo motor used in this prototype.
9	SG90 9G Servo Motor Mini	It is a 180-degree rotational motor, able for precise positioning based on the degree of rotation.
2	3.7V 1100mAH 1S Lipo battery	The prototype is using 3.7-4 volts for an energy source. Batteries will allow it to be portable however it can use USB cables to connected to another energy source with enough volts.
-	Jumper cables / various other cables	It is used to connect input and output.
-	Wearable Conductive Sewing Thread with Stainless Steel Support	This is used to connect the conductive fabric to the cables or the Arduino board, it is not necessary it can be replaced with cables.
-	Woven Conductive Fabric	It is a fabric used to create the touch sensor by sensing the skin conductance.
2	2-Position Slide Switch	To switch the energy source on/off.

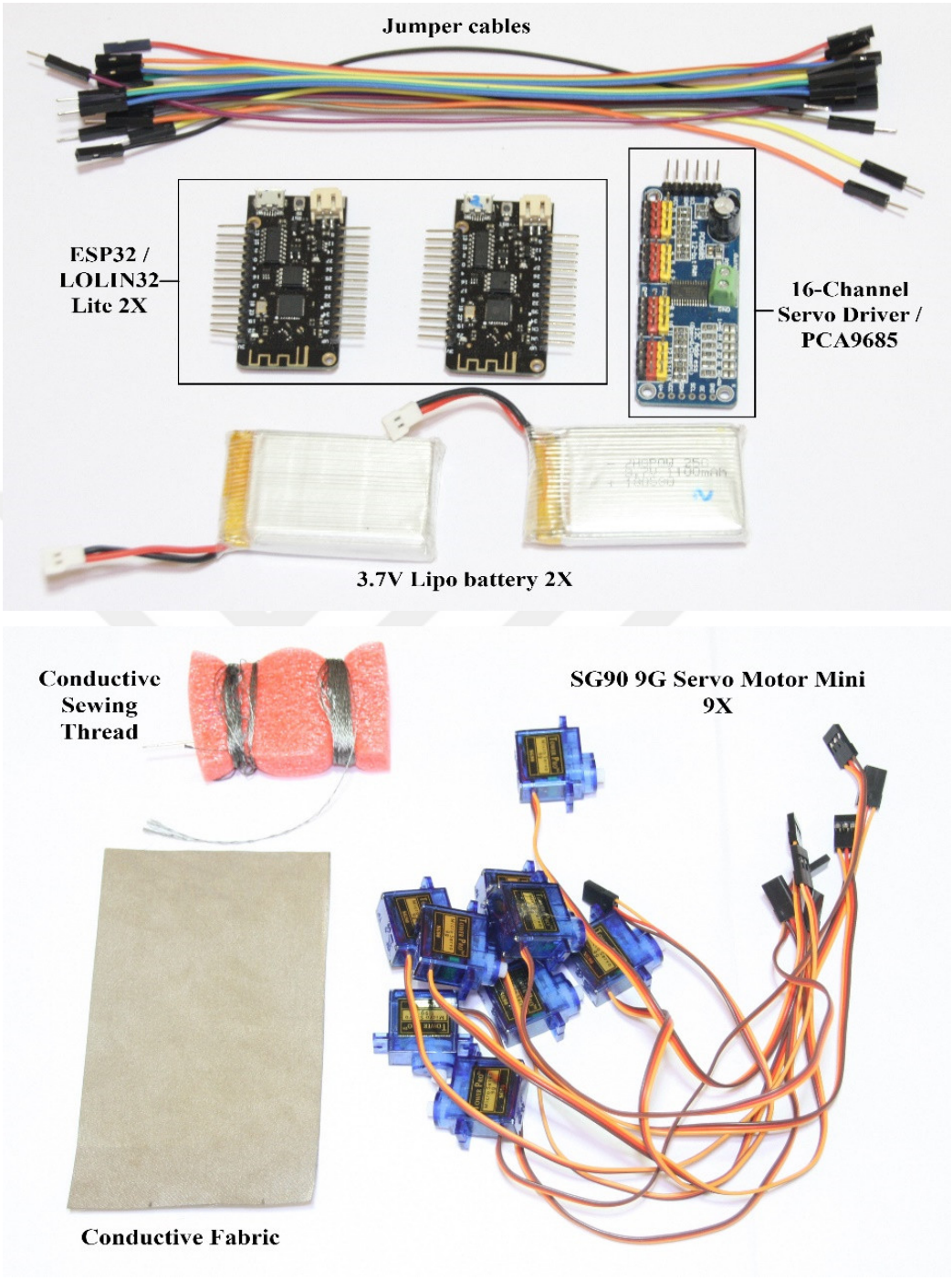


Figure 3.4. Materials used in the prototype making

3. Putting the material together: after collecting all the materials trial-and-error phase started to find the best way to put all the material in a way to deliver a remote social touch communication.

    - First, all the electronic parts were put together based on the diagram illustrated in Figure 3.5. The sender part consists of the electronic board and the touch sensor. This part can be powered by a battery or a 3- to a 4-volt energy source. The touch sensor is made of two layers of conductive fabric with a separation layer Figure 3.6, when the sensor is touched it allows the current to go through which will yield a successful touch indication. The receiver part consists of the electronic board and force feedback actuators. This part can be also powered by a battery or a 3- to a 4-volt energy source. The receiver part contains 9 servo motors that make the force feedback actuator. The actuator delivers the feedback based on rotation that feels like a light pressure on one's skin. All 9 actuators are arranged in 9X9 grid format as can be seen in Figure 3.6. The communication is done in a live manner, as soon one touches the touch sensor the actuator moves.

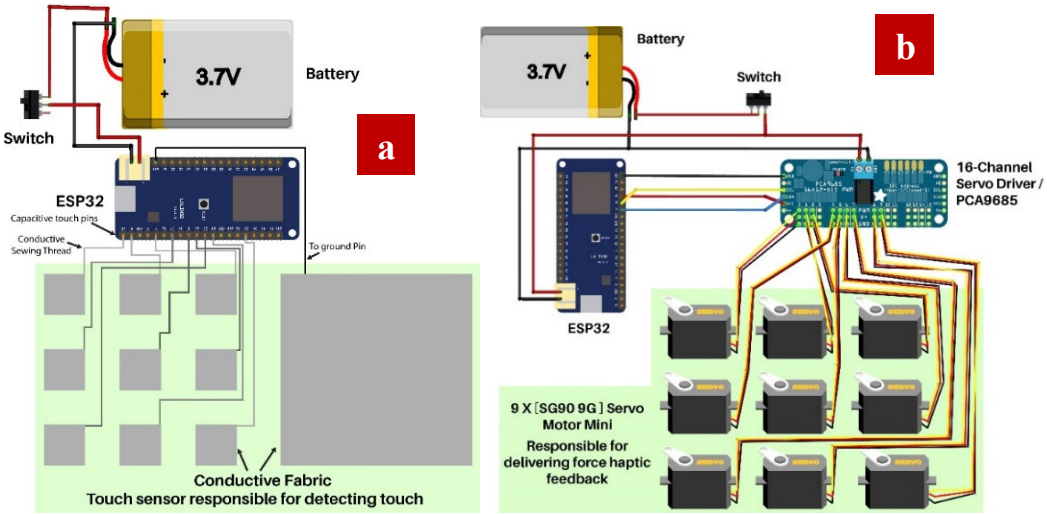


Figure 3.5. a. Sender Arduino diagram, and b. Receiver Arduino diagram, illustrated by the author, check appendix A for higher resolution

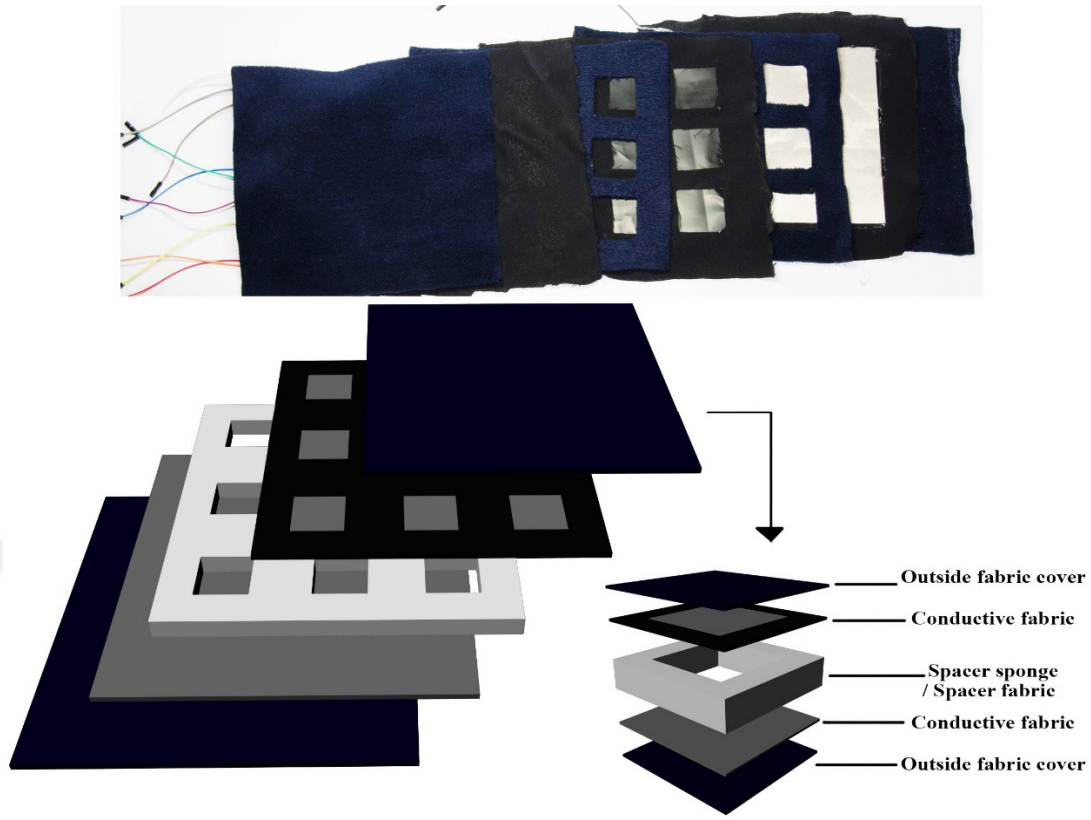


Figure 3.6. Touch sensor diagram 9x9 grid

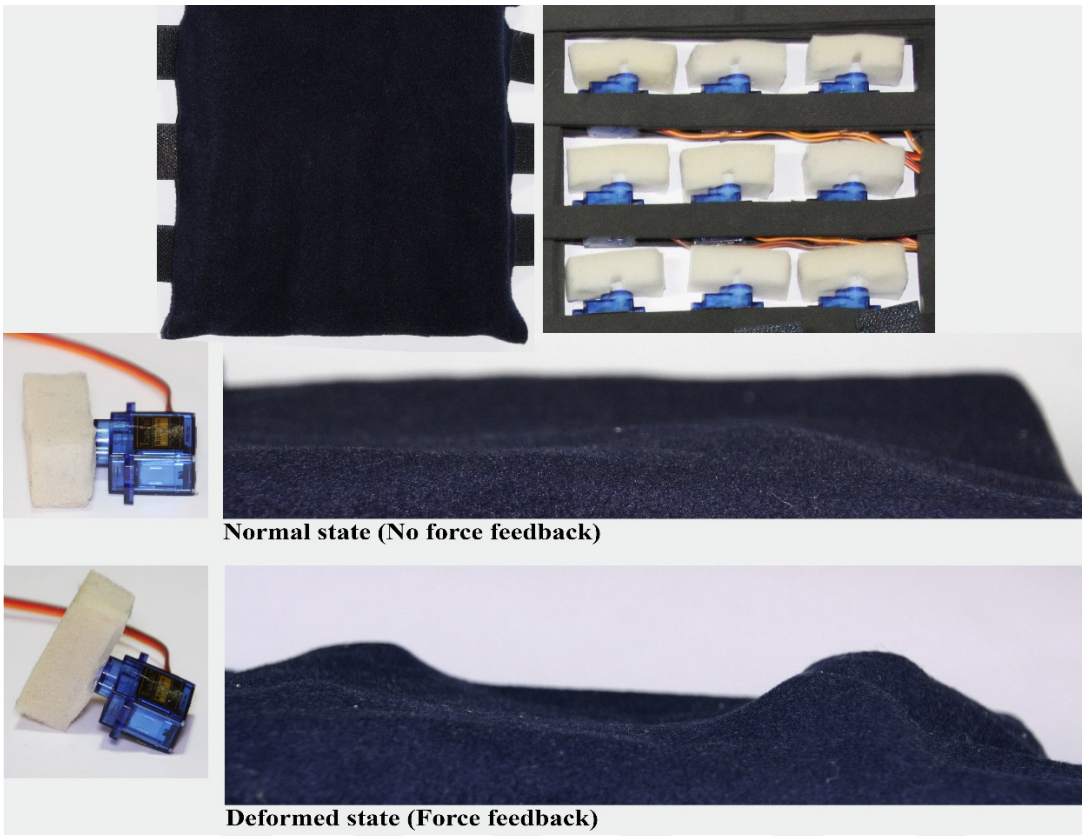


Figure 3.7. Force feedback

- Second, Arduino boards were coded i) to set up the communication between the two Arduino boards, ii) to render the haptic by communicating between the board in the servo motor, and iii) to sense the touch by communicating between the board in the conductive fabric. The C# programming language was used for the code part, refer to appendix B for the full code for both the receiver and the sender parts.

- Then, all parts for the sender part and the receiver part encapsulated with sponge and fabric to give it the final look and make the prototype easy to handle, and to protect the electronic part from the outside elements. The final look is not meant to resemble a final product but just to allow an easy test of the remote social touch concept without worrying about damaging the electronic parts.

4. The prototype underwent a few iterations (Figure 3.8) to reach the current state (Figure 3.9 and Figure 3.10). each iteration a self-test underwent to see if the electronic part can communicate and do what is intended to do. Also, changes happened to the outer material that encapsulates the prototype to find a way to have the RST experience without damaging the interior parts. The main idea behind the self-test is to see how RST functions and to see if such a prototype can be made to deliver the experience of RST. This is because the researcher wanted this prototype to be easily replicated by another designer or researcher wanting to explore RST and experience it.

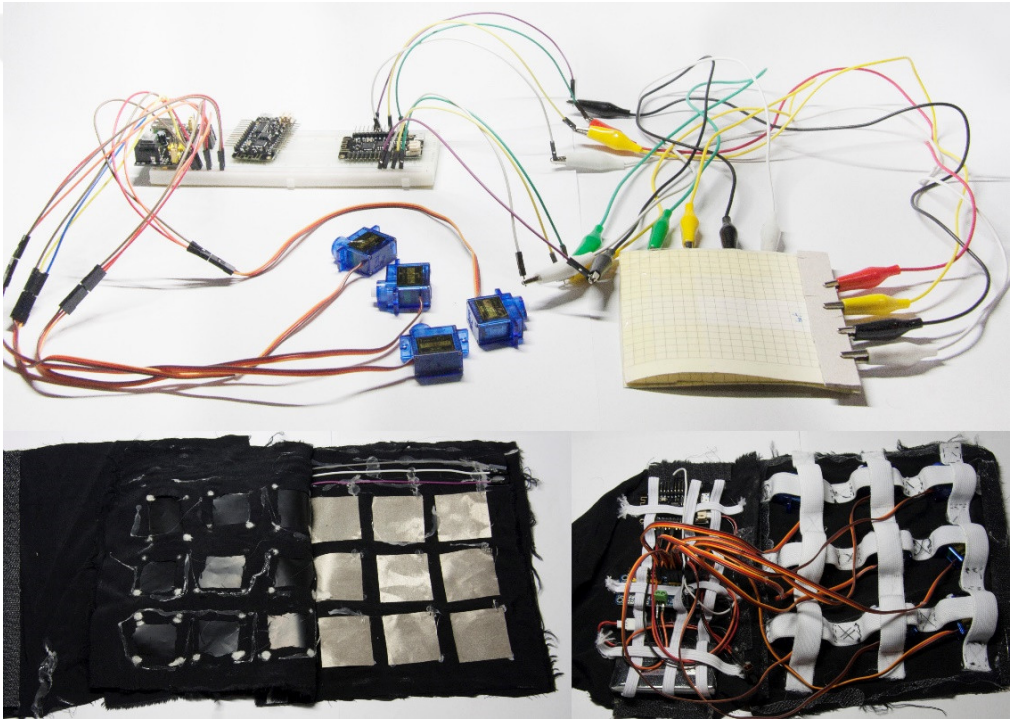


Figure 3.8. Various iterations and testing initial electronic parts.

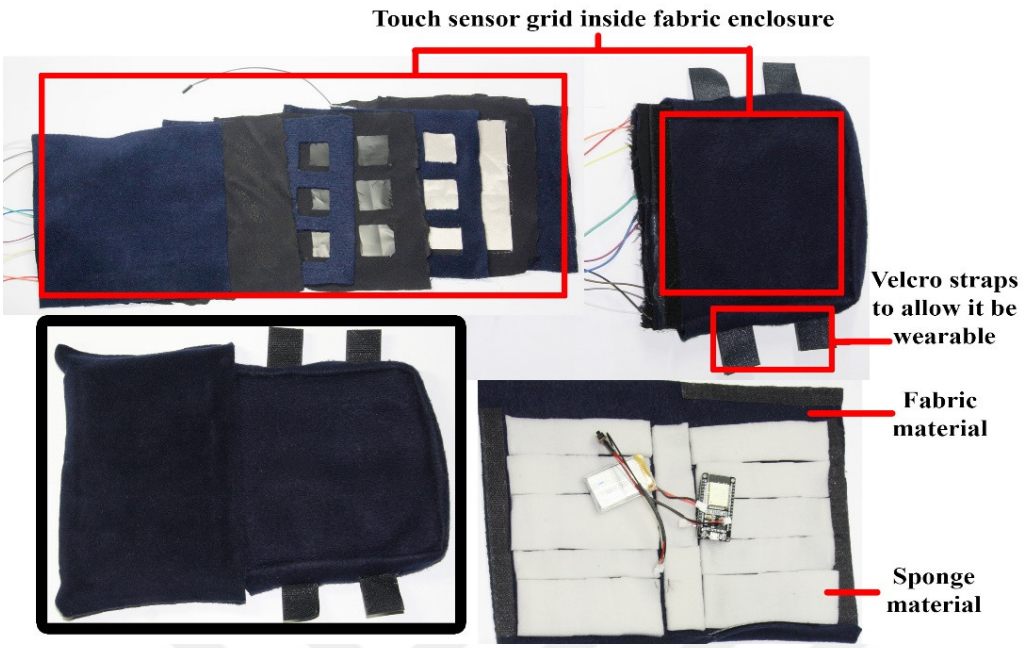


Figure 3.9. The sender part of the prototype, final iteration

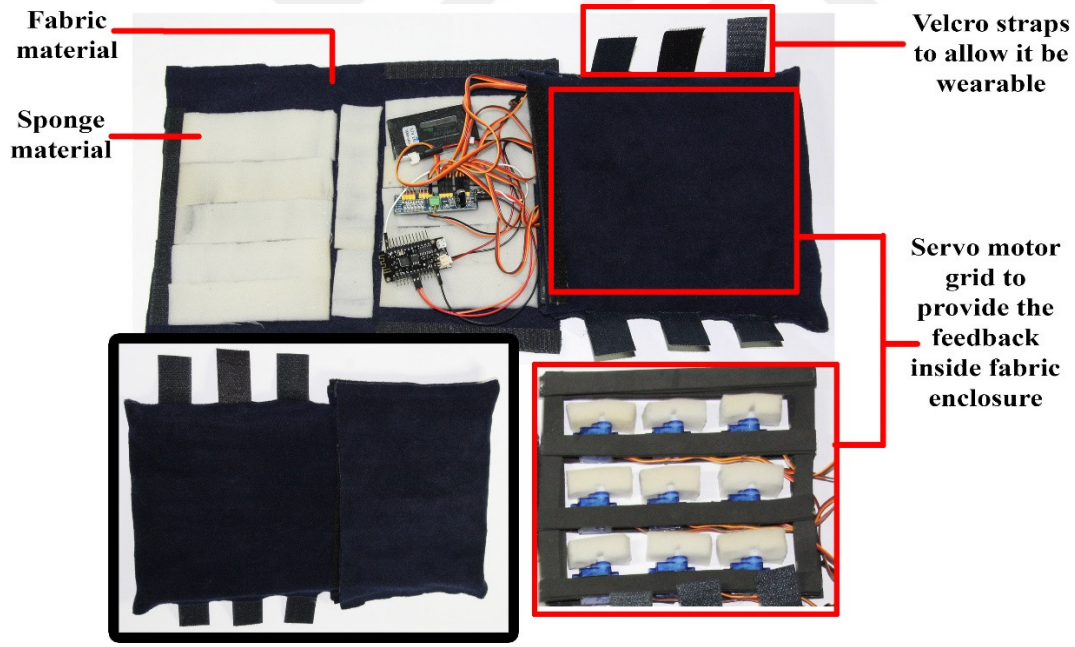


Figure 3.10. The receiver part of the prototype, final iteration

3.4.3 Reflect on the self-exploration stage and the prototype

The activity of prototyping to understand and explore an issue helped the researcher to gain much understanding about RST principles and characteristics. Prototyping allowed the researcher to link the information gained from the literature to the physical tangible remote social touch “objects”. This is important especially while working on issues related to the touch sense, prototyping allows the activation of the touch sense as a tool for learning in accompanying to the text and visual materials. From the researcher's point of view, for subjects related to the touch sense and haptic technology, it is useful to use the hand as a tool to learn and understand the subject. Additionally, the self-exploration stage prototype allows simplifying RST into a set of objectives or points needed to be tackled which makes it easier for the researcher to understand RST as a whole.

As a result, from this self-exploration stage few points were learned:

- The first point that this stage helped to understand is how the technology could limit the creation of a product's functionality. Knowing that a final product could use a higher-end material rather than the off the shelf materials used by the researcher, a certain point was raised while self-exploring. Testing a simple version of RST communication can be achieved especially a symbolic way of communication, however, a complex communication or higher degree of simulated communication is rather troublesome to achieve and complex. This point could limit a researcher's aim in the creation of a prototype, limit to what degree the prototype could help the researcher in his/her quest in finding the answers. This point was the answer for the research why some research output and prototypes made by earlier research in RST were taking certain direction rather than other ones.

- Another point learned from the self-exploration stage is the ability to manipulate the placement and the form of the prototype which could be translated the same to a RST product. This could have advantages and disadvantages. For example,

manipulating the form could allow the user to personalize the artefact to fit the needs. On the other hand, manipulating the placement of the received haptic feedback could spark an ethical discussion related to consent and unwanted touches.

- A third point that this stage illustrated to the researcher is that the material of the artefact and the haptic feedback and the interaction elicited past feelings or memories. Interacting with the material of the artefact "the soft fabric material" the researcher remembers the feeling of interacting with certain individuals physically (the fabric of the prototype resembles certain cloth materials). Moreover, the fabric itself was enjoyable for the researcher to manipulate and interact with which made the interaction with the prototype pleasant for the researcher. Additionally, the haptic feedback rendered by the prototype on the researcher's body resembles some past physical interaction with certain individuals such as poking or random touches to graph attention. However, these feelings and emotions could be different from another individual interacting with the prototype.

- A fifth point learned by engaging in this stage is while prototyping and working by hand the novelty of the activity brings motivation and interest to continue the research. From the researcher's point of view, the self-exploration brought personal engagement into the subject which increases the interest in the research in accompanying the textual materials. Additionally, documenting and sharing the self-exploration activity could be used to introduce the subject to other individuals, researchers or designers, as it could help to catalyst a discussion from other researchers related to RST.

- A fifth point learned from the prototype is from what the participants of this research and other individuals who tried the prototype, both versions the final one from this stage and the simple rough version extracted from this stage, express. The main obvious interest expressed was about the novelty of the technology and the idea of sending and receiving touch. Some individuals there

were interested in the “novelty” only however they do not see themselves using it. Other individuals thought the idea that the prototype illustrates could be used as a symbolic way of communication to grab attention in a similar way to emojis, such as fast messages “thinking of you”, “hey I am here”, and “poking”. Some individuals who tried the simple rough version of the prototype express that it could be used between friends or people who work together to grab their attention or alert them about something discretely in contrast to voice or text messages. One point could be infrared from what individuals expressed, that the views from the individuals were direct output to what individuals see and interact with. This point strength the researcher's views that using only a prototype to elicit information could limit the participant's imagination (one will judge what one sees and touch), thus limiting the resulted information related to RST.

3.5 Initial Proposition for the Remote Social Touch (RST) Framework

Most of the remote social touch (RST) literature that focuses on designing or engineering new devices that utilize the haptic sense for remote affective communication seeks the idea of cause and effect. For example, one person touches an object and the other person is then touched by another remote object. This concept can be considered as one possible direction or one cycle affect, where emotion flows from one person to another mostly without going back to the first-person (i.e. initiator). Figure 3.11A is illustrated by the researcher to represent this communication direction. However, during face-to-face communication, there is a cycle, where person A discloses a piece of information (verbal or nonverbal) that is going to cause a certain reaction in person B (verbal, nonverbal, or emotional) (e.g. an angry face can case a second person to ask why he or she is angry, one can initiate a hug action which leads the other person to accept or reject). The cycle continues after person B expresses the reaction, where person A is going to express back a certain response (verbal, nonverbal, emotional, or action response) (e.g. Person A

talks about what made him/her angry, person A going to be happy because person B accept the hug offer) (Figure 3.11B).

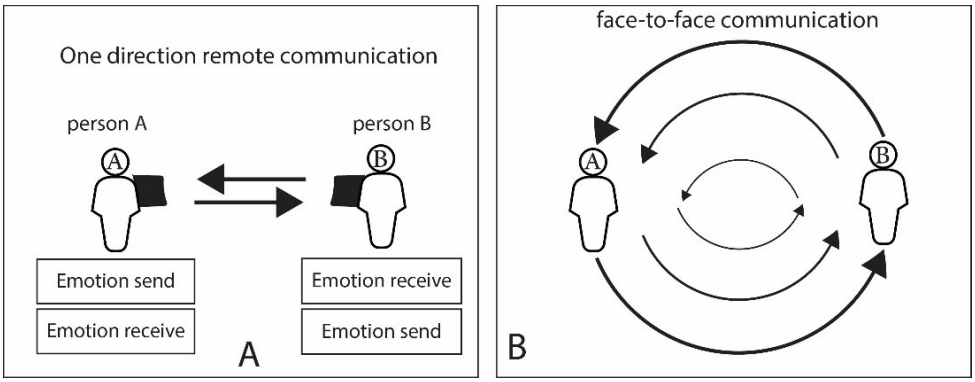


Figure 3.11. A. One direction commonly utilized by RST literature, and B. face-to-face cycle communication, illustrated by the author

The first consideration while proposing remote social touch (RST) framework was **"acknowledgment"** aspect of the communication, this can allow continuance bidirectional communication of the emotions behind the communication until the communication is terminated by both individuals. This was to dismiss any feeling of "wondering" or "worrying" about the questions that may come into mind, such as "What happened to my message? Has it been received? What reaction did they show?" and that may impose a level of mental distress. Within the framework, the cycle of RST communication consists of sending the physical interaction (PI) message, receiving the PI message, then replying to it. Based on the broaden-and-build theory by Fredrickson and Joiner (2002), the cycle can help to accumulate positive emotion, which leads to upward spirals enhancing emotional wellbeing and it can help to enhance the coping mechanism against future negative events. Additionally, it can help to decrease the lingering of the negative emotions as well as to fuel psychological resiliency (Fredrickson, 2001).

Another aspect that the framework should highlight is the **"frequency"** of an event, which is associated with judgments of happiness (Lucas et al., 2009). If an event produces positive emotions, accumulating these will lead to upward spirals enhancing emotional wellbeing (Fredrickson & Joiner, 2002). In current RST

literature, available models and frameworks lack in explaining the frequency aspect of the communication. Such communication has a value not only at the moment emotional impact but also could last and revisited after the communication is terminated (saving the message). Thus, frequency is the second consideration that should be added while proposing RST framework. The frequency in RST communication can be achieved by allowing saving the touch message or providing asynchronous communication.

Building on previous RST literature, existing models, and frameworks, the proposed RST framework considers the following aspects:

- **Acknowledgment of the interaction** allowed by focusing on the cycle of communication (receive – reply – send).
- **Frequency of experiencing physical interaction** achieved by allowing asynchronous communication with the ability to save the message.
- **Qualities related to communication** which is the way a message is sent (simulated or symbolic), synchronization (synchronous or asynchronous communication), and the way to feel the message (implicit or explicit).
- **Qualities related to touch feedback** including intensity, duration, and frequency of the touch feedback.
- **characteristics related to touch feedback** through haptic technologies, such as force, texture, temperature, and active/passive feedback.
- **Location of the haptic feedback** (the message) on the body to be incorporated by the sender or the receiver; location of the body that a product (artefact/interface) to be placed/interacted with; and how the user should act/interact to send the physical message (way of interacting).
- **Emotional impact of RST** between the sender and the receiver (person-person interaction) and between the sender/the receiver-product (person-

object interaction) (Figure 3.12). As indicated in relevant RST literature, sending physical interaction messages can arise certain emotions, such as valence (positive or negative) and/or discrete emotions (e.g. fear, love, anger). Additionally, a human-product interaction can arise certain affect, touching the materialistic product is involved in jugging the product and may/may not provide a positive experience (Crippa et al., 2012; Peck & Childers, 2003).

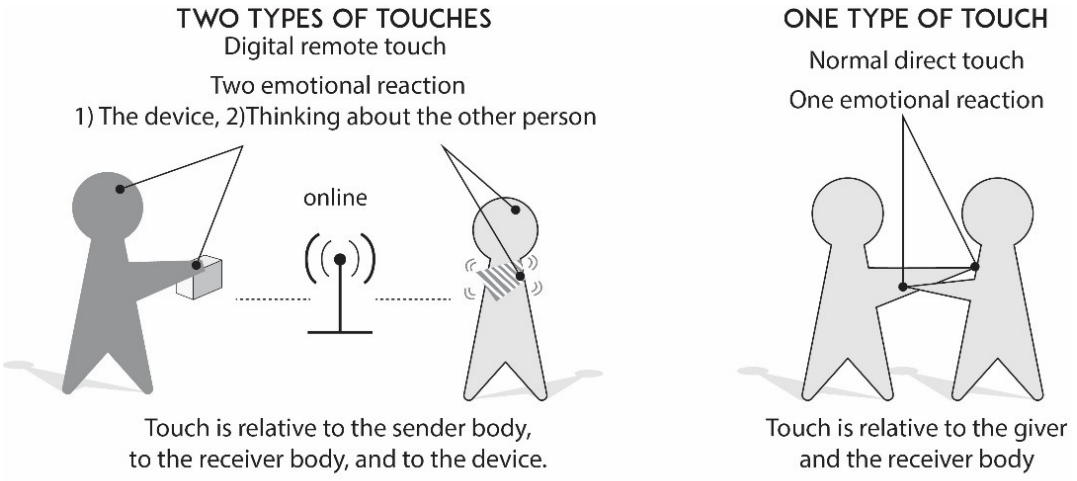


Figure 3.12. Emotional arousal in remote social touch vs. direct touch, illustration by the author

- **Multisensorial aspect of communication,** even though the framework is more directed toward RST and the touch part is the main sensor modality to carry the message however other sensor modalities impact the usual touch communication among people, this should be highlighted in the RST framework.

- **Directions of integration**, person-object, object-object, and object-person. Each direction has its own aspect that impacts the interaction, for example touching the product after reviving a message to reply will evoke two kinds of feelings, one is about the received physical interaction, the other is about the interacting with the product itself. Object-object interaction in the

current version of the RST framework is more related to technology, such as how two objects communicate rather than their psychological implications.

As the conclusion of this section, an initial (first stage) RST framework is put forward (Figure 3.13). This framework can be used to design and research RST, however, it needs to be further validated and developed to be sure that the elements mentioned able to explain various considerations related to RST. Thus, the framework was used to build and plan the methodology part of this research. This to test the proposed RST framework and to elicit the information needed to refine the framework.

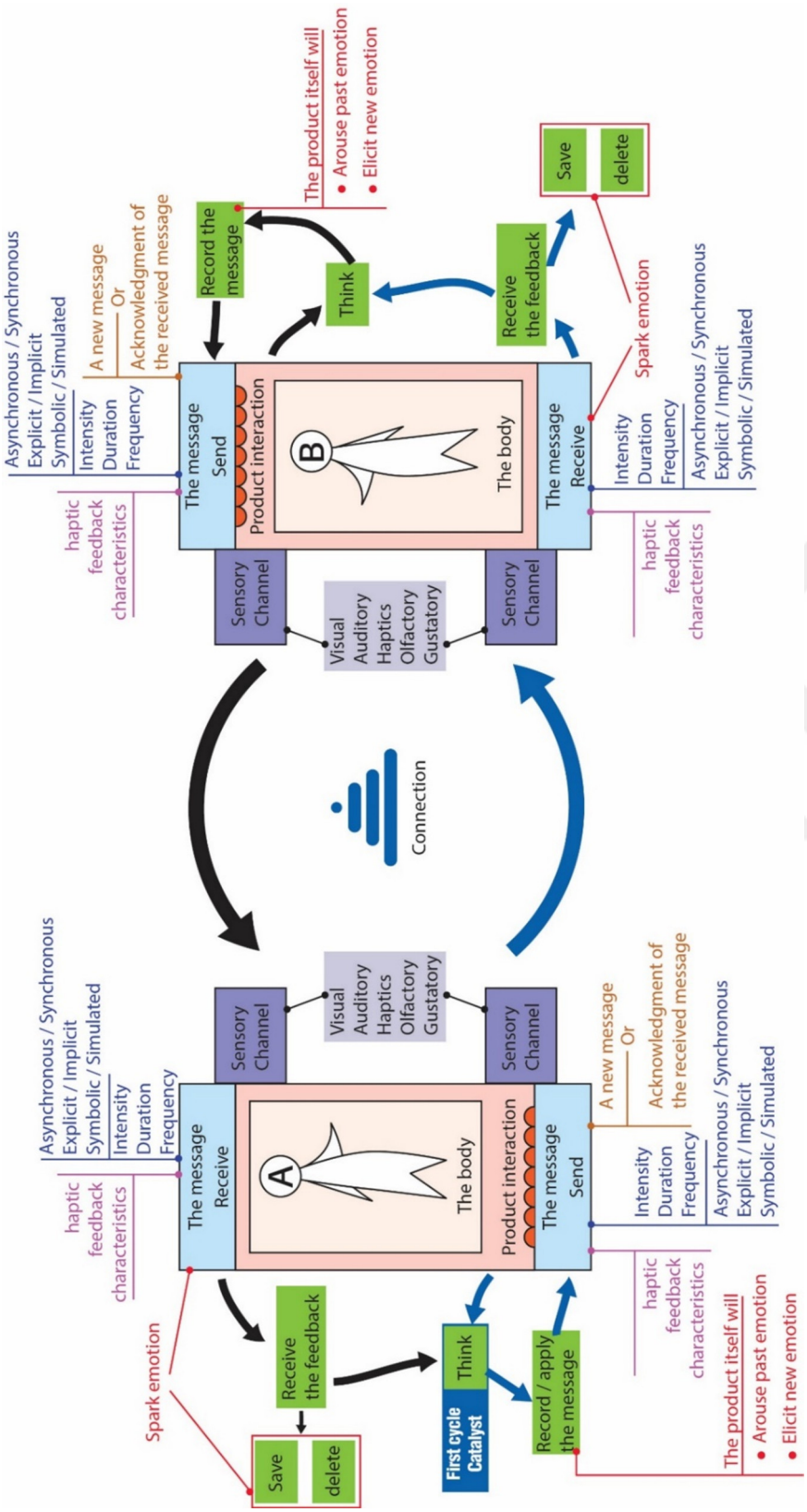


Figure 3.13. Initially proposed RST framework

3.6 Utilizing the Initial Remote Social Touch Framework in This Research

To investigate the initial RST framework (see Section 3.5) in a research setting, it was used to set up the questions for the one-to-one interview sessions. The initial RST framework is divided into three main elements each has its own dimensions, i) the users, ii) the product, and iii) the communication. The main and first element in the framework is the individuals themselves, thus the first set of questions in the interviews is about the relationship, physical interaction, their communication behaviors, and their thought about RST after they get introduced to the technology.

For the other various proposed elements in the framework, the fantasy phased were used (see Section 3.7.1), to guide the session various questions in addition to a set of prepared cards which was extracted from the framework elements. For that, the second set of questions is about the communication qualities and characteristics such as the communication cycle (receive-reply-send), the kind of communication, and the haptic feedback qualities. The final set of questions is related to the future RST products such as the characteristics of the product and the way to interact with it.

3.7 Data Collection Methods and Materials Used in The Fieldwork

This section is divided into i) methods and ii) materials used in the fieldwork. Figure 3.14 illustrates the methods and materials utilized in the fieldwork.

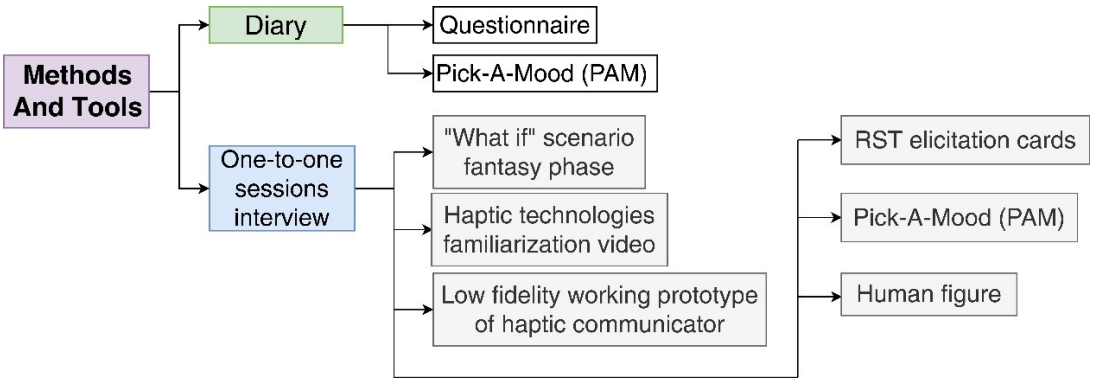


Figure 3.14. Methods and materials utilized in the fieldwork

3.7.1 Tools and Methods

Online Diary

The diary method is suitable for this research because it can elicit structured personal information that document individuals everyday routine process of a certain issue. The diary method can be used to track individuals' behavior patterns to provide the researcher with a snapshot of the experience individual had at a certain time. Diary can include checklists, questionnaires, and/or open-ended questions. In the analysis stage, diary answers can be coded to find emerging themes and subthemes about individual experiences (Given, 2008). Additionally, as suggested by Visser et al. (2005), diary-keeping found to be a useful method to allow participants to think and reflect on a topic under investigation prior to the interview, and to enhance the quality of their contribution. Thus, the diary method is picked to be used in this research to enable participants to understand their own behavior toward the main issue of this research and to sensitize the participants before the interview session.

The Interviews

The main method employed to elicit information from the participants is sim-structured interview sessions. The interview is a way to listen to people's lived experiences and the meaning they make of them (Seidman, 2006). It is a way to hear individuals' opinions, and express their lived world. It is a conversation that has a purpose and structure in a certain way to gain thoroughly knowledge from the individuals (Plas et al., 1996). In this research interacting directly with the effected users of the subject under study is important and one of the main motivations to undergo the research. Users input can help with enhancing the knowledge about the subject under study. In this case, the interview is a semi-structured interview based on one-to-one sessions due to the sensitive subject of "touching among people". The interview consists of prearranged and open-ended questions to allow the freedom for the participants to share their thought and experiences yet in an organized manner.

Additionally, the interview method allows the ability to utilize various tools to elicit information designed especially for the case under study.

“What if” Questioning

In literature, it is possible to come across various methods for incorporate target users while creating new technology, such as the use of future workshops (Schuler & Namioka, 1993). As remote social touch (RST) promotes new uses of technology and (most of) the target users have no previous experience with it, a future workshop was one type of workshop that this research adopted to overcome this issue, however with few changes starting with calling it “what if” questioning technique. The other two changes to the “future workshop” need to be made to alter it to “What if” questioning:

a) First, a “workshop” format is not going to be used, i.e. few participants coming together discussing and making solutions to solve an issue. This is because from the researcher's point of view social touch is a sensitive and personal issue to discuss surrounded by other people. Thus, not to worry that participants may withdraw information, the “workshop” style changed to one-to-one sessions, the participation was individual and had an interview setting. This gave more focus on each participant.

b) The second change, a typical “future workshop” is consist of three phases (Schuler & Namioka, 1993), however, only the second phase “the fantasy phase” was moved into “What if” questioning which incorporated in one scenario; sending or receiving touch without technology limitation. This is because the main issues and problem-related to the user group were introduced to them earlier and explain before starting the fantasy phase (replacing the first phase), and the implementation phase (the third phase) was infused with the fantasy phase by incorporating elements of implementation if RST were to be implemented (which were taken from the initial purposed RST framework).

3.7.2 Materials Utilized in the Fieldwork

Typically, in "future workshop" the participants would immerse in activities such as brainstorming, drawing, and mock-up making to externalize their thoughts and imagination about the topic being investigated. However, this research does not translate the same for the one-to-one sessions, instead certain tools are put to help to elicit information. This is because haptic feedback has a wide variety of inputs/outputs. In other words, for the participants to imagine what type of haptic feedback they would like to communicate their messages with would have not been so straightforward. Bringing together all the material and possible technologies that simulate a variety of haptic feedback, and following that asking a participant to build a mock-up, could have been implausible and it could have not fully encapsulated all the haptic feedback available. Additionally, it could have been very time consuming to use different technologies to build the imagined concept.

Therefore, in order to overcome these limitations, a combination of methods were chosen by the researcher to replace hands-on workshop exercise. The researcher devised several data collection materials to facilitate the research as the best alternative to the participants being involved in the making. These are: i) **Haptic Technologies Familiarization Video** to introduce the concept and principles of RST; developed ii) an **Early Stage Working-Prototype of Haptic Communicator** showing the principles of remote social touch; iii) the set of **Remote Social Touch (RST) Elicitation Cards** to encompass terms and elements used within the proposed RST framework.

i) **Haptic Technologies Familiarization Video.** In order to introduce various haptic technologies that give the sense of touch, a one-minute video is prepared consisted of multiple clips representing specific technologies to create haptic feedback. The aim was to illustrate a range of technologies that can carry touch from one place to another, and that of provoke the touch sense. The video was also aimed to alert the participants with examples of such technologies that can

help with the fantasy phase in the one-to-one sessions (i.e. to support their imagination about a wide range of possibilities). Through the video, the researcher introduced various terms that were necessary for the participants to understand. The researcher acknowledges that watching video-clips demonstrating the haptic feedback is different from personally feeling it, however, it was thought to be useful to catalyst the imagination of the participants. The video also clarified the following terms: tactical feedback, low- and high-resolution tactile feedback grids, texture feedback, force feedback, contactless haptic feedback using ultrasound, joint manipulation feedback, temperature feedback, simulated feedback, and symbolic feedback. Appendix C includes references for the video-clips as well as an explanation of these terms. A screenshot from the video-clip can be seen in Figure 3.15.

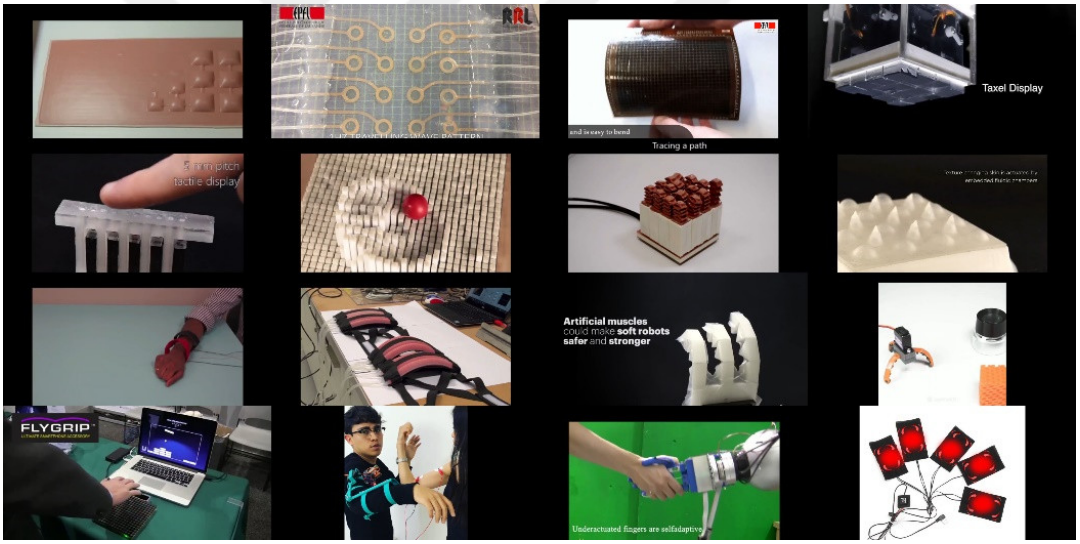


Figure 3.15. A screenshot from the video-clip prepared for the participants

ii) **Early Stage Low Fidelity Working Prototype of Haptic Communicator.** In addition to video, an Early Stage low fidelity Working-Prototype of Haptic Communicator was developed by the researcher to demonstrate the principles of RST (see Figure 3.16). Prototypes in addition to videos can help with communicating ideas to participants and help participants to experience an idea instead of witnessing someone else experience it (Buchenau & Suri, 2000). The

prototype in this research aimed i) to let the participant understand what haptic feedback is with something tangible instead of imaging how it feels like, and ii) to show the working principle of a 'remote social touch'. Therefore, it can be said that the early prototype was presented to the participants as a technical illustrative tool, but it did not aim to present a complete design as it was not too advanced prototype to allow the participants the freedom for imagination. The prototype was built by the researcher after the early RST prototyping self-exploration stage (see Section 3.4). Refer to Figure 3.16 for material information, and see section 3.4 for extra information about the prototype. The prototype consisted of two parts: a sender part (Figure 3.16a) and a receiver part (Figure 3.16b). The sender part has two touch sensing areas to read how long someone presses on them, then send it (the message in the form of touch feedback) synchronously to the receiver. This means that the communication is performed in a live manner, where one can send then the other can feel the message directly without any delay. This can help to feel the direct effect of the message sent and received when one interacts with it.

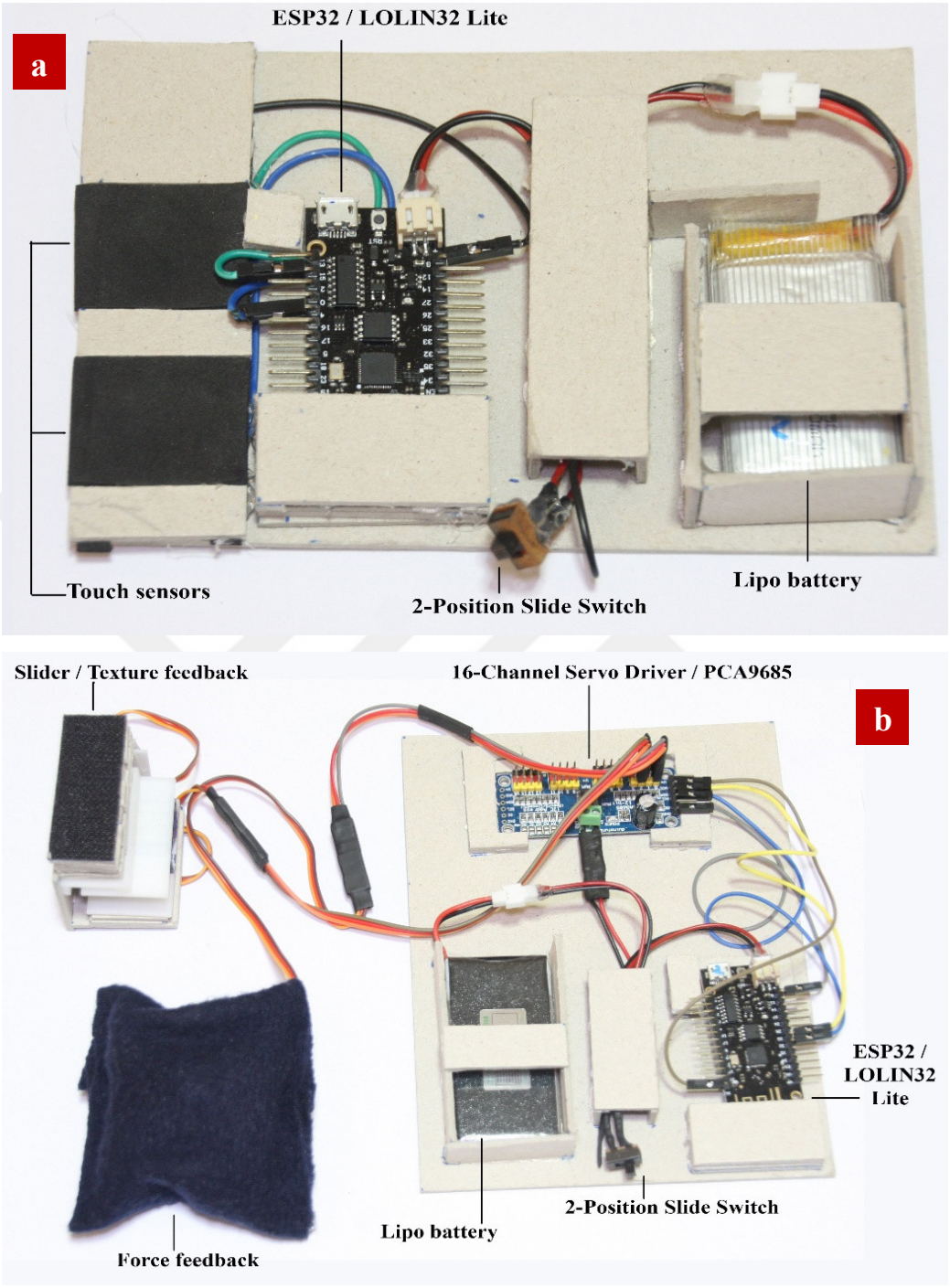


Figure 3.16. Early-stage low fidelity working-prototype of haptic communicator, a. the sender, and b. the receiver

When the receiver receives the information (in the form of haptic feedback) then he/she has two options to respond: through i) force feedback which produces a light

pressure or push against the skin (Figure 3.17), or ii) a texture movement in a linear fashion back and forth which can be felt passively (Figure 3.18) (the texture is the rough side of a Velcro tape, see Figure 3.19). These two types of feedback were chosen by the researcher as i) the haptic feedback they provide were distinctive by the touch sense, and ii) visually apparent in case a video was made explaining the prototype. The prototype aimed at practically demonstrating how RST works, and how synchronous communication, texture feedback, and force feedback can be experienced. The present research is also interested in 'saving' the message (to be accessed later), however, the early working prototype did not include this feature, and the desirability of this idea is explored during the interview sessions.

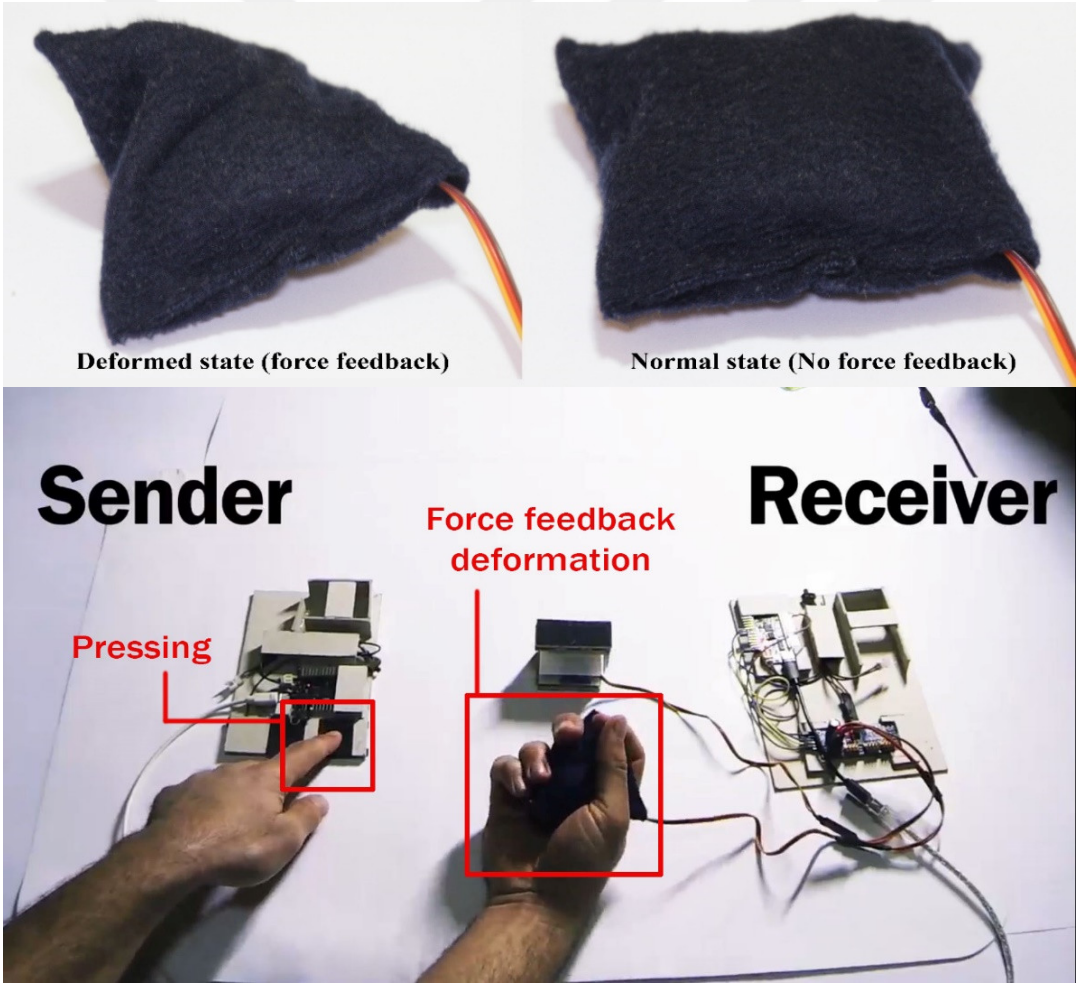


Figure 3.17. Force feedback

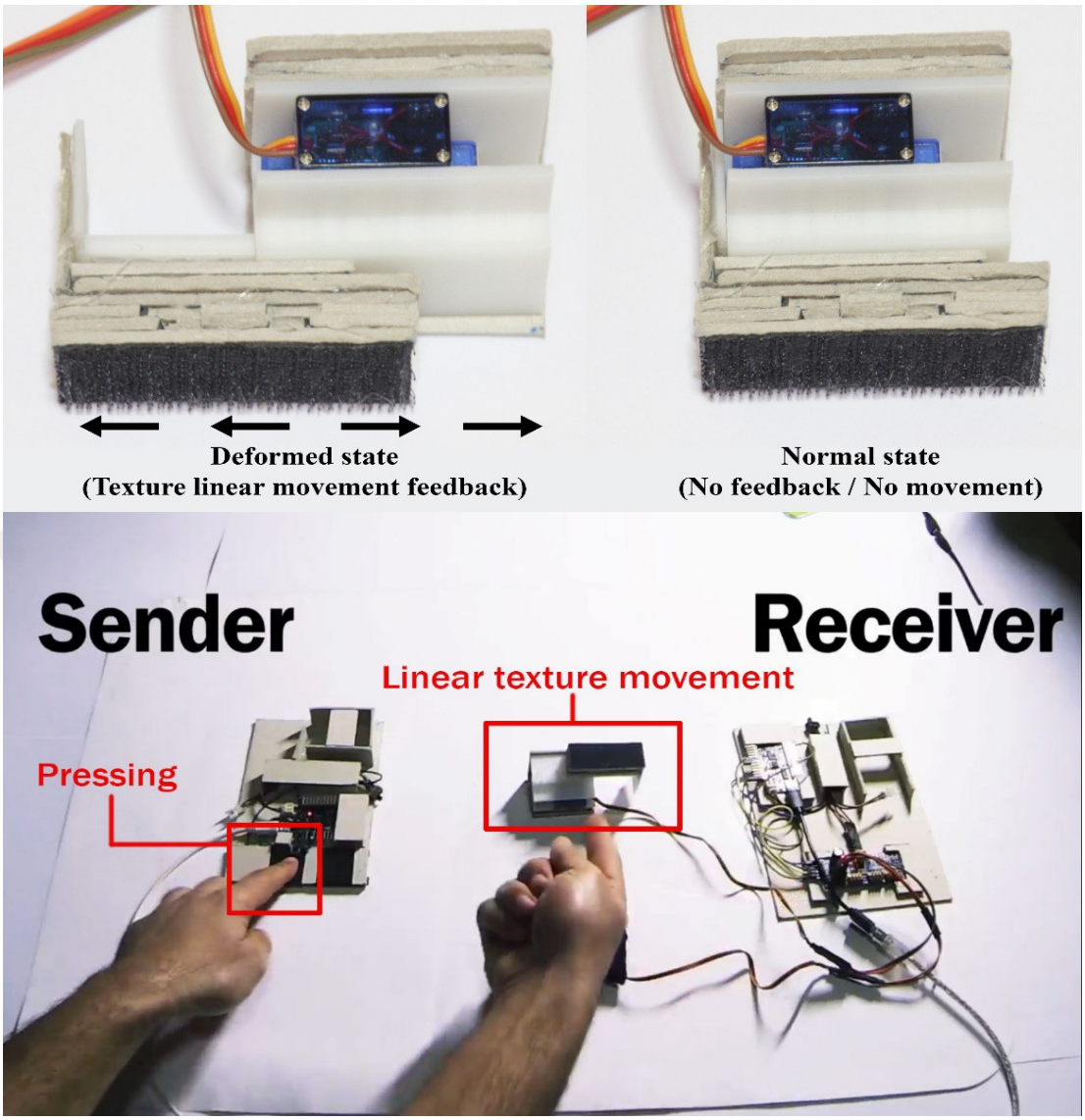


Figure 3.18. Linear texture movement

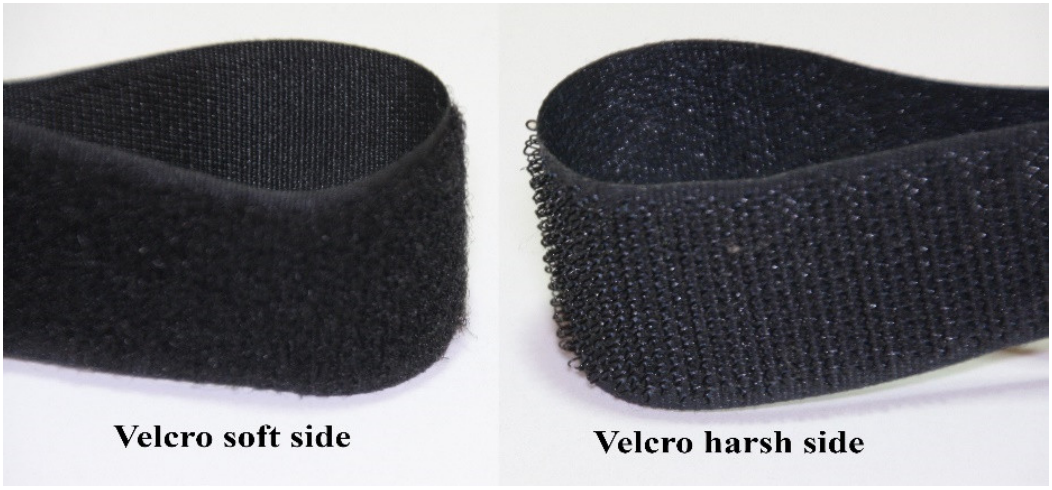


Figure 3.19. Velcro the rough side and soft sides

iii) **RST Elicitation Cards.** The set of Remote Social Touch Elicitation Cards (see Appendix D for the full set) were prepared with the information synthesized from the literature survey into haptic communication. The set aimed to be used as a guide to elicit the information in the interview session. It was believed that the cards would facilitate the discussion between the researcher and the participants. This is because having the elements of the framework represented directly with examples in front of the participants could trigger the intended discussion much easier than the verbal explanations. The cards are also believed to help the participants to focus on a certain characteristic at a time. The set included the following categories of cards a) Pick-A-Mood (PAM) cards; b) frequency card; c) communication characteristic cards; d) Haptic feedback characteristics cards; e) haptic feedback qualities cards; f) product characteristics cards; and, g) human figure card. A photo of all the cards can be seen in Figure 3.20. and an explanation about the card can be seen in Table 3.2.

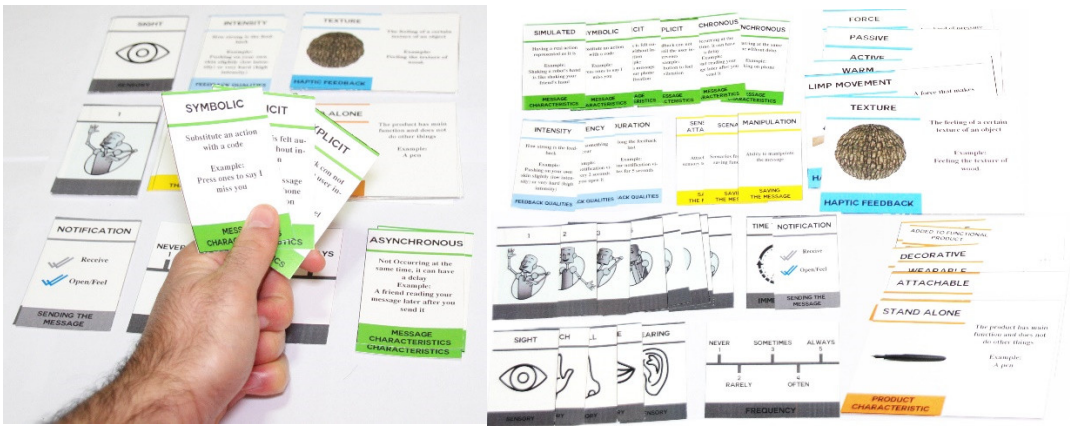


Figure 3.20.The set of cards used as a data collection material in the interview

Table 3.2 The content of each card category in the remote social touch card set (For full images and layout see Appendix D)

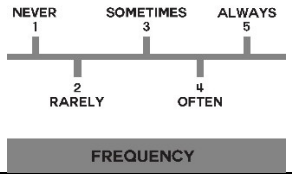
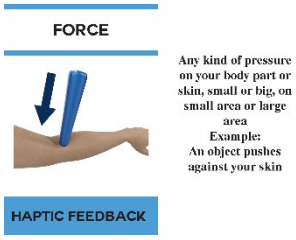
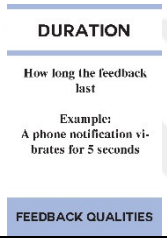
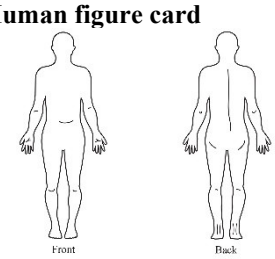
No	Name and visual representation of the cards	Explanation / Purpose of use in the fieldwork
a	**Pick-A-Mood (PAM) cards** 	Nine cards representing various emotions/feelings (i.e. excited, cheerful, relaxed, calm, bored, sad, irritated, tense, neutral) through a robot-looking character.
b	**Frequency card** 	This card is intended to accompany the question 'How often…? It is believed to make it easier for the participants to have a reference scale of frequency in front of them. The scale included: Never (1) - Rarely (2) - Sometimes (3) - Often (4) - Always (5)
c	**Message characteristics cards** 	This category of cards consisted of explanations of *simulated* (performing the PI to send it) vs *symbolic* (substitute the PI with a code), *synchronous* (feeling the PI at the same time) vs *asynchronous* (the PI message can be recorded and felt later anytime), *implicit* (feeling the PI message without the user intervention) vs *explicit* (the user intervene to feel the PI message).

Table 3.2 (continued)

d	Haptic feedback characteristics cards 	**This category of cards included representations of force (the feeling of a force against oneself), texture (feeling of either a texture change or a texture move along the skin), limp movement (feeling ones limp move in a certain way), form and size change (deforming of an object to deliver the haptic feedback), passive (feeling the haptic feedback being applied on oneself), active (one need to do something to feel the haptic feedback), and temperature changes (whether one want to feel cold or warmth to represent the PI). Vibrotactile feedback is excluded from the set to study how other kinds of haptic feedback can be utilized as the vibration was widely used in RST literature.**
e	**Haptic feedback qualities cards** 	His category of cards included explanations of intensity (PI haptic feedback strength), duration (how long is the PI haptic feedback last), and frequency (within the same message how many PI haptic feedback).
f	**Product characteristics cards** 	This category of cards aimed at facilitating the discussion on certain product features that would be desirable to the participants. The features included: stand-alone (a product only for RST), non-wearable v wearable; attachable, portable, accessory-like, ad-on (RST product added on to a functional product used daily), decorative (a product can be for RST and also decorative or fashionable), and a clothing item.
g	**Human figure card** 	This card illustrated a human-body from the front and the back. The participants can indicate "where on their body they would like to feel the PI", and "if a wearable product was available where it should have been located on the body". The human figure used in this research is adopted from Jones and Yarbrough (1985) research where they used a similar approach to check the non-vulnerable and vulnerable part of the body for touch.

iv) **Pick-A-Mood (PAM)** tool (Pieter Desmet et al., 2016a) PAM consists of cartoon characters that express eight different moods stats divided into four main categories (Figure 3.21): energized-pleasant (excited and cheerful), energized-unpleasant (irritated and tense), calm-pleasant (relaxed and calm), and calm-unpleasant (bored and sad) (Pieter Desmet et al., 2016a). As mentioned in PAM

cards can be used both as a tool for measurement (i.e. to enable researchers to measure the moods of their respondents) and as a tool for communication (i.e. to enable people to communicate their mood in social interactions) (Pieter Desmet et al., 2016b). Therefore, in this research, PAM was used for probing the participants about the question: "How do you feel about doing/missing the physical interaction?" and generating insights about their feelings and affect on their mood. Additionally, it was aimed to motivate a discussion about their interest in physical contact and the importance of social touch. As advised by the authors (Pieter Desmet et al., 2016b) out of the three possible character representations (i.e. female, male, robot) the robot version representing a genderless character was used. See Appendix E for details on the meaning of each character.

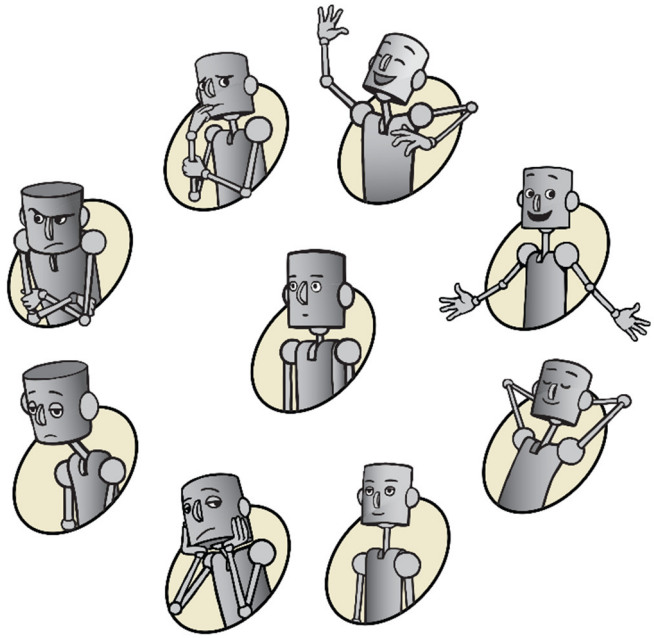


Figure 3.21. Pick-A-Mood robot character, by Pieter Desmet et al. (2016b, p. 7)

3.8 Fieldwork Set-Up

3.8.1 Ethical Approval

Prior to carrying out the fieldwork, necessary ethical approvals were obtained from the Graduate School of Natural and Applied Sciences at Middle East Technical University that has the number: 28620816/438 (see Appendix F).

3.8.2 Participant Selection

The main criterion for the participant selection was to be living away from the loved ones. For the research purposes, there was no specific relationship considered, rather the invite was open to any individuals including, for example, the ones living away from their partners, family members, etc. This was to allow information to be gathered from various backgrounds.

Following the 'opportunity sampling method' (Brady, 2006)- asking members of the population of interest if they would take part in this research - it was decided that the university students would represent an obvious user group, as potentially there are a lot of students living away from their loved ones to study, including international and non-international students. As the researcher's most immediate access, a call for participation in this research was made to Middle East Technical University students through online posts and e-mails (with the help of the international student group), and offline through notice-board posts (see Appendix G). All the participants who were interested in the research were invited without excluding anyone.

Any individual, who was willing to participate in the study, was referred to fill-in an online Google form (Appendix H) to leave their contact details. The form also described the aim of the research and explained the expectations from the participants. The researcher then contacted each of the participants either through WhatsApp or by e-mail to further explain the research and answer any questions that

they may have. In total, 42 participants were secured to participate in the study, most of them were directed from the international student group. There are no rewards or incentives for participating in this research to be sure only interested individuals to share their experience related to the research subject participate. This is believed could help increase the quality of the information.

3.8.3 Data Collection Stages

Data collection is carried out in two main stages: i) online diary keeping, and ii) one-to-one interview sessions. All the data collection in the fieldwork is carried out in English.

i) Online diary keeping. After securing the participants, each of them was sent a brief questionnaire and asked to fill in every night for seven days to form an online diary. The questions were directed to understand the participants' daily communication behavior with their loved ones (an online Google form, Appendix I). A total of 42 individuals participated in this stage.

In this research, the aim of the online diary-keeping is to sensitize the participants about their communication behavior before they get invited for the one-to-one interview session. Also, the diary can help with answering the question of whether individuals living away from their loved-ones miss physical interaction or not, and how they feel about it. Seven-days / a-week-long diary is believed to be long enough for most of the participants to contact/or needing to contact their loved ones at least once, and if they did not, make a note of why. On the last day of the diary, the participants were contacted to arrange a one-to-one interview session.

ii) The one-to-one sessions

Venue and Equipment

The interview sessions were carried out in a quiet environment (e.g. a lab or a classroom located on the Middle East Technical University campus), each session took around one to one and a half hours with each participant (19 out of 36 participants). Touching (to someone) and talking about your touch (to someone) can be a sensitive topic. Therefore, one-to-one interview sessions were preferred to offer the right atmosphere -as much as possible-. The interview sessions were audio recorder (Piranha Voicemaster Q Type) and video recorded (GoPro Hero 3). The main purpose of the video-recording was to capture when participants act out a gesture to send a certain physical interaction and the way that they interact with a product. Together with video recording audio recorder is also used for transcribing the interview sessions. Figure 3.22 shows the room setup.

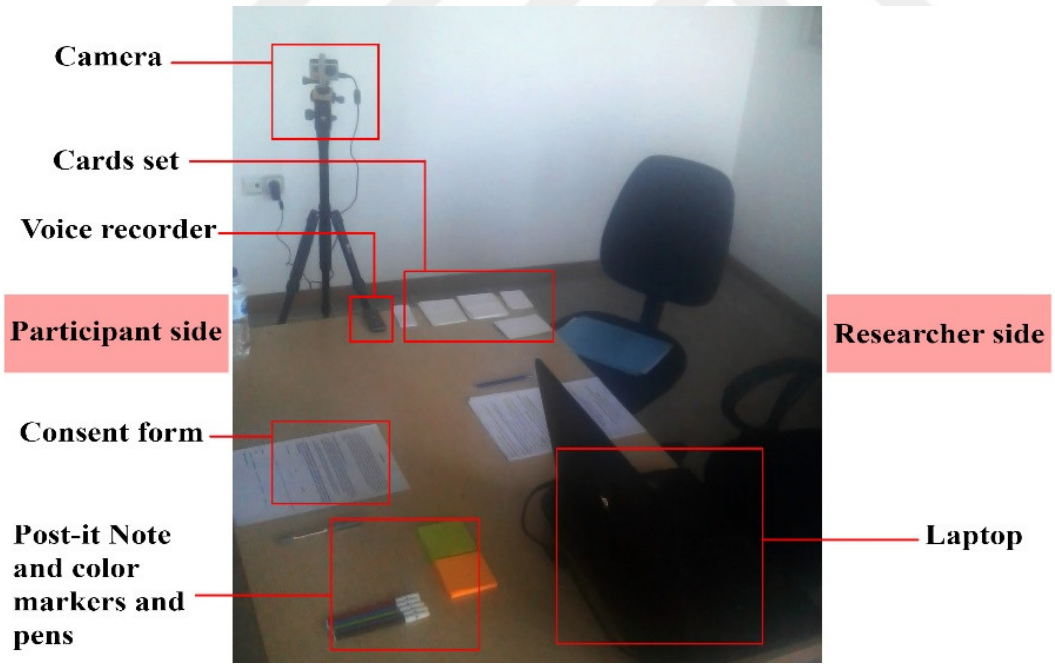


Figure 3.22. Room setup

Consent Form

The consent form, which contains information about the study and the interview, also mentioned that they will be video and audio recorded. The participants were also reminded that they can leave the study anytime should they feel uncomfortable about continuing the remaining (see Appendix J).

Interview sessions

Interview sessions followed a certain flow of activities as illustrated in Figure 3.23, and it is divided into 5 parts. Refer to Appendix K for the interview questions.

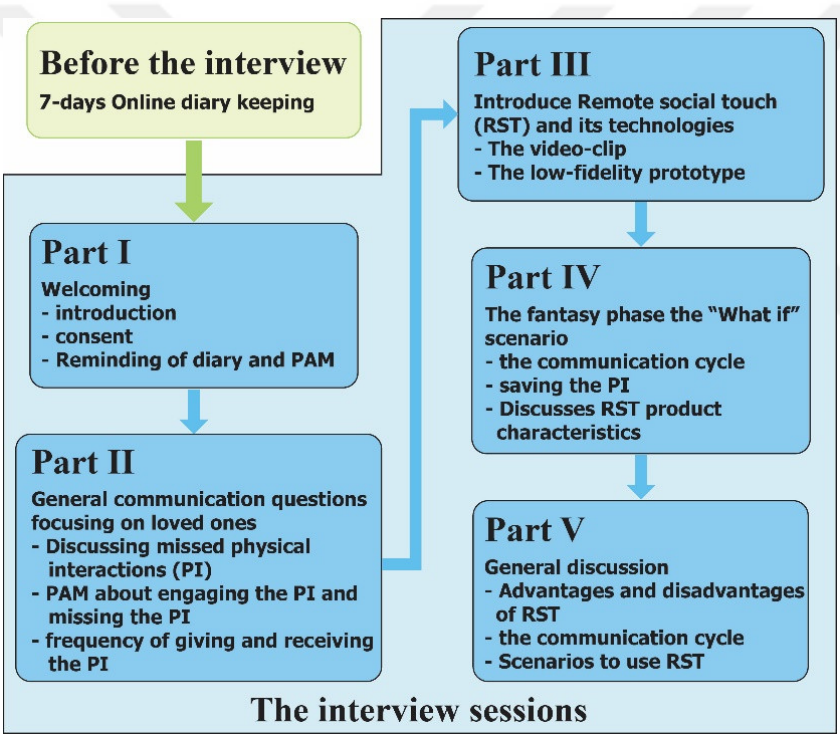


Figure 3.23. Summary of the interview session

i) In the first part, in order to make the participants dive more into the subject and ready for the interview, in the first section of the interview, the researcher reminded them about their online diary answers, including their responses about what they used to communicate and why, the physical interactions that they miss,

and their answers to PAM. After that, the researcher asked them to elaborate more about their PAM choices (to put meaning to the face of PAM character).

ii) The second part of the interview focuses on the 'loved-one' that the participant reflected about on the diary-keeping stage. The participants might have communicated with more than one loved-one in the seven-day diary. The questions prepared for this part were to understand how they communicate with their loved ones, what physical interactions (PI) they miss engaging with their loved ones (the answer PIs written on a Post-it Note), how they felt while engaging the PI and missing the PI, and the frequency of giving and receiving the PI. This is to understand the participant behavior towards physical interactions while living away and to elicit common physical interactions related to the relationships they mentioned.

iii) The third part is for introducing RST concept in general and potential technologies to realize it through a video-clip. Also, in this part, the low-fidelity prototype was shown/tried out by the participants to explain RST principles accompanying the researcher's explanation (see Section 3.7.2).

iv) The fourth part is for the introduction of the fantasy phase the "What if" scenario (the fantasy phase) "by knowing that everything is possible and without limitation of technology answer the next questions". The set of cards prepared by the researcher (see Section 3.7.2) was used to initiate discussion and to elicit information from the participants. This section is divided into 3 sets of questions:

- The first set focuses on questioning the communication cycle concerning remote physical interaction. It is about the detailed characteristics for each part of the cycle (receive, reply, and send the message). This section started by discussing receiving the physical interaction message from the loved one they picked in the beginning. This is to get information related to haptic feedback characteristics and where the participants like to feel the message on their body. Then, the following set of questions about replying to this PI message they

received. This is to understand the urgency in replaying to PI message and the kind of reply for it. Then the following set of questions is about sending the PI mentioned at the beginning of the interview to the loved one they picked. This is to find individuals' preferences toward haptic communication in specific to what represents the PI, the characteristics for sending, and the interaction style to send the message (gesturing the action).

- The second set discusses saving the PI message by introducing the concept of saving a social touch forever and the ability to feel the message any time. This is to understand how this concept will change their life, when and where to use it, and if they like to have other people PI saved (other than the loved one they picked).

- The third set discusses the product characteristics that the participants prefer in RST devices or products. This intent to help in understanding the product's needs for future RST products.

v) The fifth part is a general discussion about the participants' speculation about the advantages and disadvantages of RST. The advantages are used to extract areas to use RST, ways to enhance it, and points to focus on while designing RST. However, disadvantages are used to extract concerns areas in RST to further research or to focus on resolving while designing for RST. Moreover, they also discussed the scenarios they see themselves using it. This can help to find areas where RST can contribute.

After all the parts are done the interview session is ended, and the participant thanked for his/her time and contribution to research. Refer to Appendix L for the interview process.

3.8.4 Changes Happened Throughout the Data Collection Stages

COVID-19 Pandemic and Implications for the Interview Sessions

With the precautions taken across the world in relation to COVID-19 pandemic, the access to Middle East Technical University was cut off and a curfew was enforced. Hence, face-to-face interviews were no longer an option. Of the 36 participants, 19 were interviewed face-to-face and were able to interact with the early stage working-prototype of haptic communicator, but 17 participants after COVID-19 measures had to see a video of the prototype experienced and narrated by the researcher, and the remaining of the interviews had to be carried out by online means using Zoom and Skype video conference.

Originally, there were few reasons why the interview session was preferred to be carried out face-to-face: the ability to try RST through the early-stage prototype (main reason), and displaying all the cards in front of the participant to help with eliciting information (which can be done alternately online). Following changes had to be made to accommodate the online interview.

- The consent form became a Google form document that the participants fill in.
- The researcher and the participant had to write the missing PI on separate sheets in the online version, instead of writing down on a Post-it Note in the face-to-face version.
- Instead of trying out the early-stage prototype physically, the participants had to watch a video demonstrating the tool with the researcher's explanation of how it works and the RST principle.
- Different categories of cards within the full set were grouped as a single image.
- The human figure card, which the participants used to draw is moved to an online cooperative drawing website (awwapp.com).

Moving the interview sessions to an online platform is believed not to bring major implications in the results. Moreover, the online interview made it possible to check to research remote social touch using online tools instead of the usual on-hands (touching something) way of research even though it was not planned initially.

Other General Changes

Additionally, qualitative data analysis is entwined activity withing the research (Schilling, 2006); through the time there were few changes especially after the pilot study with the first five participants, as follow:

- The video recording started from the beginning instead of filming only the part where they act out the interaction this was to reduce the nervousness as some tend to forget about the camera.

- PAM tool, in the beginning, was presented as a wheel (circular) layout as to how it presented in Pieter Desmet et al. (2016a), however, some participants thought it was representing a scale from good to bad (as in 1 is something good to talk about and 9 is something bad), thus the change was made to present them as individual cards that one can pick and talk about the feeling that the card represented.

- Some of the questions moved to a card as it was obvious that the participants were more engaged in conversation when the cards were represented in front of them. These included PAM, the five sensor modalities, frequency, notification, and saving the message.

- The order of some of the questions was changed for example question-related to saving PI used to be asked in two parts, the first part was before introducing the haptic technologies, the second part after the questions related to the communication cycle. Later it changed to be all in one part after the communication cycle question as it was apparent participants understand the concept better later.

3.9 Data Analysis Procedure

This research will follow a qualitative data analysis approach by utilizing a content analysis method. Content analysis is a systematic procedure that code and extract categories to generate themes and patterns out from the data and to look for relation among the themes (Given, 2008). It can be used to extract information, themes, and patterns from various materials such as interview materials, videos, and open-ended surveys (Cho & Lee, 2014). Schilling (2006) content analytic procedures model (Figure 3.24) is going to be followed in analyzing the data of this research. The model consists of 5 phases, i) converting the various data types into content able to be analyzed (raw data), ii) converting the raw data into condensed protocols, iii) converting the protocols into preliminary categories, iv) the preliminary categories are going to be used to generate coded protocols, v) analyzing the coded protocols to generate interpretations about the subject of interest.

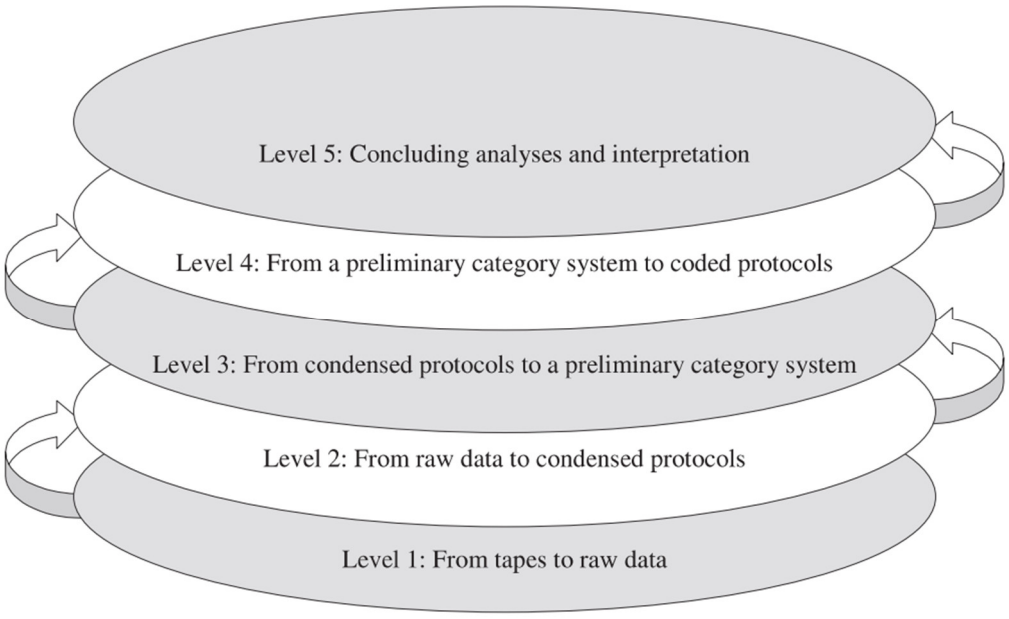


Figure 3.24. The qualitative content analysis spiral, (Schilling, 2006, p. 29)

The data is going to be divided based on the data type and related research question the data should serve. The data types in this research are literature materials,

subjective data (diary and interview questions), video footages, drawings materials. Moreover, the data is going to be divided based on which part of the proposed initial RST framework it was elicited for. The process for analyzing the data is going to follow the illustration in Figure 3.25.

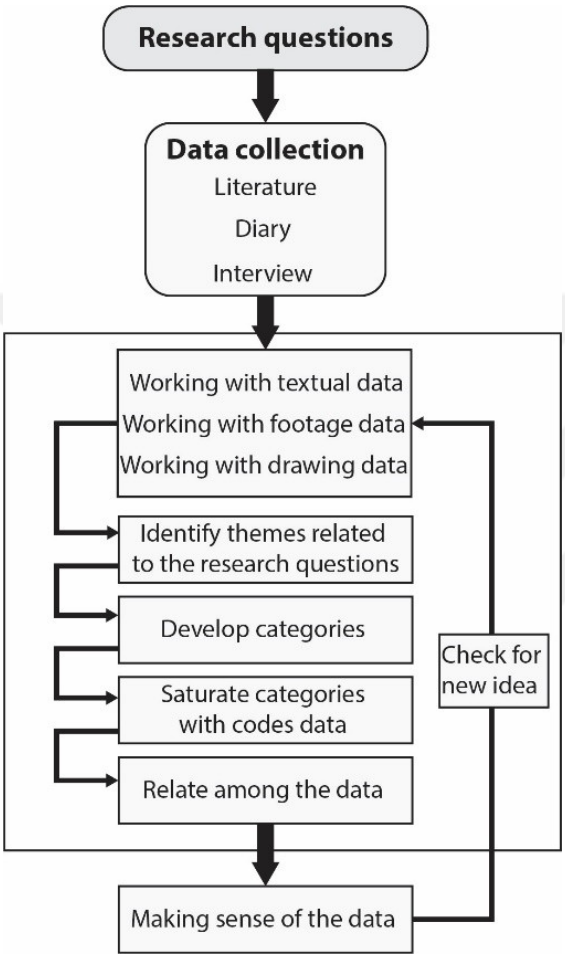


Figure 3.25. Data analysis procedure illustration by the author

3.10 Trustworthiness

Trustworthiness in qualitative research depends on: i) credibility (internal validity), ii) transferability (generalizability), iii) dependability (reliability), and iv) confirmability (objectivity) (Guba, 1981).

Credibility in qualitative research implies the notion that the responses of the participants and the research interpretations are consistent and make sense to the reader and the participants (Given, 2008). It is a way to ensure that the research measure what it is intended to do. Shenton (2004) and Maxwell (2012) state a few ways to increase the credibility which this PhD research employed, these are:

- Familiarity with the subject matter and the culture under scrutiny. In this research, there are two main subjects needed to be familiar with; the targeted users (individuals separated geographically from their loved ones) and remote social touch technologies. A deep literature investigation related to the two subjects carried out and documented in Chapter 2. Moreover, to get familiar with the technologies of RST the researcher carried out and documented a self-exploration related to the technology (see Section 3.4).

- An explanation behind the selection of the individuals for participating in the research stated in Section 3.8.2

- Utilization of various tactics to ensure the participants giving an honest response. This is done through i) give the freedom to the participant to refuse participation which helps to include only those genuinely willing to participate, ii) the indication of "there are no wrong answers" which allow the participant to share their response without the fear of losing integrity Infront of the eye of the researcher, and ii) no incentives or reward were given to ensure only those genuinely willing to share their experience will participate.

- A thick description of the subject under investigation and the data gained. This is to allow the reader to have the actual details of the situation, extend, and context that surrounds the subject of the investigation.

- Examination of previous findings related to the subject under investigation and relate the finding of this research to the existing body of knowledge.

- Utilization of various data collection methods and materials, in this research online diary and interviews employed to answers the research questions. The literature was used to develop an online diary and interview materials and questions. The interviews helped to explain the participants' answers in the online diary. A sim-structured interview was used with open-ended questions to allow participants to fully explain their answers. Various tools were used in the interview to allow participants to explain their thoughts concerning the research questions. To be sure participants understand the subject understudy two materials were used, the video and the prototype tool with the researcher's explanation.

Transferability in qualitative research refers to the extent to the finding can be applied to other situations and population. Qualitative research is specific to a small number of people it is impossible to show that the findings can apply to other situations and populations. However, the researcher has to ensure sufficient information of the fieldwork, participants, context, geographical place, time, and the limitation of the research to allow the reader to make inferences on how far they can be transferring the findings to other situations (Shenton, 2004). Additionally, two main considerations can relate to the concept of Transferability, i) the boundaries of the findings, and ii) the degree the participants linked to the context under study (Given, 2008). Following Shenton (2004) and Given (2008) on ways to increase the transferability in qualitative research, this PhD research:

- Include a thick description of the methodology, context, fieldwork procedures, and participants selection. This is to allow a full picture for the readers to infer how transferable the finding to their context.

- Purposefully sampling participants who are related to the subject under study and explaining the rationales behind the selection.

Dependability in qualitative research refers to providing enough information to the research methodology so others can follow the same procedures to replicate the research. The researcher should document not only the procedures of the research but the changes that happened through the research (Given, 2008). All the information provided could allow other researchers to reach similar results (Shenton, 2004). In this PhD research, to tackle this issue in-depth coverage of the research producers, fieldwork, and the changes that occurred throughout the research are described in detail.

Confirmability in qualitative research refers to reliability and objectivity of research, the degree of the results are based on participants' perception not based on the researcher bias (Given, 2008). To provide ways to increasing the confirmability, a researcher can admit his/her beliefs, the limitation of the study and provide a detailed description that allows audit trail (Shenton, 2004). To this extend this PhD research provided a thick description to allow audit trail and the limitation of the research is stated.

CHAPTER 4

RESULTS AND ANALYSIS

4.1 Introduction

In this chapter, the results and analysis of the fieldwork data are put forward. The final result and analysis data were put in this chapter following main categories set initially to organize the data, these categories are 1) participants information, 2) the current utilized communication media by the participants of the research, 3) missed physical interactions mentioned by the participants, 4) the importance of social touch, 5) perceived RST benefits, 6) perceived concerns with remote social touch, 7) remote social touch usage scenarios, 8) remote social touch communication cycle, 9) saving physical interaction, 10) product characteristics for remote social touch, and 11) Touch-related behavior patterns and persons.

4.2 Analysis Procedure

Before starting the analysis process the data needed to be prepared and organized carefully for sorting the data into the analysis framework (coding plan or extracting information plan). All the data need to be cleaned and labeled based on certain categories considering the research questions, there were few passes of analysis, the first one was following the framework to arrange the data in main categories such as receiving, replying, and sending the physical interaction. The second pass was for arranging the data into subcategories (code or patterns). Open coding, axial coding, or selective coding were used depending on the stage of analysis following certain rules. Table 4.1 shows i) the rules put by the researcher for preparing the data, ii) rules for transcribing the interview materials, and iii) rules for coding the data.

Table 4.1 Rules for preparing the data

Rules for Preparing the data	Rules for transcribing	Rules for coding the data
• Arranging the diary answers into two main subcategories. • Generate initial text code/pattern after reading open questions in the diary sections. • Transcribing all interviews based on certain rules (refer to rules for transcribing). • Arranging the interview text transcription into subcategories. • Generate initial text code/pattern after reading the text transcription of the interviews in each subcategory. • Review each interview video to extract interaction type and time code. • Arrange all the drawings of the human figure questions. • After preparing the data all questions that can be put in numeric value will be graphed to be easy to read.	• Writing in paragraph style. • Not adding the researcher question unless it is not scripted. • Not adding filling words such "mmm…" • Adding the time code of the video/audio recording based on the section of the question or paragraph. • Writing researcher comments between brackets. • Adding noticeable behavior related to the questions as researcher comments. • Word for word transcript necessary for the sentences that will be used as quoting in the thesis to explain ideas or examples.	• There will be code for main classification and subclassification. • The main codes can be few wards. • Subclassification code can be a sentence length. • All code should have meaningful titles. • The code can be for text and behavior observation (acting).

Data analysis was carried out with the following stages: i) finding relation or comparing between the data, and ii) identify emerging themes or clusters. All the data from the diaries and the interviews were put into these categories: a) Diary text answers, b) Interview text/audio/video, and c) Drawings on the human figure. Based on the deductive approach in qualitative analysis, the data are grouped in categories based on research questions. However qualitative data analysis is flexible (Schilling, 2006), for that emerging categories were added based on the induction approach, thus they are complementary to each other.

Figure 4.1 illustrates the data analysis process. “Making sense of the data” is divided into parts. The first part is direct output, the data used directly without the need for interpretation these are 1) the missed physical interaction (e.g. a hug), 2) interaction style (e.g. the participant act how to hug), 3) communication characteristics (e.g. simulated communication), 4) haptic feedback characteristics (e.g. force feedback), and 5) product characteristics (e.g. wearable product). The second part is interpreting the data a) Extracting RST Issues and needs, b) Linking data with literature, c) Extracting communication behaviors, d) Extracting reasons behind the choices the participants made related to RST communication cycle and characteristics, e) Extracting information related to saving touch concept, f) Extracting where and why to use RST.

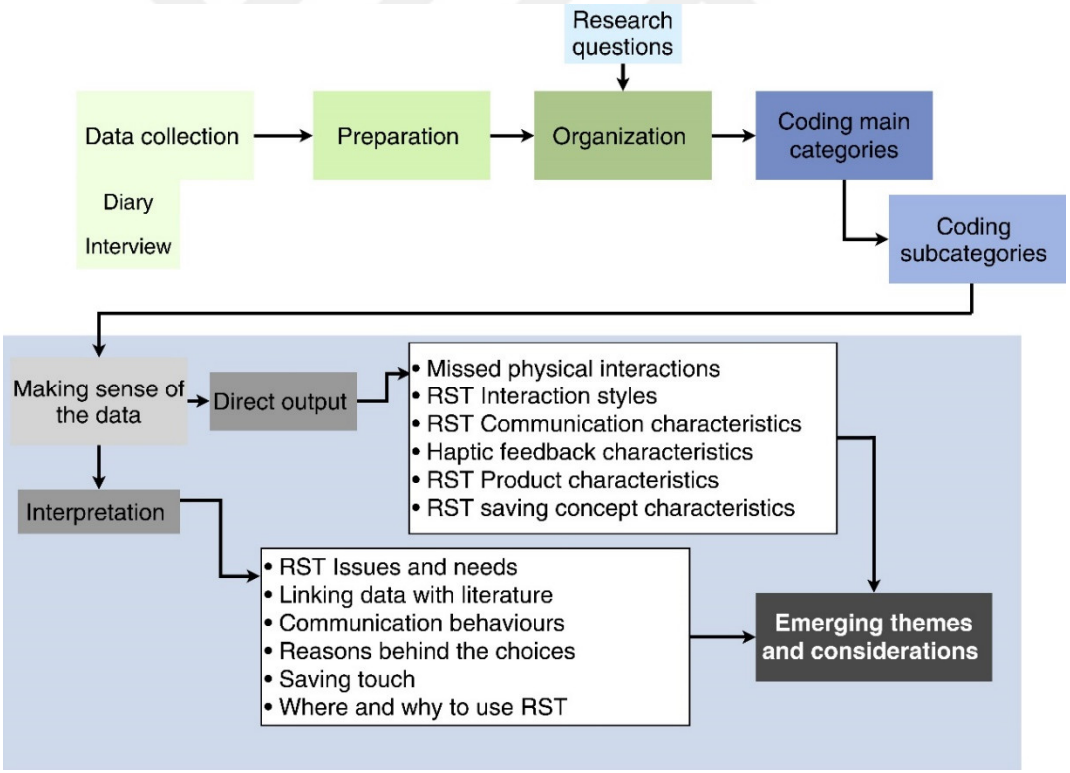


Figure 4.1. Data Analysis Procedure

After the preparation stage, the coding started, it was based on certain rules as mentioned previously. Open coding, axial coding, or selective coding were used

depending on the stage of analysis. Table 4.2 shows the primary coding used for categorizing the data from the online diary and interview.

Table 4.2 Diary and interview initial coding categories of 36 participants

<table>
<tr><th colspan="4">Diary</th></tr>
<tr><td colspan="4">– Communication medium
– Communication reason
– A reason not to communicate
– Pick-A-Mood (PAM) Physical interaction (PI) missing</td></tr>
<tr><th colspan="4">Interview</th></tr>
<tr><td colspan="2">– Relationship
– Time living away
– Communication medium
– Missed PI
– Communication Behaviors or reasons
– PAM doing
– PAM missing</td><td colspan="2">– Frequency initiating
– Frequency receiving
– Remote social touch (RST) communication cycle
– The advantages of RST
– The disadvantages of RST
– Saving RST Concept
– RST product characteristics
– Scenarios</td></tr>
<tr><th colspan="4">Remote social touch (RST) communication cycle</th></tr>
<tr><td>Receive Haptic characteristic</td><td>Replying Haptic characteristic</td><td>Sending Haptic characteristic</td><td>Saving Haptic characteristic</td></tr>
<tr><td>– Simulated and symbolic
– Async and Sync Implicit and Explicit
– Haptic feedback characteristics
– Body touch feeling placement</td><td>– Immediacy
– Senses replay
– Kind of touch replay</td><td>– Feedback quality
– Public/private
– Warning messages
– Notification
– Sending/interaction gestures</td><td>– Extra Explanation
– Scenario to use it
– Message manipulation
– Senses attachment</td></tr>
<tr><th colspan="2">Product characteristics</th><th colspan="2">Saving RST concept</th></tr>
<tr><td colspan="2">– Kind of product
– Features characteristics
– Interactions
– Product body placement</td><td colspan="2">– Want to save
– Manipulating
– Attaching other sensors
– Other relation to save
– Usage Other PI to save
– Emotional related
– Usage</td></tr>
</table>

4.3 Participants Information

4.3.1 The Online Diary

For the online diary, there were 42 participants, 22 males and 20 females between the age of 17 – 41 (77% between the ages 17-24) and they are mostly undergraduate students. Figure 4.2 shows the participants' countries. Throughout the seven-days not all the participants answered every day, some did answer fully answer for six days and some answered only a few days (Figure 4.3). The data gained from such a participant pool will represent mostly international university students in their 20s, as this is could be their first time and not a long time away from their loved ones. There are six participants in the online diary did not continue to the interview stage, their age, education, and country are unknown because it was only required from the interview participants to disclose this information (they are represented with N/A in the figures below)

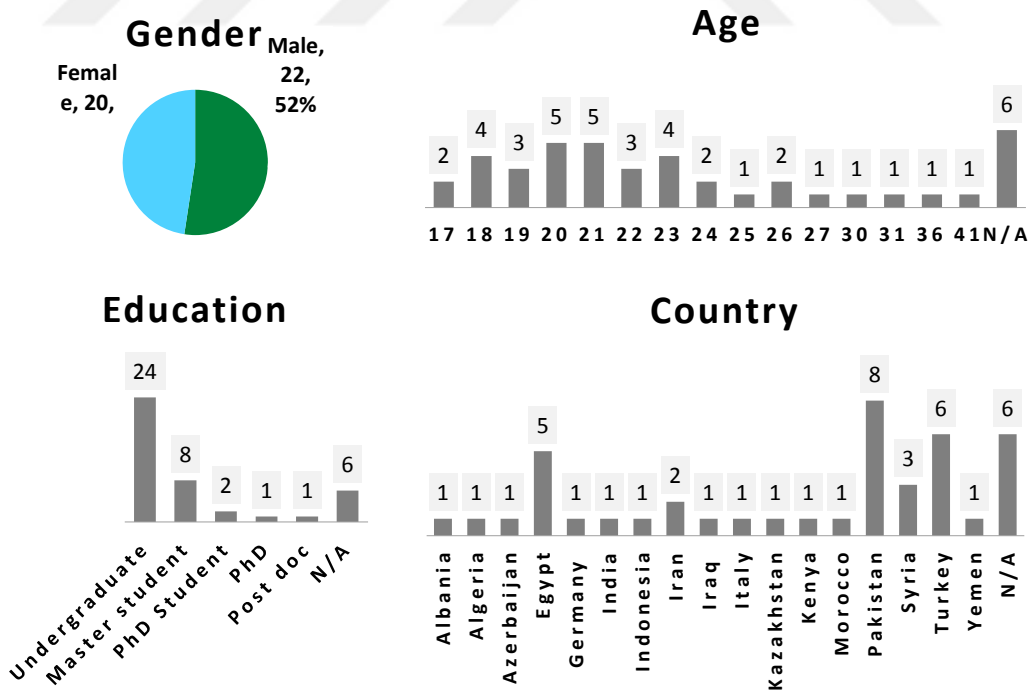


Figure 4.2. Participants information for the online diary (42 participants)

Figure 4.3. Answering frequency through the 7 days in the diary (42 participants)

4.3.2 The Interview

The interview sessions are made with 36 participants from the 42 who logged the diary, female participants were 19 (54%) and 17 were male, between the ages 17 and 41 however most of them (77.8%) fall under the 17-24 age group (Figure 4.4). Figure 4.5 shows most of them (66.7%) are undergraduate students and some (22.2%) are master students, the figure also shows their representative country. Of the 36 only one was living with the loved ones thus the interview was about him remembering the time when he was living away from the loved one. Due to the COVID-19 outbreak and the closing of the university, 17 participants out of the 36 did their interview online through Skype or Zoom instead of face-to-face without a noticeable difference.

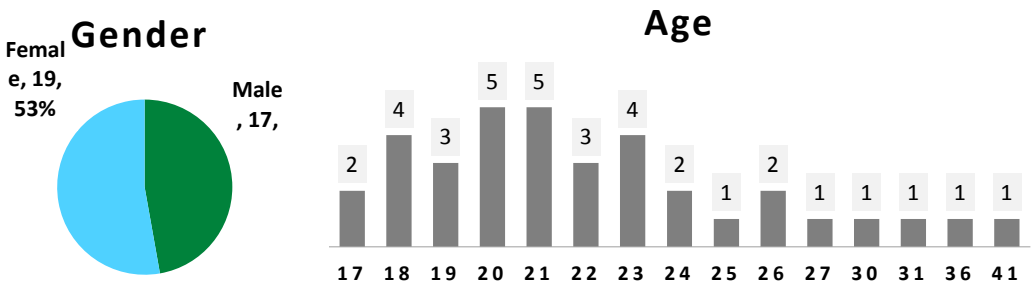


Figure 4.4. Participants information [Gender and Age] for the one-to-one interview sessions (36 participants)

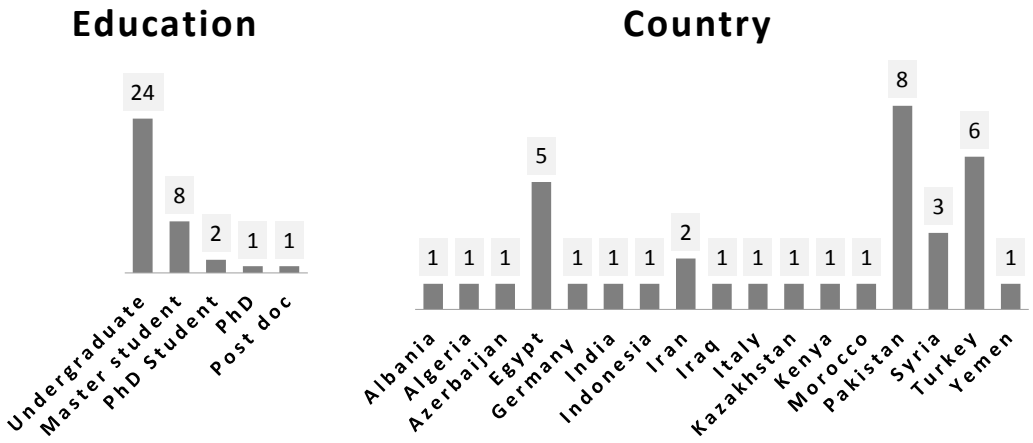


Figure 4.5. Participants information [Education and Country] for the one-to-one interview sessions (36 participants)

4.4 The Currently Utilized Communication Media by The Participants of This Research

In the online diary stage, after collecting all the answered, the total individual answers are 267 answers. From those answers, a total of 189 individual communication was logged between the participants and their loved ones. Individuals may communicate at least 3 to 4 times a week with their loved ones, each communication can be from few minutes of text chatting or recording audio messages to few hours of voice or video calling (Figure 4.6a). The user group of this study used current communication media and social media such as WhatsApp to stay connected with their loved ones. Figure 4.6b shows the various media used by the participants, note that a participant may use a few applications throughout the week. These applications may be common among loved ones and peers thus are utilized among this research's participants, or/and that these applications are not costly (mostly free only the cost of the internet subscription), this is especially important for students. Current communication applications only offer video, audio, and text communication (including sharing pictures, emojis, audio, and videos) which is seen utilized by this research's participants. Other sensor modalities such as touch are

underutilized in the communication between the participants and their loved ones due to the limitation of the current way of communication.

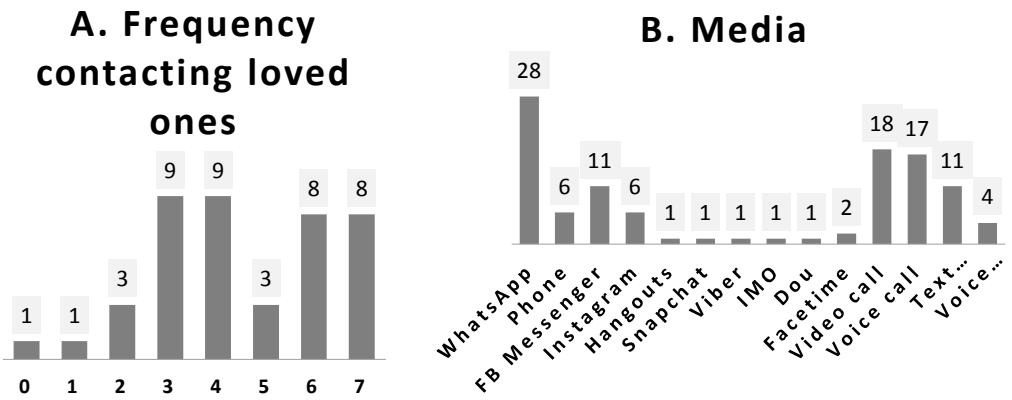


Figure 4.6. Online diary stage: Frequency of logged communication happened between the induvial through the 7 days for each participant/media used (42 participants)

While preparing for this research there were no obvious stated reasons why people who live away from their loved ones do communicate with each other. The online diary helped to uncover some of these reasons, however, these reasons are linked to what current media can offer (video, audio, and text communication). Table 4.3 shows all the reasons mentioned by the participants in the online diary sage of this research. The most common reason (37 out of 42 participants) is to check on each other, the participants, and their loved ones. The online diary uncovered four categories for why people communicated with their loved ones.

- The first category is “complex communication”: both sides need to indulge in detailed conversation to get information about each other such as discussing something or a certain topic. This is can be done easily with the current communication media using video and audio chatting.

- The second category is “simple communication”: both sides need to know simply the existence of the other person or the interest of the other person in them such as just saying hello.

- The third category is “sharing communication”: both sides indulge in sharing activities of digital things such as images and videos they take or see on the internet.

- The fourth category is “one be among others”: both sides indulge in group communication where one joins the other side group event or one with others join digitally in a group chat, for example, this can be for a social event or general family gathering.

Table 4.3 Reason for communicating the loved ones

Reasons rephrased	F#*	Example reasons by the participant
Complex communication		
Checking on them or they on me	37	“I just called to ask how they were doing” [P1]
Discussing my day, something or certain topics	11	“My mom contacted me first and we talked about my big sister's upcoming wedding” [P8]
Asking for advice or (something) or question or prayers	7	“I asked for recipes from my mom” [P35]
Discussing certain things e.g. Objects/shows	3	“Just talking about a show we watch” [P2]
Shearing good news or event happened in one’s day or new thing happening	3	“First was to share important news related to ourselves, early in the morning” [P10]
To help with (something) or to solve a problem	3	“Helped him with his homework” [P13]
Tell the loved ones about plans for (something)	3	“I had to tell them my plans for the winter holidays” [P9]
Learn about loved one’s news	2	“He had a conversation with his professor, after that he called and told how the conversation went” [P10]
Planning things together	2	“Talking about an object we are planning to buy” [P2]
Expressing feelings about issues	2	“I discussed many of the things that we had shared as well as my frustrations at living in a foreign country” [P28]
To know about loved one’s activities	2	“How did you study” [P10]
Check on the epidemic outbreak in their region	2	“Just to ask them about their situation with the Coronavirus outbreak” [P41]
To celebrate (Something)	2	“Sister’s birthday” [P14]
Checking on how I did in (something)	1	“It was my mom who contacted me first to talk about my grades (they are out today) and how I was feeling about it” [P8]
Follow up on (something)	1	“I had to update them about something we were planning on doing” [P29]
Resolving issues or answer question	1	“Resolving issues about going back home” [P24]

Table 4.3 (continued)

Simple communication		
Routine Hello and Greeting and general talk	11	"Just to say hello, as a matter of routine" [P7]
Missing the loved ones or to feel close to them or to stay in touch	11	"Missed them I wanted to see them because of the virus and my mood" [P27]
Wishing (me best of luck) / loved ones a nice day / happy birthday	3	"Called me to say best of luck for a midterm exam" [P5]
Because I have to do so / Ritual fulfillment	2	"Catching up. Ritual fulfillment" [P24]
Leave the connection open while doing something to be connected	1	"I put the phone in front of me and did my daily routine housework while chatting" [P10]
Reminding the loved ones about certain things	1	"Just to remind one of friend's birthday" [P10]
Checking whereabout	1	"My mom called me to check where I was" [P8]
Feeling lonely	1	"I miss them and I feel lonely" [P20]
To be motivated	1	"To be motivated" [P33]
Sharing communication		
Sharing photos or memories	4	"Share photos and family updates" [P3]
Be among others		
Group call or chat	2	"It's Friday so the whole family gathers in my grandmother's house so I wanted to call to talk with them all" [P16]
Join in a social event	1	"They were at a family event and wanted me to join" [P6]

* frequency of the same statement mentioned by the participants

The researcher of this research believes that the second category "Simple communication" is where RST can contribute as sole medium or with other media, Feeling the presence of the other person or simply sending a simple message such as happy birthday but through other sensor modality such as touch. RST can be used in this category to keep people connected throughout the day and stay knowledgeable about each other whereabout. For example, "SHAKER" by Strong and Gaver (1996) can fit in this category, it is a simple prototype to send shaking between individuals which simple messages can be coded for presence feeling

For the other categories, RST can be used to enhance communication such as attaching an emotional touch message with the video, audio, text, or image. For that, the framework that this research is aiming to develop should be able to explain RST strengths and limitations concerning these four categories. It is possible to notice

some RST research fall under such categories. For example, “POKE” by Park et al. (2013) can enhance audio and video chatting by including touch with the experience to enable nonverbal communication.

However, current communication media have some limitations. This is obvious from the reasons why the participant in this research could not establish communication with their loved ones even if they wanted to do so. As the majority of the online diary participants (34 out of 42 participants) were mostly students, they have exams and assignments, being busy is a common reason why the participant could not connect with their loved one. Other reasons mentioned such as not knowing about the other side's availability or problem with technology (Table 4.4 quotes some examples from the participants). These reasons could be an indication not only about the limitation of the current communication media but can be considered as some of the issues people who live away from their loved ones face with their daily communication. Knowing about these issues can further help in developing products for RST as one can find a way to overcome these shortcomings of current technologies. These reasons could be considered as ways to further develop the RST framework or explain the limitation of it. RST framework needs to explain how to overcome: i) the issue with not knowing the availability of both sides, ii) if one is busy but both need to establish a communication what will happen then, and iii) when technology fails what will happen then. Some RST literature overcomes some of these issues by including asynchronous communication, allowing them to record the touch message to feel it at a later time. For example in “Hug Over a Distance” by Vetere et al. (2005) the individual can accept to receive and feel the hug request or decline, when accept one will feel the hug and the sender will receive a thank you message with a kiss sound as an acknowledgment that the receiver felt the message.

Table 4.4 Some of the reasons not being able to communicate (Diary Q.6: still did you want to contact them but you couldn't? if yes why you couldn't?)

P5	"…I think he is busy that why I didn't contact him…"
P7	"…They were not at home…"
P15	"…Had a long day at classes and exam over the weekend. Studying for them is keeping me busy…"
P19	"…I got distracted while working then it was too late…"
P20	"…I wanted to contact my brother. I couldn't due to midterm stress…"
P35	"…My sim card wasn't working…"

Additionally, the interview stage uncovered other behaviors to stay connected with loved ones. Through the time living away from their loved ones, participants tried various ways to stay connected such as doing an activity together remotely or sharing postcards or collage (Table 4.5 shows some of these behaviors). One can see these behaviors especially related to intimate relationship couples, some behaviors are driven from a traditional way of communication (non-digital ways), however, these behaviors show the creative effort one does to stay connected. Some relationships could require to put their own touch on a common communication to make it theirs. Thus, the RST framework that this research is aiming to develop should be able to take notice of i) creativity, ii) customization and iii) personality of the communication. There are some examples from literature which they provide personalization such as "TapTap" by Bonanni et al. (2006), which is a piece of garment, for example, a mother leaves it with her child, one can personalize the look, the touch message, and the placement on the body to feel the feedback.

Table 4.5 behaviors to stay connected with loved ones

P1	"…listen to music at the same time…"
P1	"…one-page PDF like a newspaper putting images that I recently take…"
P1	"…having dinner with each other over a video call…"
P1	"…we played video game adventure puzzle game she was playing sharing her screen …"
P10	"…postcards writing it and send it by mail because I like those kinds of things. it is like memories … he can use this as a bookmark or pin it to a board on his wall…"
P25	"…share my activity with them what is happening with me sending photo and stuff…"
P6	"…I bought a cat but now my parents taking care of the cat so when they called they show me the cat video or images …"

Additionally, some of these behaviors show that the artefact used for communication can be transformed from the communication media (e.g. message on a postcard) to an artefact that has especial value and a way to remember a loved one. Whether it is a tangible or digital means of carrying a message, it can be also a means to remember a loved one. This feature can be carried along to RST product, the designer can look at the product not only as a means to deliver a message but as an artefact itself carry value.

4.5 Missed Physical Interactions

One objective of the interview is to know the missed physical interaction (PI) for the people who live away from their loved ones. The first step is to pick one relationship that the participant likes to talk about throughout the interview. This is to keep the information detailed and focused on that relationship instead of scattered information about many relationships one participant has to talk about. The researcher did not force the participants to talk about a certain relationship but it was open to the participants to pick. This is to elicit as much information about the various relationship, Figure 4.7a shows all the relationships the participants picked. The most common relationship was “Mother”, 24 out of the 36 decided to talk about their mother. Also, out of the 17 males who participate in this study 15 picked their mother, out of 19 female participants 9 talked about their mother. Other relationships mentioned are father, best friend, boyfriend, younger sister, younger brother older brother, niece, husband, and wife.

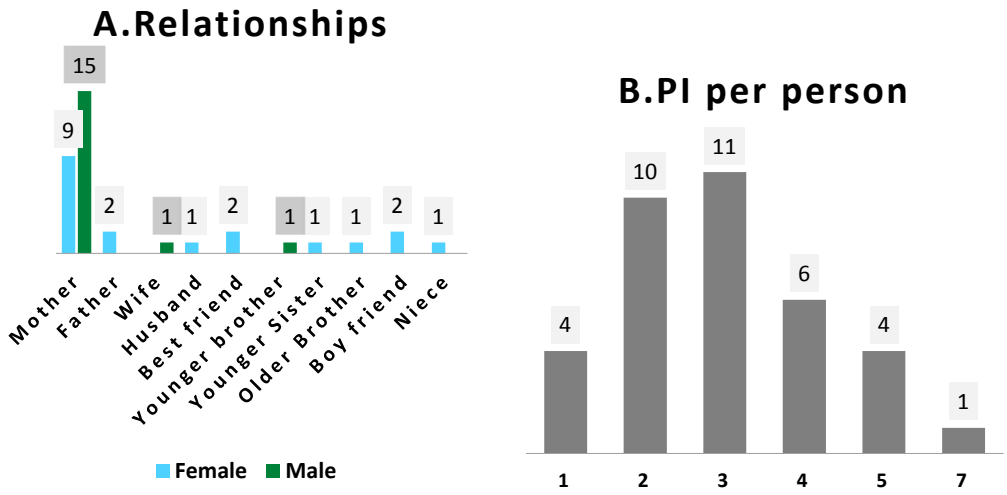


Figure 4.7. A. Relationships mentioned, B. Missed PI per person mentioned (minimum one PI mentioned per session, maximum of seven PIs mentioned in the session) (PI= physical interaction) (one-to-one sessions, 36 participants)

After picking the relationship, participants had to say the most missed physical interaction (PI) with their loved one. Figure 4.7b shows how many PI mentioned by each participant. Most participants (21 individuals) mentioned in their interview 2 to 3 different missed PI; only 1 participant mentioned 7 different missed PI and 4 mentioned only one missed PI. Figure 4.8 shows all the PI mentioned by the participants with a total of 25 different missed physical interactions and a total of 108 missed PI input with repetition. Hugs are the most missed PI, 35 out of 36 participants mentioned they missed a hug, Kisses are the second missed PI then holding hands in the third spot. “Mother” relationship has a wide variety of PIs individuals may miss while being away more than the other relationships. There are some PIs special to a mother relationship such as sleeping on a mother's lap and some are more general such as a hug. Certain PI may vary from relation to another, for example kissing may include the forehead, cheek, hand-kissing. Refer to Figure 4.8 for a full list of missed PIs.

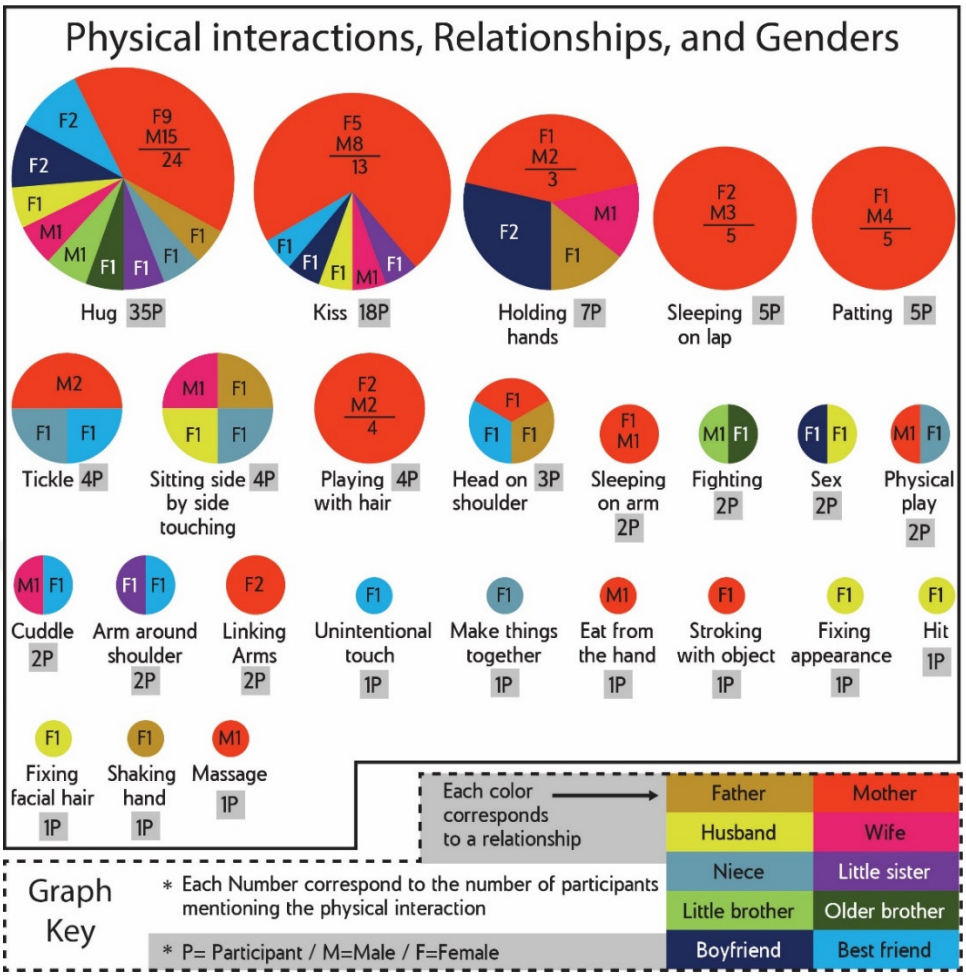


Figure 4.8. Physical interaction mentioned comparing with relationship and gender

These findings can justify why many RST researchers are pursuing making prototypes and research related to a hug such as "Hug Over a Distance" by Vetere et al. (2005) and Mueller et al. (2005). Additionally, this finding may promote the idea in the future "Hug RST Products" could have a wide audience user group. Also, even though these findings suggest that mother-children relationship is commonly talked about concerning RST among individuals similar to this research participant pool, however, it is rare to see RST research focused on such scope. One example that can be mentioned is "Huggy Pajama" by Teh et al. (2008) which is a wearable system that enables RST of a "hug" between parent and child.

Moreover, usually RST research is done related to a specific common PI such as hug or kiss, but especially for mother, this research uncovers vast more PI under-researched can undergo it is own research concerning RST such as sleeping on the mother's lap or eating from her hands. This is could be because the uncommon PIs found in this research are not widely express by people to be noticed in comparison to the hug or the kiss. It can be interesting for future research to excavate more information about these uncommon PIs. The findings of this research can give a new direction for the future researcher not to neglect other physical interactions that are important to certain relationships. The findings may also help in developing new technologies or utilize current technology to enable the transmission of certain PIs such as stroking the hair or patting. The findings also suggest that researching in the way this study was done can help shed the light on relationships such as a niece, and PIs such as eating from a loved one's hand otherwise uncovered previously. Concerning the proposed RST framework in this research, it should consider different relationships and PIs one may want to use RST for.

4.6 The Importance of Social Touch

One of the main reasons for the online diary is to prepare the participants for the research subject and to gather some indication of remote social touch (RST) importance in one's life. Also, from the interviews, it appeared that the participants were more open to talking about their problems being away from their loved ones after they noticed their own need and behavior through the 7 days.

In the diary, the participants were asked to indicate if they missed physical interaction with their loved ones. From 267 individual online diary input, 149 entries (56%) indicate missing physical interaction on the day of data entry (Figure 4.9a). Through the week, some participants indicated missing physical interaction throughout the 7 to 6 days of the online diary (13 of 42 participants), few did not miss physical interaction at all or at least ones through the 7-days online diary (9 of 42 participants), and most (20 of 42 participants) did miss physical interaction

between 2 to 5 days in the week of the online diary (Figure 4.9b). Additionally, to understand how the participants felt by missing the physical interaction, they have to choose from the Pick-A-Mood (PAM) character sheet (Appendix E) how they feel about missing the touch on that day. Figure 4.9c shows all the different choices participants picked. The graph shows that 147 feelings logged, plus 2 extra feelings "very sad" and "frustrated" which one participant thought there is no representative of these 2 feelings in PAM, (2 other feelings + 147 = total of 149) median and the mode is 6.

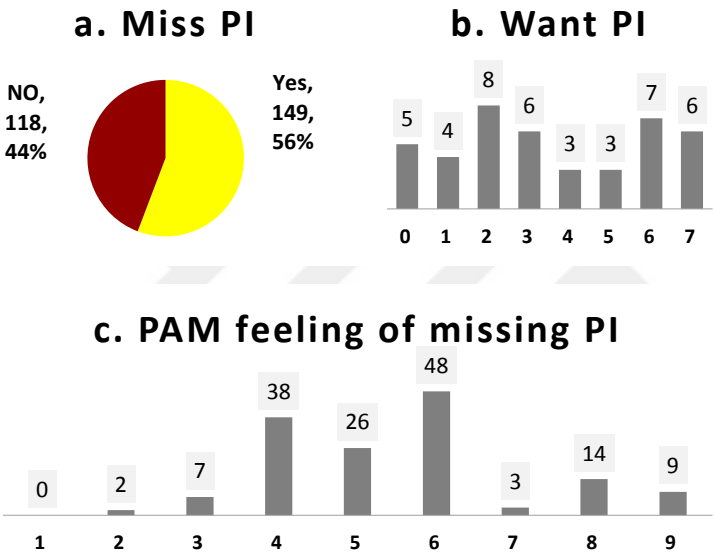


Figure 4.9. a. how many said yes for missing physical interaction out of 267 entries, b. within the 7-days online diary how many times the same participant said yes to missing physical interaction, c. PAM representing the feeling of missed physical interactions (147 indications), refer to Appendix E for PAM meaning (PAM = Pick-A-Mood / PI = Physical interaction) (Online diary, 42 participants)

The results from the online diary stage indicate that some people (38 of 149 indications) who missed physical interaction felt neutral trying to hide their emotions "it is ok", others (48 of 149 indications) felt sad and bored thinking about it, and some (19 of 149 indications) felt very sad and frustrating about not able to have physical contact with their loved ones. These findings do show that physical

interaction is important for many individuals and some may miss physical interaction a few days a week, accumulating these negative feelings of missing physical throughout the time being away from a loved one (could be weeks or months), can result in developing depression by empowering these negative feelings (Fredrickson & Joiner, 2002). Moreover, these findings are aligned with the literature that stresses social touch is important in one's life, refer to Chapter 2 Section 2.2 for the importance of social touch in literature. From these findings one-point can be added to the proposed framework for RST, the time frame, RST need to support communication not for one time only but on multiple occasions within a day or a week. This can be translated to the availably of touch communication when needed whether it is live or a messaging communication.

Similarly, in the interview stage, participants had to talk about their feelings about missing the psychical interactions (PI)s they mentioned using PAM cards (in a similar manner with PAM in the diary). However, since there are 25 different PIs associated with 10 relationships, most of these PIs discussed only by few participants which resulted in gaining a very minimal amount of details about other PIs in comparison to the mother's hug. This can be considered as a limitation to discuss these PIs (other than mother's hug) concerning how people feel about missing them. For that, the next section will only discuss how participants felt about missing Mother's hug. However, refer to appendix M for information about other PIs.

Quoting the participants within the text is done in a certain way in this research Figure 4.10 illustrate how to read through the quotes. Within the body text there is double brackets that contain "PX", "P" refers to participant, and "X" refers to the number of the participant.

participants felt happy, warm, and joyful [P4] [P14]. They hug to feel comfortable [P6], satisfy [P9], and safe [P25]. A hug from the mother gives one the sense of being loved [P30].

Table 10. participants feeling toward having mother's hug

	Feeling while having the hug
P4	"…feeling happy and warm enjoy to hug your mother after a long... it is joyful to hug your mother…"
P14	"…I feel like it is so happy feel like dancing…"
P6	"…hug feel comfortable…"
P9	"…satisfaction feeling or you accomplish something and someone is happy for you…"
P25	"…happy relief safe everything is okay I have nothing to be worried about I am there she still loves me I feel I am safe with her…"

Figure 4.10. Quoting the participants

4.6.1 A Special Case: Mother's Hug

To understand more about the importance of social touch, the first part of the interview is set up to elicit information further related to physical interaction and its related relationship. As the results explain in previous sections the mother's hug is the most common physical interaction (PI) indicated by the participants which yields enough information for this objective. Thus, this section will take the mother's hug as a special case to analyze further.

The findings related to this section shed light that a mother's hug may contribute to one's emotional wellbeing having it may induce positive feelings and missing it may induce negative feelings. Moreover, participants' discussion illustrates how social touch is important in one's life and how missing it could affect one's emotional wellbeing. This finding can be linked to what Diener et al. (2009) state that The frequency of negative feelings could impact one's wellbeing negatively.

participants explained their feeling toward having and missing mother hug by using PAM cards (Appendix E). PAM cards were used in the interview to elicit information about how they feel and not intended to be used for it is exact number measurement. While engaging in a "mother hug", participants picked PAM numbers one (8 out of 30 times), two (10 out of 30 times), and three (10 out of 30 times) -participants allowed to pick multiple numbers for the same physical interaction-. Number four

picked 2 times to represent a neutral state, oneself not much effect while engaging in a "hug" the mother action.

To understand more about their feeling while engaging in a "mother hug" action, one can read through participants' discussions. While being around their mothers, participants felt happy, warm, and joyful [P4] [P14]. They hug to feel comfortable [P6], satisfy [P9], and safe [P25]. A hug from the mother gives one the sense of being loved [P30].

Table 4.6 Participants feeling toward having mother's hug

	Feeling while having the hug
P4	"…feeling happy and warm enjoy to hug your mother after a long... it is joyful to hug your mother…"
P14	"…I feel like it is so happy feel like dancing…"
P6	"…hug feel comfortable…"
P9	"…satisfaction feeling or you accomplish something and someone is happy for you…"
P25	"…happy relief safe everything is okay I have nothing to be worried about I am there she still loves me I feel I am safe with her…"
P30	"…very loved and I am the best person lucky…"

However, for missing a "mother hug", participants picked PAM numbers four (8 out of 32 times), five (8 out of 32 times), six (9 out of 32 times), seven (1 out of 32 times), eight (2 out of 32 times), and nine (4 out of 32 times) -participants allowed to pick multiple numbers for the same physical interaction-. Number 4 or 9 usually picked to represent "it is ok I am used to it" feeling related to missing mother's hug.

To understand more about their feeling related to missing a "mother hug" action, one can read through participants' discussions. While being away participants may feel anxious thinking about the hug [P8], or feeling sad and bother when in need of a mother's hug [P9]. Also, participants may feel uneasy [P17], sad [P18], disappointed [P30], and lonely [P35]. While being away participants may try to hide their emotions even if they need the hug [P6], Some participants may feel not bothered much by missing the hug since they are used to living away without the hug [P14][P15].

Table 4.7 a. participants feeling toward missing mother's hug

	Feeling while missing the hug
p8	"…anxious really thinking about it and worry…"
p9	"…I feel sad of something is bothering me I'm looking for the hug so look kind of sad because I did not get it…"
p17	"…I feel like I can't relax … you need to reconsider what you are doing it is like a crisis face…"
p18	"…sad mood is not really good it will be better if she was here…"
p30	"…I feel like I am very disappointed. I don't love the world. no one likes me…"
p35	"…I feel sad and I feel lonely … isolated from her. and I feel like a part of me is missing. I feel like I don't want to be in this situation but I feel sort of hopeless that I cannot help it…"
p6	"…when missing a hug you feel like you want to you need it but you need to hide your emotion that's why you are straight you don't want to show you need hug…"
p14	"…because I used to it right now being away maybe when I first time I came or being away maybe I was more crying sad … it is like a okay I can't live there anymore I feel more independent I just accept the fact to do this stuff I need to pay for that to be independent I have to pay the price of being away and missing these but I just accept the fact and move on with my life…"
p15	"…initially maybe when I first left it could be different but now like I got to use to it I have better thing in my mind so if I'm not getting hug I am in difference to it … I live by myself I'm always busy when I'm a free always call my mom every weekend I call my mom…"

Participants who indicated they feel neutral, not sad or happy while missing a "mother's hug" [P16], could be due to their busy life or having a friend for support [P19][P32]. However, feeling sad or not depends on certain situations [P22][P24][P29]. Moreover, one participant who says that he is not a "touchy" person (i.e. do not like to engage in physical interaction with other people), indicated that he engages in the action of the hug for his mother's sake but because he is away, he cannot give her that and that is making him sad [P3].

Table 4.8 b. participants feeling toward missing mother's hug

p16	"…not happy not really satisfied like neutral…"
p19	"…life is hectic I have a lot of study I do have friends around me so I do have support when I needed I'm busy all the time so I don't have specifically the time to miss these interactions unless I am going through a very stressful or sad event…"
p32	"…I kind of sad that I cannot do that I am also ok I am getting used to staying away not that sad about it and not that happy about it in the middle and have friends so I have physical contact I think it help…"
p22	"…it depends on the situation sometimes it is ok … when I feel like I need her with me or I feel I have some obstacles I would feel like sad…"
p24	"…sometimes I am indifference … but sometimes I feel like helplessness and sometimes contemplation on my situation feels bad my decision me be away so sometimes I question my decision me be away did I do the right thing…"
p29	"…it depends on the day I am used to living away from my mother it's been 2 years I am happy generally that I do not need the physical interaction because I'm used to not having it … but usually I don't miss it but if it's bad situation or bad day…"
p3	"…it does not affect my mood or whatsoever I don't really need it or don't miss it however because I know my mother feel the need of it and I cannot give her that it make me feel sad but doing it itself I don't care about it projecting her needs on me I know she will be happy if she received a hug so I do it for her…"

Additionally, Figure 4.11 shows the frequency of giving and receiving a hug in general between the participants and their mother. The figure illustrates it is frequent that people (of this research) engage in the physical interaction of the hug, this can further explain the importance of social touch in one's life. However, one participant indicated that the mother rarely does initiate a hug even though one may want it. Also, in another case a participant does not like social touch but engages it with the mother for the mother's happiness. These findings can develop the proposed RST framework by indicating the importance of the frequency of interaction among individuals engaging in physical interaction communication.

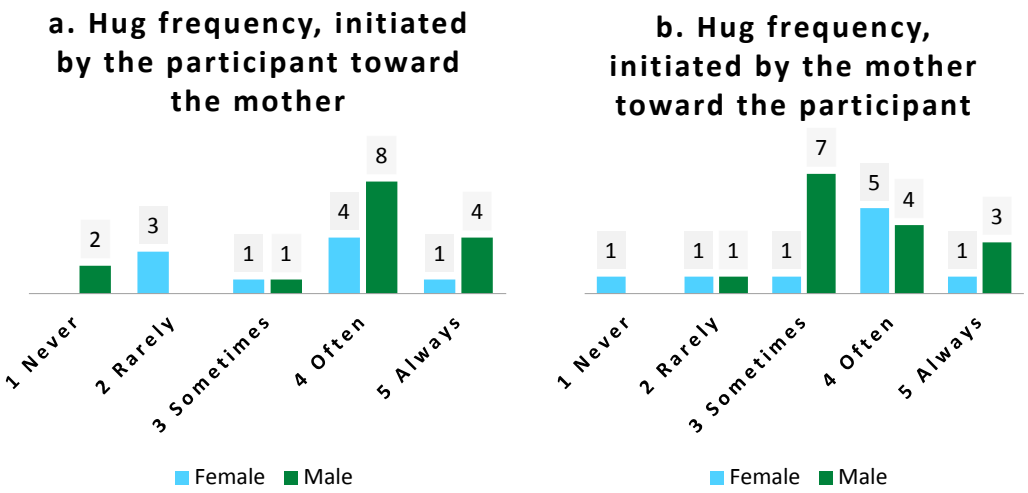


Figure 4.11. Frequency of hug interaction in general (from the one-to-one sessions, 24 participants talked about the mother relationship), (interview question 2.8: When you meet them in same physical space how often do you initiate these physical interactions with them / your loved ones initiate these physical interactions with you)

4.7 Perceived Remote Social Touch Benefits

Participants of the interview who come to understand and be exposed to remote social touch (RST) principals and technologies perceived some benefits from RST. The points discussed by the participants is similar to what other RST literature discussed (see Chapter 2 Section 2.3). The benefits the participants of this research expressed can be seen as areas where RST should help, areas where RST can enhance, new areas for research, or areas to focus on while designing for RST. All the points discussed by the participants are subjectively mentioned about RST, this is what the participants thought "the good" in remote social touch based on what they understood about RST from the researcher, the videos, and the low fidelity prototype.

The main points discussed in this section are related to emotional wellbeing (12 participants talked about this point), connectedness (10 participants talked about this point), enhancing current communications (9 participants talked about this point), and 10 participants talked about other miscellaneous points. These points can be

translated into the proposed RST framework of this research, the proposed framework should take notice of the emotional side and the presence of RST. Also, it should illustrate how RST can be combined with other sensor modalities and other communication media.

The first area participants believed RST may add to or enhance is their emotional wellbeing. Participants mentioned having this kind of communication could likely reduce the feeling of being alone [P2], detoxing from stress, reducing bad feelings [P14], and making people happy[P22]. They see RST as a way to relieve ill-emotional state [P29] and could provide an energic feeling. RST may be used for specific people that can benefit from it the most such as individuals experiencing emotional hardship and their social skills cannot help them with that [P4]. Also, can be used for individuals attached to touch and cannot have access to it anymore [P35]. RST could be useful for students, from time to time when they feel lonely and homesick [P23], it may give them the motivation to push forward [P26], and give them the social support they need [P28]. As for children, they could still get the affection they need if they are forced to live away from their families [P8]. Furthermore, it makes being away easier on relationships and reduces worrying about them [P25].

Table 4.9 Perceived Emotional wellbeing benefits

P2	"…even that person far away from you know they are thinking of you and initiating physical touch with you okay it is like I'm not alone as I think I am…"
P14	"…making people happier because make body produce more endorphin so they going to be happier…"
P22	"…like for me and my mother would still feel like we are in touch maybe it can make the feeling of bad less…"
P29	"…the advantage that it will have whenever I want it I can have it, it will change too many things in that specific day for example when I'm really stressed I could find something that really reduce my stress or when I have exam I can feel someone can help me be much more productive and efficient than just a call or video message…"
P4	"…this could be beneficial to people to have it especially who go through depression and hard time or shy or their social skills are not that great asking for help show this to can work as a passive way to ask for help…"
P35	"…for people who are who feel like you know, physical interaction is an important part of showing love like people like me, it would be a good chance to feel somebody or somebody touch to even though they're so far from you, which is, in my opinion, one really good use of technology advancement..."

Table 4.9 (continued)

P23	"…if it became reality it will solve a lot problem not just for me but for all the other student even though no one chooses to talk about these things loneliness homesickness not that much but everyone has it I think if it does that it will cure a lot of problems, we have..."
P8	"…I've heard that it is good for children who are away not receiving enough touch from their parents might have enough affection from their parents yes I want it for people in special occasion…"
P25	"…I came from a country where they are having war right now and I cannot go back and see my family so remote social touch can give the people a chance to feel something from their parents even if they are worried about them also is going to give the feeling that they are still with you…"
P26	"…I am a student and as a student sometimes I need motivation maybe the advantage is that I can feel my family or my loved one to continue my study …"
P28	"…I feel like definitely you get this sort of support that you really need on some days and you really need…"

The second area where RST can contribute is the feeling of connectedness. "Presence" is seen as an advantage of having such communication [P2]. It could allow individuals to feel their loved ones without the need to wait until returning to them [P5], which reduce overthinking about them [P23], and worries [P27]. Feeling presence could reduce the feel of the distance and open the door for having support [P30]. Additionally, having touch communication may increase the sense of belonging [P4] by having extra information about the loved ones [P21]. RST possibly allows maintaining the feel of closeness [P11], and it may make the experience of being away from a little easy [P27].

Table 4.10 Perceived connectedness benefits

p2	"…you need some sort of affirmation that person is there so this will allow all people yes this person is there the other person feel…"
p5	"…I wait for 1 year to meet them but in this way, I don't need to wait one year I can just feel their presence at any time so it will help me and relaxing and feeling better…"
p23	"…you will not spend time overthinking they are far away and I am all alone over here…"
p27	"…in term of other people like my family they are living away in different city nowadays I'm missing them because I'm really nervous about their health anxious about so remote touch can be at least hugging it can be sort of way of interaction between all of us they are so worried about me…"
p30	"…it will make people feel not very distanced about the love people or the loved ones you can feel like they are with them all the time…"
p4	"…you leaving away from your loved one you are leaving them in their time frame when you go back everything will be different they moved on and develop differently so having access to this interaction can help to keep in touch so always keep you in contact with that environment in general it will leave you with a sense of belonging so you have this story you have this environment that you can belong to so you are not alone anymore…"
p21	"…like the situation right now with corona virus having some information from your loved one can be something nice…"
p11	"…for me physical interaction is important for me to feel the love of someone on closeness to feel better and to feel care…"
p27	"…home just a few steps away from you it's acceptable you don't need to touch them but this kind of technology making our experience a little bit easy…"

The third area that RST can enhance is the current communication media. First of all, it could enhance the current communication by providing a part similar to face-to-face communication. It can add a new layer on top of the other communication media [P1], a private way of communication [P21]. A sound recording can be heard by others in case they have it but touch does not carry meaning only to the right people. RST can be on its own as a new communication medium or service. The idea that someone physically has to communicant brings about the thought that the loved ones are physically available for them [P31]. Another benefit of RST is when communicating with children, usually, they are less attentive with video or audio communication media, however, this will give them the choice of physical play while communicating to stay in touch [P27].

Table 4.11 Enhancing current communication

P1	"…because of the globalized life we are living away from our loved one it is good to have another layer of communication to keep in touch…"
P21	"…with symbolic messages the secrecy that you were talking about quite interesting because no one else can understand that message it has greater value you can say whatever message you want maybe even text messages that can be translated to symbolic touch and it is leap forward and privacy…"
P31	"…it's another dimension of the feelings. so actually you never could perform the action, that actual action without being physically available. oh, I guess it's a yes, it's very good. so you have more options to communicate with your loved ones when you're in a distance…"
P27	"…she was even smaller at that time she was not able to be attentive in skype talk she doesn't want to talk with you she just want to play with you so it was not possible at that time so it can't be fostering in term of experiences they have together maybe it would be quite useful for us…"

Finally, there are a few other points related to the perceived benefits of RST. For touch avoider individuals they may use it as a way out of social constrain in such as allowing the loved ones to send but they have the choice to feel it or not [P3]. Also, on the other hand, it may remind people of the importance of the social touch they took it for granted [P4]. This technology also may inspire the advancing of other technologies [P6]. Additionally, with RST one can save touch which will bring back what one lost [P10] and help in remembering events just like pictures do. Lastly, psychotherapy and rehab can see an advantage in this for therapy purposes [P28].

Table 4.12 Other thoughts about the advantages of RST

P3	"…you can disable the interaction from your side if you don't want it… so I'm doing the social interaction because it's required from me… my mother maybe increase the intensity and for me I will lower the intensity…"
P4	"…physical is true connection you invest in yourself doing it you feel it with your body or hormone your brain reacting we need that people are becoming less social they don't value such interaction it will work as a reminder that you need it even if you don't realize it …"
P6	"…I think this technology can lead to another technology where you can physically send something for example if I want to send an apple they will receive apple…"
P10	"…more important to have social touch or remote touch not to the people are living away from us but the people we lost because I know that because I know I can re-hug or re-kiss my husband in a week or a month again but now I don't have a chance to hug my grandmother anymore this valuable thing…"
P28	"…it's also very good for psychopaths and people like you know, who no one wants to go near and just for their rehab situation, and then normalization, it's a very good technology, use it in prisons, use it for psycho …"

4.8 Perceived Concerns with Remote Social Touch

Due to the lack of literature on the negative impact of RST the researcher at the beginning of the research assumed that RST has minimal disadvantages, however, this section uncovers concerns not brought before to the researcher's attention. There are some issues individuals perceived from the understanding of RST principles, which could be seen hindering the acceptance of RST technology among people living away from their loved ones. The researcher acknowledges that all these issues are subjectively mentioned about RST, this is what the participants thought "the bad" in remote social touch based on what they understood about RST from the researcher, the videos, and the low fidelity prototype.

The finding of this section should open the door for future research about the negative impact of RST on individuals living away from their loved ones. There could be psychological or social impact by the prevalence of RST. Even though the information subjectively gained from the participants and these concerns may or may not surface when RST becomes reality and available to everyone, the information sheds the light on some concerns that RST researchers or designers need to be aware of. These concerns can be the reason in the future people will not adopt RST, or these concerns can help in establishing an ethical boundary for RST so it will not be exploited.

Participants of this research expressed some concerns that adopting this technology could result in or encourage to happen. The main points discussed are related to negatively impacting emotional wellbeing (15 participants talked about this point), the impact on real-life physical interaction (19 participants talked about this point), and concerns about the communication or product itself (11 participants talked about this point). The most common keywords mentioned in this section related to concerns with RST are addiction, privacy, safety, devalue the real physical interaction, not able to move on, not tending to the real person, not authentic, and emotional concerns. The proposed RST framework should include a hint about these

issues especially concerning privacy and safety, and also hint to an emotional impact on both sides of the communication or on one side in the case of saving the touch.

The first set of issues participants mentioned against RST is related to the emotional state while or after using RST. After losing its novelty, over time it could bring depression by reminding people that they cannot get the real touch from them [P7]. And face-to-face (F2F) interaction may be better for emotional support even if one has to travel for it [P29]. Additionally, the memory RST evoke may bring people to sadness [P8] and negatively making people miss their loved ones more [P25].

Table 4.13 a. The impact on emotional wellbeing

P7	"…I think it's going to be depressing having a robot to feel this and physical interactions maybe in the beginning interesting affectations but overtime I think it will become depressing having a robot to substitute physical contact…"
P29	"…if I still have this device I still will go to Istanbul because the feeling is different from having a device the device will help sometime when I'm stressed and I'm really busy I cannot travel but when I really need it I will go cuz I really need the interaction the interaction will not be covered by a device or robot…"
P8	"…if this is in the market we can't control how people will use it just like the phones maybe it's wall bring a lot of money but make people sad…"
P25	"…for some people they may think why I'm doing this to a device I should go and see them this can turn to a negative thing it will make them miss them more…"

And saving the touch message could bring cravenness to touch the loved one who is not alive anymore [P11]. It could be painful [P27] by reliving the memory of touch by feeling it instead of the touch being in the mind only. Moreover, if RST widespread it could make people tend to be lonelier [P8] by tending to it more. Not only that but RST may make it harder to move on after losing a loved one [P13], and cannot progress in life [P36].

Table 4.14 b. The impact on emotional wellbeing

P11	"…I think it would make people to crave the physical interaction even more in case of saving you are feeling their physical interaction but you know the person is not there anymore maybe it's an advantage you can still feel the person but yet you are feeling in through device not the real person reality still reality it doesn't matter through the device…"
P27	"…it quite painful for me to have these after sometime later lose these people or even I will be gone for them maybe it should just a memory in our mind…"
P8	"…I don't want it to be accessible to everyone because birth rate is going down and people get being more lonelier introverted…"
P13	"…someone died you need to be able to move on if you have these messages you can play it again and again it will make it more harder for you to move on with your life you will know that person is not here anymore you can manipulate reality with these messages impact yourself with this messaging give you the feeling they still around but they are not it will make things harder…"
P36	"…my mother's hug would keep it from me forever. when I will hug her even for example, if she's dead, she died, then I will have her hug. I still have a hug, but I will never like go through the fact that she's died because I will always have something left of her. so it's like you will never progress, you know, like you, as if she's here, but she's not here. you cannot talk to her. we can't do anything. we just have her hug. so you sit back and you cry because she's died. but if you don't have physical contact with her, or anything that reminds me that reminds you of her. you will get used to her absence. so move forward…"

RST could produce addiction too, especially for people with weak mantel state [P18] which could produce a new "X" syndrome [P21]. Additionally, RST may give a reason for people to stay away for longer which makes one misses many things that cannot be replaced by technology [P17]. Also, RST could give parents an excuse not to tend to their children physically by letting them be away for a long period [P9].

Table 4.15 c. The impact on emotional wellbeing

P18	"…sometimes you really miss the touch of person who are not really with you anymore but at the same time that could be switch that craziness really fast let's say somebody will go for real simulation of the physical interaction for example of a robot that stimulate their mom or dad's or partner will be an addiction to it it is a simulation it is not the real person it's a collection of his idea in a simulation even if it's look like him it's not going to be good for people not very strong psychologically maybe it is good for people who are strong psychology…"
P21	"…I would like to know how this will affect our brain because when you send a receive notification there's this release of dopamine and for some people it can be addictive like social media addiction … there's this disease I don't remember that name fatigue syndrome nowadays people receive too much information they have a trouble what is the implication of RST in that aspect it should be studied more in that area…"
P17	"…if this thing is available I will not go for the hassle of buying the tickets so this waiting for four months it can be increased to more like 9 months or a year so this is a disadvantage the presence with other person … the disadvantage is less feeling the need of going back home and I will miss many things cannot be replaced by technology…"
P9	"…maybe they will use this as a substitute for sending their children away hostels to focus on their studies because some parents focusing on their children instead so they will send him to a good institute when they are young and they will use this thing as an alternative not to being there to cover the real thing…"

The second set of concerns participants mentioned against RST is the real touch could get affected by the prevalence of RST. Missing touch is part of human emotional development, emotional will grow and mature when missing touch but RST may impact this. Also, missing touch may add value to the real touch, one will fantasize about it and wait until be able to touch a loved one [P1][P9]. RST may make touch available anytime which could reduce the value of the real touch [P6][P36]. This availability of social touch through a device may make people tend to it more than the real person [P7], which could diminish the need for a real person over time and missing the loved one less [P9]. It may impact F2F interaction by making it less needed [P29] and the real physical interaction (PI) may be replaced by it [P32]. Thus, RST could make people less social by tending to machines more [P35].

Table 4.16 a. The impact on real touch

P1	"…I think it is human nature to miss someone to miss the physical communication and maybe fantasies and think about it miss how holding hand or think about holding hand I think the human nature is to be separated and miss each other for example if this technology was exist 100 or 200 years ago the most successful poet will not be so successful because when you miss someone your imagination will take over start writing poem stories draw their loved one it is very natural thing…"
P9	"…not being a close to your family it's a good thing sometime it will help you to grow get experience with your feelings and emotions to be mature sometimes you need some distance or space from your family I think this thing remote social touch are not useful at all unless for someone who's going to stay for really long time away…"
P6	"…you may take it for granted so the value may decrease for example the value of hug so you will not need your mom for that you just use the device it is like whatever you can get from your mom the device can achieve …"
P36	"…this social distancing it gives you more value to the hug is like when you will find when you finally can hug or touch someone you will feel more joy … let me tell you something this progress in technology and like you can access everything you can even access hugging, touching someone, but you're not really touching it I think it's, it's kind of wrong because you just take the value from…"
P7	"…I think people will get captivated by this idea and they tend to it more than the real physical touch … it is bit concerning it may take over the real touch…"
P9	"…maybe the original thing will lose it just touch feeling and you will get to use the artificial thing which mean that the real person will lose the need to be with because this thing is more convenient…"
P9	"…make you not messing with them more just like the Virtual Reality where people staying in this machine instead of going in the real life…"
P29	"…it can replace the main physical interaction same with video call not able to talk face-to-face or messages instead of being able to talk to…"
P32	"…I'm afraid people will replace them with the real human touch connection nothing ever can replace human touch I think if people get to use this so much it may end up replacing and eventually reduced social interaction…"
P35	"…it may for some people reduce the chance of actually going out and interacting in real life because you can get lazy…"

The other issue about RST, it is not authentic physical interaction (PI) [P36]. It is an illusion that should only be used to trigger the memory not to replace the PI, it is a machine that gives the PI not a real person [P19]. All that could devalue the real physical interaction [P12], a machine simulates the PI anytime without limit on the time it will not be spontaneous anymore [P36]. When something feels finite it gains value but if it is reproduced anytime it may devalue, it will lose its limitedness which makes the live interaction less valuable "just send it as a message I will feel it later" [P31]. This technology takes something humane and makes it inhumane [P28].

Table 4.17 b. The impact on real touch

P36	"…I feel like it's not authentic. I mean, I don't know but the fact that it's not her who gives me this maybe I give too much credit for her hug but like, I want to be with her when she does it I mean, I don't want something I think it's it just breaks the concept of physical contact… you don't you don't share the moment with your mother you just sharing the moment with a robot or anything…"
P19	"it will create some kind of illusion this is the life you're not going to see them you are going to miss physical contact …yes it's hard losing someone being away from them but you cannot just mimicking it to convince yourself they are still there … remembering it it's nice but not mimicking the other person…if you keep a picture video or audio you use it to recall that memory but not reliving it by machine the machine is just projector actual event this is her voice saved on the machine this is her actual video saved on the machine … if you make a virtual device that make you live that moment again this is an illusion…"
P12	"…maybe it will turn like Instagram everybody sending hug each other or touching each other but no one really touching anymore digital closeness bring about physical distance…"
P36	"…you see, it's like it's a hug, I mean you can just transfer hug from someone so and it has to be spontaneous you know, it's not you feel whenever you want it lost, it will lose its value. it will lose it spontaneity I am against it just loses the value of it…"
P31	"…if you have all the time, so devaluate the value of the actual hug so in that sense, when you actually hugging your mom, you feel it … that is precious … understanding that something is finite it makes some feelings more valuable … and if it's devaluated it could affect negatively to the actual human interaction …I mean, because before that if someone called you and you didn't have another options to communicate, you would probably open I mean, get that call but right now, you know that you can just like communicate, and you can call text, whatever whenever you want, and how long you want and it lost its sense of limitedness…"
P28	"…it takes something that is special and cheapens it ruins it. it drops it down from a level of being something really sacred something really human and it's not anymore it's something anyone can send with a click of a button and it doesn't mean anything anymore it loses meaning…."

The third set of concerns participants mentioned against RST is related to the communication itself and the product encompasses this communication. A participant felt that RST is not suitable for complex messages only for simple touch [P1]. Touch alone is a limited experience, social touch is a multi-sensorial experience [P3]. It should remind about the other person but not to replicate the real touch [P9]. Saving the touch is considered a disadvantage because the touch should come directly from the sender [P26]. Also, the communication may foster unwanted annoying touches if not planned well [P35]. Moreover, the product itself may fall in the wrong hand [P13][P15], be misused [P28], or hacked and all these concerns related to privacy [P12]. Pricing is another concern, the physical product can be

expansive which makes it harder to get for people who need it, for example, the students [P5].

Table 4.18 Miscellaneous concerns about RST

P1	"…I wouldn't use such technology to convey complicated message because human relationship is very complex everything how someone look on someone looking to the other eyes little movement of the face all that it will affect the general meaning of the message for that I don't want to use it in complicated complex message…"
P3	"…tactile is not the only experience it's important that add depth to that perception as a whole I see it relevant in that context for virtual interaction with the people you need more than touch audio visual interaction if it is stimulated of the action or close to the action…"
P9	"…it is artificial thing not the original thing I don't think so it will be much of a help or I am going to use it because the basic idea is just to remind the other person that I'm thinking of them which is video call or messaging can do the same thing…"
P26	"…for me save it will become disadvantage because it is not real it does not objective which is subjective the sender is not there I am just taking it it should be a sender behind that application I don't want to save it as a memory…"
P35	"…could be unwanted touches I mean I personally signed up for something that would notify me but if somebody does not have that option then it would maybe like lead to it can get annoying or it can get overwhelming sometimes…"
P13	"…privacy issues if it gets in the wrong hand…"
P15	"…privacy invasion if someone can get hold of it…"
P28	"…think about what people will do they'll use black magic or use it to torture people…"
P12	"…hacking computers like taking someone phone and hugging their husband…"
P5	"…the cost it will be expensive maybe availability be disadvantaged maybe I can access it but they cannot…"

4.9 Remote Social Touch Usage Scenarios

Another objective of this research is to elicit information related to the intended usage scenarios of this technology. After the participants understood the principles of remote social touch (RST) and gain enough information about its technologies, they discuss how they will use it. The scenarios uncovered in this section cover a wide variety of cases where RST can fit in. Some of these scenarios had been explored before in literature such as for long-distance relationship "kiss messaging" by Saadatian et al. (2014), emotional support "TapTap" by Bonanni et al. (2006), and using RST with current commination media "Flex-N-Feel" by Singhal et al. (2017). However, there are other scenarios not explored or there is a lack in the literature about it such as social rehabilitation, habit change, forced isolation (such

as the case of social distancing to reduce infection diseases), and young adult-parents' relationships. This section is going to discuss the scenarios concerning three main categories; 1) emotional, motivational, and support (17 participants talked about this point), 2) daily general messaging (12 participants talked about this point), and 3) 18 participants talked about other various scenarios.

Firstly, the main reoccurring mentioning of how the participant could use RST is related to emotional, motivational, and support scenarios. RST could be used as a tool to express a bad mood nonverbally [P5], when one under stress, or feeling hollow and down [P23]. It could be used when one in need of emotional support and motivation when lonely [P17], feeling unwell [P31], or depressed [P7]. Moreover, RST may be used as a way to share good or bad happening [P6], such as when feeling happy and achieved something [P5][P35].RST could be used when in need of a hug when one did good in life but not use it to share one's bad feelings [P14]. It could be used to reduce worrying about the other person and give the loved one the support when in need [P10], and comfort them [P9]. It may be used when an individual is alone sleeping, doing an activity, or not surrounded by people [P4].

Table 4.19 Emotional, motivational, and support scenario s proposed by the participants

P5	"…if I have a bad day and I want to tell my parent but not verbally so maybe I want to show some of these actions maybe send a gesture…"
P23	"…I will be using every single day I want that so that I don't feel that hollow feeling to get rid of but specifically when I feel down…"
P17	"…saving it and using it later it will be really big deal maybe when I feel alone, I feel something like it's going to be okay is it going to be fixed…"
P31	"…maybe if I feel sad or feel just like discouraging or demotivate or have some personal psychological, so support it also could help…"
P7	"…it can be used when someone is depressed or demotivated…"
P6	"…maybe when I'm happy about something like having good marks or maybe when I am depressed about something or I have something to share or being low it could be related to ups and downs in life maybe your friends are busy and you need someone to talk to…"
P5	"…maybe I am in a happy place may be traveling somewhere and I want my family to be there so maybe I'll send them a gesture to tell them I want them to be here…"
P35	"…when I'm very happy that I've achieved something, let's say I got an award and my parents so my mom is not around and I would want to hug her or kiss her for all the hard work that she has put in…"
P14	"…I get the job offer to get accepted and it's cool or I graduated my birthday mother day I will definitely use this or great news not going to use it in a bad day I will not send my bad feeling to them but best ones…"
P10	"…he's (the husband) very tired and maybe have a bad day then he needs this hug…"
P9	"…maybe if someone is in problem and I would like to comfort that person I will use this…"
P4	"…when I am alone because it's a personal thing I do a lone walk everyday maybe on the time because it has personal value and it's personal thing so only do it when I am alone maybe in my room at night because also I don't like to talk with my parents when I am with my friends so physical thing could be the same but if I'm doing the physical interaction with my friend I can do it anywhere so with my family alone personal space when doing with my friends can be public or private…"

Secondly, RST could be used for daily general messaging. Messaging to uplift the mood [P1], impulse "thinking of you" messages instead of texting [P2], and casual touch [P11]. Also, RST can be used for ritual routine physical interactions [P10], and between close circle loved ones and friends [P13] [P21]. It could be used daily like how they use current communication media or social media [P22]. RST could be used as complementary or enhancement for the current communication media [P12]. One scenario for touch avoiders RST could be used is allowing the other side to express their love or affection physically which is good for the loved one (the sender) emotional health, but the touch avoiders (the receiver) could choose to "On" or "Off"

receiving the physical interaction on their side as they are not very interested in physical touch [P3].

Table 4.20 Scenarios for general touch messaging proposed by the participants

P1	"…communicating with my wife during the day for example I just felt vibration from my phone it could be a kiss from my wife I would feel happy about it and it is symbolic meaning…"
P2	"…going to be impulse thing you can initiate the physical touch any kind of moment you are thinking of that person I just like texting hey I'm thinking of you…"
P11	"…I'll use it with my friend like I usually when I meet people I like punching them on the shoulder or just top them hey how are you and then tap them on the shoulder…maybe for my mother I will send her arm on the shoulder … maybe the kissing I'll send it to some people…"
P10	"…for example when I wake up I send a kiss …"
P13	"…for all kind of friends and family … I can use it for everything physical that can be represented by these devices anything physical that I can do with any relationship that I can send if I want to touch an ear that I can touch it, it can be used in various situation … good night and good morning messages it's mean a lot would these physical touch"
P21	"…I would like to use it with family I don't want to use it especially the stimulated one in office environment with colleague from work…"
P22	"…every time like how I use WhatsApp and social media…"
P12	"…I would use it to supplement facetime I would use it to improve experience of current remote communication attach it to another existing communication like I'm chatting with someone on skype and they can touch me … maybe I'm texting with someone instead of sending a gif of hugging I could actually hug them…"
P3	"... it will be used to disable the interaction from my side if I don't want it and let the other side used it when the social context requires to do social touch…"

Finally, there are various other scenarios mentioned for RST. The common ones are related to feeling the physical interaction (PI) for example between parents and their children [P7], especially children with a low attention span for them could be used as a playful physical way of communication [P27]. Also, it could be used for intimate relationships, and anyone staying for a long time away from their loved ones [P24]. RST may be used for certain user groups such as the elderly in retirement houses [P8], sick people, and medically isolated individuals to prevent the separation of diseases [P23]. Moreover, RST could enhance life for people with social anxiety and social rehabilitation [P28]. It could be used as a gift to trigger memories [P7]. RST may be used for habit changing [P11], also for education in similar to audiobooks, one can pass physical experience combined with other sensor modalities to the next generations [P21]. Remote touch in general could be used functionally as a

cooperative tool [P33], military for its privacy [P21], or remote controlling and feeling things [P36] such for disabled people [P19]. Finally, for future use, it could be utilized in space exploration [P30].

Table 4.21 Various other scenarios proposed by the participants

P7	"…if it is used between parents and their children especially when they're away it's got to be something useful…"
P27	"…she doesn't want to talk with you she just wants to play with you so it was not possible at that time so it can't be fostering in term of experiences…"
P24	"…when the situation that I am away but if I am in the same city I prefer to go to her but here when I can't … it's better to have this interaction…"
P8	"…I wanted it to be used in special occasion for example for old people in their retirement houses maybe people are sick…"
P23	"…I think this RST can be used with patient isolated in ICU the family cannot be there no one can be there and this moment they will feel really isolated so they can have that to feel their family still with them…"
P28	"…it could be used to sort of normalize and reintegrate individuals with social issues with problems with being in society or who have some kind of development issues or whatever. or maybe children who were, you know, raised in foster homes or whatever they turn into criminal…"
P7	"…it can be used just like how a picture can be used as a memory…"
P11	"…I would like to use it in to watch other people habits forming their habits both know they shouldn't do something and if they did it I will send them a message like a pinch to remind him not to do it for example stop thinking about this…"
P21	"…besides that I can record myself like the whole experience as I mentioned before my mother cooking I can feel and smell and taste and everything if I want to pass on something to a later generation … if famous scientist will record their life learning and teachings they can record the whole environment and save that message … nowadays we have audio book and movies now we you can have all these combined we can have books in this form where people can learn by experiencing the whole senses…"
P33	"…for example, when there is a work can be done together with two people maybe so can be as a physical device, like helping each other mean it could be not just not like holding some maybe for example as I architecture student and to have a group mate maybe sitting in another city now so I need to show him my idea so if I have such a device so that I can make some movement in my hand and showing it and he can see it…"
P21	"…military person can be used in that because you have layer and layer of protection…"
P36	"…for example, if you work in a company and you have to do all the paperwork for something you have for example you have to sign papers or stamp something you can do this I mean from far away from your house…"
P19	"…for disabled people if we are talking not about the social aspect of it…"
P30	"…everything about the human like even if you go into space or something and you maybe will live in space for like I use the time to come home, because the long distance this will make life much, much greater…"

4.10 The Remote Social Touch Communication Cycle

One objective of this PhD research is to understand the communication cycle of RST concerning communication characteristics and haptic feedback characteristics. The cycle includes receiving, replying, and sending social touch messages, bidirectional communication. All the discussions in this section with the participants happened with the idea of "everything is possible" and the idea of RST is currently in use. Receiving, in this case, is when a loved one sends a remote social touch message, participants discussed how they prefer to feel it. After that, the participant discussed how to reply to this RST message. Also, the participants discussed how to send a first time (not as a reply) RST message to their loved ones. Refer to Chapter 3.7.2 for the materials used for this section to elicit information from the participants.

4.10.1 General Observations about Remote Social Touch Cycle Communication

There are a few general observations about the touch communication cycle.

- Some physical interactions (PI)s only receiving some only sending. Also, the reply will depend on the direction (from which relationship to another) and/or the kind of PI. For example, kissing the hand, the son will send a kissing hand message to the mother but will not expect that from the mother, or the mother sending patting to her daughter but the daughter will not send patting to the mother, however, reply with different PI such as a kiss or a hug or sending a visual or an audio message.

- Additionally, the meaning of the same PI could be different between the relationship depending on who will send it and who will receive it. For example, one would like to receive patting from the mother with the meaning of "well done", however sending patting to the mother the meaning will be change to support when the mother is sad "do not be sad".

- Another point to be mention, replying to a PIs could be with the same PI received or replying with a different PI from the PI received. For example, one will reply to his mother's patting message with a kiss on the cheek, or reply with something not physical such as a video message.

- Related to the haptic feedback characteristics, usually, a participant picks feedback close to how the real PI usually feels, for example, a hug is associated with force or squeeze.

- Remote social touch (RST) characteristics are driven based on context, mood, and usual physical touch behavior among individuals. Also, individuals may choose a certain way to carry out the physical touch remotely based on the relationship and PI wanting to communicate.

The findings strongly suggest that there is no one fit all type of product for RST. This could complicit the design unless it was fit for a very focused group of users or allow high customization. However, in RST individuals may incline to choose something more toward a realistic manner to social touch to communicate the physical touch within the cycle of communication.

Additionally, the physical artefact could force certain behavior from the user related to the communication, for example, the user only will use the artefact in a private place which means the artefact will not be used anytime in contrast to real physical touch, consequently, the user may choose certain characteristic to suit such contexts such as warning messages, or async communication. However, an artefact that allows the user to use a symbolic way of sending the message may allow it to be used anytime, however, some users may perceive symbolic messaging negatively because it will not allow them to simulate the physical action. Further product characteristics will be discussed in detail in Section 4.12.

Since the interviews uncovered many different relationships and various missed physical interactions this section will discuss only the frequently mentioned relationship which is “Mother”. This is because the other relationships do not contain

enough information to discuss due to the very few participants talking about it. Related to the mother relationship, this research uncovers 14 missed PIs (Figure 4.12). This section discusses only the mother's "Hug" (24 participants talked about it) and "Kiss" (13 participants talked about it) physical interactions due to the lack of enough information about the other physical interactions.

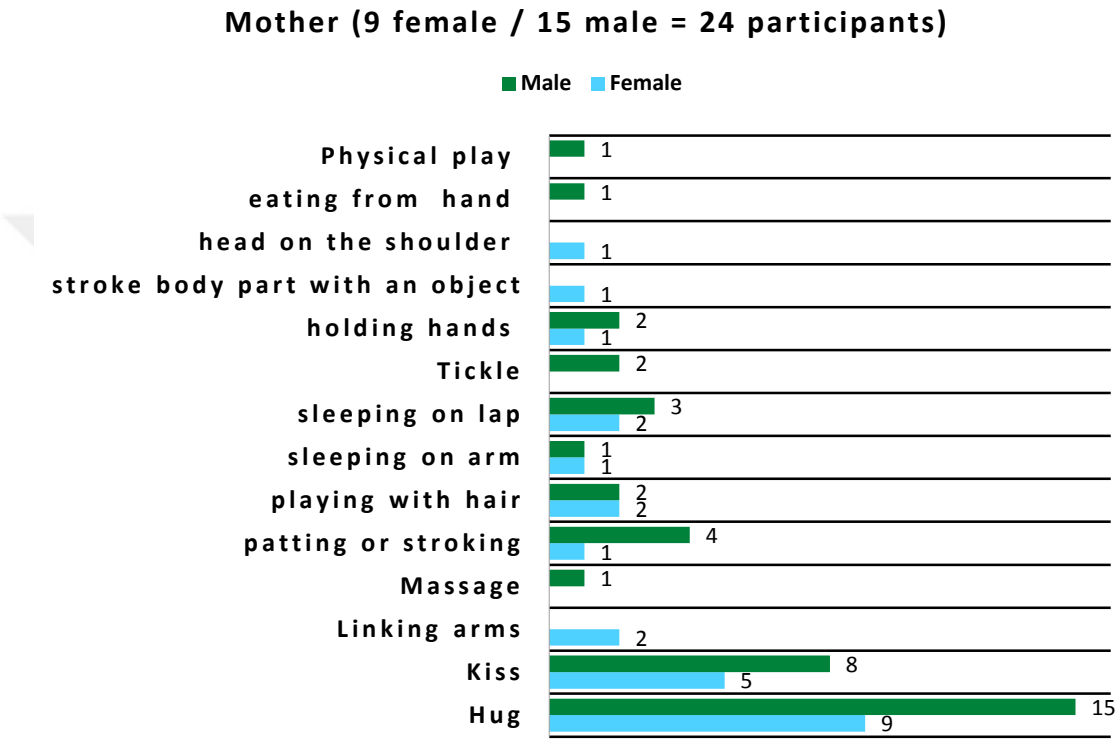


Figure 4.12. Missed physical interactions for a "mother" relationship

The detailed discussion below is an example of how one can use the information extracted by this research methodology to gain detail subjective information related to the cycle of haptic communication especially if one focuses on only one physical interaction and one relationship as the subject under research. Additionally, this section shows an example of what kind of information can be gained from using the proposed remote social touch (RST) framework in research. This section gives information on what participants perceived about each characteristic in the RST communication cycle which can give some expectations when implementing them in future RST products, however, these characteristics need to be further investigated

in future research to gain more solid information. The next sections are divided as i) receiving a mother's touch (the hug and the kiss are in separate sections), ii) replaying to a mother's touch, and iii) sending a physical interaction to a "mother".

4.10.2 Receiving A Mother's Touch

4.10.2.1 A Hug

The first point discussed was the communication characteristics, simulated Vs. symbolic. 17 out of 23[6] participants selected a simulated kind of communication, 4 out of 23 selected symbolic, and 2 out of 23 selected both simulated and symbolic for receiving a mother's hug. Participants who selected simulated did so because it is similar to the real touch [P31] which is satisfactory [P32], instead of symbolic which does not carry the touch feeling [P8] and it is like the other media such as video chat [P29]. If the simulated does not feel real enough, it will be just like a notification to remind of the physical interaction [P3]. Simulated feel more personal than a coded message (symbolic) which people currently do with the current media [P24]. However, participants who choose the communication to be a symbolic message did so because simulated is like feeling it from a robot, not from the true human, it is artificial so they wanted a symbolic way as a reminder the other person is thinking of them [P7]. Also, some participants choose both ways [P30].

[6] The information from 23 participant for the hug interaction not including one participant who miss the hug however he rejected the idea of remote social touch thus the discussion with him was only about what he sees wrong in RST excluding the discussion about the communication cycle and haptic technology.

Table 4.22 Simulated Vs. symbolic receiving mother's hug

P31	"…simulated because it is more physical as far as I got I mean in it actually simulates the action rather than transmitting the feelings or I mean, encoding the giving the feeling,"
P32	"…I would like to feel the hug real more satisfactory than substituted with the code…"
P8	"…simulated because symbolic is like text message…"
P29	"…simulated because I already have a talk which can replace the symbolic especially if it was a video…"
P3	"…if it does not really near the experience of the physical interaction anything else it doesn't really matter could be any kind of notification if something does not feel a hug you could replace it with any kind of notification any haptic type would it matter touch feedback is not real hug anyway so if I receive a hug emoji or a force feedback of a hug my brain will start remembering the experience of the hug for my mother so it is meaningless for me trying to tackle something in the wrong way so this haptic interaction will be just like a notification for me I want to receive a real hug even though I'm not saying I want to it should be realistic experience…"
P24	"…because sending a code I already do I still feel the need to have simulation like physical experience that is really personal so code feel like a mediated communication it is robotic for me but simulation feel personalized and customized…"
P7	"…I don't want to receive it I don't want to feel it I don't want to feel a robotic or device doing this to me unless it is just a symbolic message from my mother she's saying that I am thinking of you …"
P30	"...I feel it when she gives me the sign. like I feel everything in my body. yeah, sometimes really you need symbolic more than simulated you need to feel it like by spirit. but in the other time needed some related you need a real hug…"

As for the way the communication is carried out either synchronous (Sync) or asynchronous (Async), 5 out of 23 preferred synchronous, 6 out of 23 preferred asynchronous, and 12 out of 23 preferred both. Synchronous because the physical interaction could lose its value if not happen at the same time [P15], and the hug is intimate interaction need to be felt in the moment [P31]. On the other hand, asynchronous allows time management [P34], and may not disrupt what one is doing [P35]. Moreover, the other way (Sync) one needs to be available for the communication which could be depressing if one cannot make oneself available to a mother, thus async so one can feel it later. Yet it may feel odd that one's mother thought of him/her and was not available for her [P7]. The people who decided that both ways of communication are preferred did so because it allows them to save the

message in case they are not available to have a live connection and replay it later [P29]. Also, allowing sync communication one may feel the urgency of the message [P9] and could carry the emotions [P32]. Situations and the kind of communication may elect the way the communication should be carried out [P30], if it is integrated with other communication media then it can be sync else RST by itself it can be async [P3]. Also, context can determine what to choose, if one does not want to worry about the other side then Async but a general positive mood can be Sync [P24]. However, Sync can be more preferred even if they choose both ways, because it could feel more realistic and allows both sides to feel each other at the same time [P16].

Table 4.23 Synchronous vs. asynchronous receiving mother's hug

P15	"…but all of these are physical mean I'm talking to you if you send it to me and I will check it later than the physical is gone … it will lose its value … I have to do the physical interaction at the same…"
P31	"…for synchronous, you have to somehow arrange or have one common time to afford the interaction. but in terms of the hug, I guess it's more intimate and you want to feel it actually in the moment. so, most probably I chose synchronous because I mean, the concept that we are talking about is more personal, more intimate…"
P34	"…because I'm not sure maybe if it's at the same time, you never know what you're doing at the same time, or maybe you miss this hug. maybe you're having a class or something. but if it's something you can read later; you can have it later if you prefer…"
P35	"…because if I'm doing something else, it would disrupt me. I would want to have it on my time of comfort…"
P7	"…the sync will have a problem because I need to be available as soon as she send a message and if I can it would be like a depressing thing but async it seems appropriate I can feel it today after however it feel weird because it is like she thought of me sometimes earlier not now and I wasn't able to feel it…"
P29	"…async is good because whenever I need it I can find it so both are good depending on the situation async you can feel it even if the other person is not available the other person does not need to be available to give it…"
P9	"…async or sync both of them are fine but sync is better because there's something may be important that I have to call her…"
P32	"…async like a message you can open it anytime you want it is not just once but you can do with more and more … if I have the ability to save the message than sync too it have the emotion from her when you feel the emotion from her you combine with the hug that you received from her it makes it more real"
P30	"…I think is both of them yes, sometimes you need a real one like you think she doing it right now. so I am hugging her right now in real and sometimes you just needed for making yourself relieved or feeling the feeling of like, I did something like I have someone who cares about me or something…."
P3	"…when I was thinking about sync I was thinking about video chat or voice chat at the same time but if only haptic feedback then async because I think doing synchronous haptic communication only it is stupid for me and doesn't make any sense…"

Table 4.23 (continued)

P24	"…async or sync depends on context because sometimes I don't want to tell her how I feel she gets really worried about how I feel for instance a saved hug could help me in situation where I feel worried so I can play that and she will not know that I was worried at that time to get the comfort that I need it without get her worry about me but sometimes I want it in the same time for instance a hug can be used in situation when I feel low are worried but for the rest are positive things add to my mood but hug can be for something I'm feeling low but it will not improve my mood…"
P16	"…it means more to me if the action is live even for voice I don't prefer voice note when voice call available I can feel what she's feeling right now and she can feel what I feel right now it is more realistic…"

After receiving the message there are two ways to allow the product to render the haptic feedback, implicit or explicit. 10 out of 23 participants choose an implicit way, 11 out of 23 participants choose an explicit way, and 2 out of 23 participants choose both ways. Participants who choose the implicit way did so because it is similar to the natural way of physical interaction [P9], especially if there is trust in the relationship [P35]. Implicit provide a surprise element that makes it more real [P24]. Also, mothers have a strong emotional connection with their children thus one wants to just feel it without notification [P32]. However, the main drive for people choosing an explicit way of interaction is to give them choice if they want to feel it or not [P31]. Other reasons for explicit interaction are one does not want to feel it suddenly [P8], or better for choosing an appropriate time [29]. However, situations also can elect either one [P14].

Table 4.24 Implicit vs. explicit receiving mother's hug

P9	"…implicit is better is more natural … I always pick something natural as the original thing just like the real thing you don't control interaction"
P35	"…I word like implicit, yeah. cuz I mean, we're just talking about my mom here. so I do trust her with whatever she would do. and I think if it all if it asked me whether I want it or not, and for me in my mind, it will lose its purpose. I wanted to be like, you know, when just out of the blue, she hugs me or something like that. it should be natural…"
P24	"…there is fine line sometimes you get creeped out if suddenly feeling a hug but if I am knowing that it's coming from my mother the element of surprise will be nice so I can say either this or that this is sort of mixed thing for me so both of them depending on the context because context is really important I don't want to really give my feeling at that moment…"
P32	"…I'm thinking about my mother case mothers have strong emotional connection with their children if she feels need a hug at a specific point of time she can send it to you and you don't have to see a notification you just feel it…"
P6	"…explicit because sometime may not needing it so can switch it off and it will not be a waste of technology…"
P31	"…explicit so I want to have control, but I want to accept I mean, some sort of with the analogy with the phone call, I prefer to accept rather than else intervenes to me. so, I mean, it can distract me or do something…"
P8	"…explicit don't want things to be suddenly playing…"
P29	"…you don't really need it to happen at that specific time having both of us living in different places different timing we don't have the knowledge what the other person " is doing" at a specific time so having explicit is much better in my situation as a college student implicit is good but for my situation explicit is better…"
P14	"…explicit or implicit it depends on the situation maybe I am at home I want to feel it directly implicit but if I'm somewhere busy I can feel it later so both…"

There are three main feedback qualities discussed with the participants: the intensity, the duration, and the frequency. Here the main issue is to know whether the participants would like to control them or let their loved ones control these qualities. 14 out of 23 participants preferred to let the sender control these qualities[P32]. However, there are 8 out of 23 participants chose to be able to manipulate the feedback such as changing the duration or the intensity**,** depending on the mood or context [P8]. Some qualities are more important than others, for example, the duration shows more of the person feeling [P25], or the Intensity of the feedback is important [P14]. Another point to mention, one participant whose mother tries to give less physical affection wanted to have the ability to change the feedback qualities such as increasing the duration or intensity, such ability could be one of the advantages of RST for touch deprivation.

Table 4.25 Receiving mother's hug feedback qualities

P32	"…the person who will send a hug put the setting for the intensity duration and frequency … because the hug is different every single time you can't have hug the same every time different time calls for different amount of hug timer length … if we miss each other I would like the hug to be longer and more intense … if something good happen or greeting then it can be short and less intense and more hugs…"
P8	"…frequency intensity and duration for the hug it depends on how I'm feeling … generally for the hug I want it to be medium intensity but if I am sad I want the duration of the intensity to be more but if I am feeling okay duration can be less also intensity less for frequency only one…"
P25	"…the most important is the duration of the time because this way you know exactly how much she wanted to hug you and for how long…"
P14	"…intensity is more important than duration and frequency…"

Participants also discussed how they want to feel a mother's hug through RST. The most common haptic feedback characteristics mentioned were Force (19 times mentioned), texture (10 times mentioned), and warmth (14 times mentioned). The other ones less mentioned were size change (3 times mentioned), form change (5 times mentioned), limp movement (2 times mentioned), temperature (1 time mentioned), and any feedback (1 time mentioned). Also, passive feedback (13 times mentioned) and active feedback (10 times mentioned) was chosen as a way to feel the hug. Force is the main characteristic associated with the hug action. It is part of the hug action [P14], it is more believable [P29], and fun [P18]. The force gives the feeling of supported or contained feel more worm [P19]. The force intensity shows the emotion of the other person [P15]. Force is part of the hug action that helps to know the emotion [P35].

Table 4.26 Receiving mother's hug haptic feedback characteristics (Force)

P14	"…the action has force that's why I want to feel force…"
P29	"…if you feel the force you feel it is really happening like for the hug feeling the force is the important part…"
P18	"…force it will be fun if you have like a bracelet and if your mother wants to hug you the bracelet will squeeze on your hand then you'll remember the action…"
P19	"…force when you interact with someone you keep feel like supported or contained so force give that feeling especially for hug tingling wouldn't be so pleasant than as much as a gentle press would be more worm…"
P15	"…the force should be the same as the sender strong or not controlled by the sander …the hug shows how much emotion sent to you if you are really sad tighter hug will relax you more"
P35	"…so, I would want to feel how she wants to hug me with the amount of pressure she's applying to which, for example, when she hugs me directly, I know that you know, she's more showing more love. so force is going to be important in that aspect…"

Warmth is another characteristic associated with the hug action. Physical contact usually warm, it gives an indication about a person [P19]. Some describe that their mother feels warmer that is why they want also to feel warm in RST [P14], if the hands always feel cold then they want to feel cold [P4]. Also, warmth means home, comfortable [3P2], and gives a sense of closeness [P7]. Some wanted to feel the exact temperature of the other person it will indicate the other person's health and environment [P15].

Table 4.27 Receiving mother's hug haptic feedback characteristics (Warm)

P19	"…warm it gives it more feeling than plane temperature usually people are more wormer…warm because physical contact usually warm, the warmth that you get from the other person it gives the special feeling if it is something just pressing without warmth it doesn't make sense just normal body temperature warmth…."
P14	"…feeling warm is something important because you don't like to touch something cold it will not feel like a real person oh yeah this is my mother … warm because of a human temperature warmth represent my mother because if it was my sister, I wanted to be cold because her hand is cold…"
P4	"…cold not for the emotional part of it but for the weather usually hair temperature is colder than me so when I feel the coldness to take all my temperature down with it so feeling her temperature…"
P32	"…warm because it feels like home comfortable…"
P7	"…warm because generally associated with closeness…"
P15	"…temperature of my mother the exact temperature cold or worm but not too cold or too hot … the temperature will allow me to understand the other side give me reassurance about the other side if for example if I feel cold and are asked why it is cold or for example I will touch you the forehead and it will understand it's warmed and why it is warm is the next person fine healthy or not…"

Participants associated texture with the hug action, the texture is more realistic between humans [P14]. Skin texture is special to the person each person can have a different texture and it is part of the hug [P29]. Texture gives the feeling of real interaction, can be human texture [P33], or smooth texture [P35].

Table 4.28 Receiving mother's hug haptic feedback characteristics (texture)

P14	"…texture because this is happening between two human and should be realistic…"
P29	"…texture of the skin … for me when I say the hug I'm missing the interaction texture play a part in it …texture is customizable because sometimes you want to feel the hug from your mother and sometimes you want to feel a hug from your siblings and both have different meaning…"
P33	"…texture because of course I need texture of the person…"
P35	"…maybe it can be replaced with certain kinds of fabric like velvet or silk or anything that soft, soft texture…"

Size and form change feedback also connected to a hug [P34], it can fit one's body shape [P32] and it triggers the feeling [P21]. limb movements such as body manipulation similar to how the hug actually done [P15], or used to guide one's to the hug action [P35] are also linked to the hug action.

Table 4.29 Receiving mother's hug haptic feedback characteristics (Size and form change), (limb movement)

P34	"…size, if it's something that actually is changing in size, …I prefer that…"
P32	"…form change so it can fit my body shape…"
P21	"…size and the form I chose them because it triggers something in you it's someone doing something if it is related to my mom ok my mom giving me something. the trigger the alert even if you are outside that gives you an alarm to know the feeling…"
P15	"…for limb movement like making my head move to put it on her lab or pulling me towards her…"
P35	"…I would want something will guide me through moving my arms does the way she would like to have…"

Finally, active and passive of feeling the feedback is important to the hug. The passive way of interacting is seen as more natural [P25], more real [P30], and gives more meaning to the action [P8]. It allows the feeling of being touched [P22]. Passive also because one is at the receiving end [P32] just feel it without doing anything, and

the action is initiated by the sender [P4] [P35]. Active is seen as more machine-like not a natural way of interaction [P19]. However, some also preferred active, so they can do something while feeling the hug [P15], or feel both sides are interacting [P18].

Table 4.30 Receiving mother's hug haptic feedback characteristics (active and passive)

P25	"…passive is you feel someone is hugging you…"
P30	"…passive because sometimes you need to feel the hug without going doing actions…"
P8	"…passive because I am receiving it … passive feedback because it has more meaning than going and actively touching something…"
P22	"…passive because the same reason with force so I can feel something against my skin…"
P32	"…passive because I don't have to do anything I just receive it…"
P4	"…sometime because my mother is more frequent to initiate the hug that's why it should be passive…"
P35	"…I want her to initiate it to me rather than me reaching out and getting the message myself. so I want it to be passive…"
P19	"…passive because active if you are doing it to feel the hug you are doing it to a machine not to the person it wouldn't feel right I wouldn't want to receive a replica what actually is but I wouldn't mind to receive some kind of warmth feeling that remind me of the support is there but not physically right here…"
P15	"…active to it too because I want to move my head to feel it..."
P18	"…I actually would like to have something that I can combine active and passive with it (a robot that hug and being hugged) …"

These findings uncover some various haptic feedback that can be used for the hug action not preciously explored in RST literature. Force and temperature are associated with the hug which is also explored in Hug-related RST literature, however other haptic feedback such as limp movement and texture are not explored in RST as part of the hug. Moreover, most RST literature uses passive haptic feedback to render the hug, however, the findings show some participants could be interested in actively seeking the feedback while also feeling the hug passively. It could be understood that due to technology limitation RST literature does not seek uncommon feedback such as active and limp movement. These findings can be a starter for future research to explore such characteristics. Additionally, using such a method to elicit haptic feedback characteristics could be used to elicit associations to a physical interaction unnoticeable previously (e.g. force, texture, and warmth associated with a hug).

4.10.2.2 A Kiss

The first point discussed was the communication characteristics, simulated (6 out of 11 participants), symbolic (4 out of 11 participants), and one participant picked both ways. Simulated picked because it is like real touch [P14], and personal [P24]. And symbolic picked because the real feeling should only stay with the real person [P35], and only used as a reminder of a person is thinking of someone [P7]. Moreover, a different relationship may use simulated or symbolic [P3]. As for the way the communication is carried out either synchronous (2 out of 11 participants), asynchronous (3 out of 11 participants) or both ways (6 out of 11 participants). Participants who picked synchronous did so because if the RST communication does not happen at the same time will lose its value [P15]. It can be also both ways depending on the situation if only haptic communication than Async but with other media than Sync [P3]. However asynchronous is more associated with time management [P22], provides accessibility to the message anytime [P29]. One will not disrupt what one is doing just to feel the message [P35]. Moreover, for the way to interacting implicitly (4 out of 11 participants), explicitly (5 out of 11 participants), and both (2 out of 11 participants). Implicit will be more natural [P35], and the interest in the element of surprise [P24]. However Explicit give one a choice [P22], especially for time management [P29]. Concerning feedback qualities: the intensity, the duration, and the frequency. 5 out of 11 participants preferred to leave it to the sender to apply these qualities [P15], 6 out of 11 participants chose to be able to manipulate it [P35] depending on the mood [P33].

Table 4.31 Receiving mother's kiss, communication characteristics, and feedback qualities

P14	"…simulated maybe because it will feel more touch…"
P24	"…because sending a code I already do I still feel the need to have simulation like physical experience that is really personal so code feel like a mediated communication it is robotic for me but simulation feel personalized and customized…"
P35	"…this is the maximum form of love that I do show to her. in my mind, it's, I do this when I'm extremely feeling affection for her... I would not prefer doing to another artificial entity, I'd rather do them in person. [you are receiving] yeah, in that case, also, I would want to feel these two things from her directly instead of an artificial …"
P7	"…I don't want to receive it I don't want to feel it I don't want to feel a robotic or device doing this to me unless it is just a symbolic message from my mother she's saying that I am thinking of you …"
P3	"…so this haptic interaction will be just like a notification for me I want to receive real even though I'm not saying I want to it should be realistic experience so there is no difference for me using a haptic feedback notification or emoji notification then I will just imagine my mother so everything is done by my brain so for example if I would like to receive a PI from my wife or son or PI them it is better to have simulated kind of experience something feel like the hug experience …"
P15	"…but all of these are physical mean I'm talking to you if you send it to me and I will check it later than the physical is gone … it will lose its value"
P3	"…when I was thinking about sync I was thinking about video chat or voice chat at the same time but if only haptic feedback then asyn because I think doing synchronous haptic communication only it is stupid for me and doesn't make any sense…"
P22	"…async because it will give me more time to reply…"
P29	"…async is good because whenever I need it I can find it so both are good depending on the situation async you can feel it even if the other person is not available the other person does not need to be available to give it…"
P35	"…because if I'm doing something else, it would disrupt me. I would want to have it on my time of comfort…"
P35	"…I word like implicit, yeah. cuz I mean, we're just talking about my mom here. so I do trust her with whatever she would do. and I think if it all if it asked me whether I want it or not, and for me in my mind, it will lose its purpose. I wanted to be like, you know, when just out of the blue, she hugs me or something like that. it should be natural…"
P24	"…there is fine line sometimes you get creeped out if suddenly feeling a hug but if I am knowing that it's coming from my mother the element of surprise will be nice so I can say either this or that this is sort of mixed thing for me so both of them depending on the context because context is really important I don't want to really give my feeling at that moment…"
P22	"…explicit so I can choose if I want to receive the message right now or later I could be doing something else when I receive the message…"
P29	"…you don't really need it to happen at that specific time having both of us living in different places different timing we don't have the knowledge what the other person " is doing" at a specific time so having explicit is much better in my situation as a college student implicit is good but for my situation explicit is better…"
P15	"…I wanted as it is as the sender send it… what is having on the other side I want it on this side too…"
P35	"…it should be I would like it to be soft and gentle … [control the message] yes I would want that but this is again, just like if we are taking my mother into the subject…"
P33	"…I want be able to change intensity and duration and frequency depending on my mood…"

Participants also discussed how they want to feel a mother's kiss through RST. The most common haptic feedback characteristics mentioned were force (5 times mentioned), texture (6 times mentioned), warm (6 times mentioned), passive feedback (8 times mentioned), and active feedback (2 times mentioned). Other characteristics mentioned are form change (1 time mentioned), limp movement (1 time mentioned), Cold (1 time mentioned), and any feedback (1 time mentioned).

Force is related to the action makes it feel more real [P29]. The texture is also important because this is happing between two humans [P14]. It can be the texture of the lib [P24] or a soft texture [P6], or perhaps customizable for each person [P29]. It can be a warm kiss to feel closeness [P7] or to represent a human interaction [P19], it can be a cold kiss [P6], or represent the exact temperature of the other person [P15]. Kiss feedback can include limp movement and form change feedback. It can be passive interaction, feeling it without doing something to feel touched [P6], or active interaction to get the sensation [P35].

Table 4.32 Receiving mother's kiss, haptic feedback characteristics

P29	"…if you feel the force you feel it is really happening …"
P14	"…texture because this is happening between two human and should be realistic…"
P24	"…texture of her lip…"
P6	"…softer texture…"
P29	"…texture is customizable because sometimes you want to feel from your siblings and both have different meaning…"
P7	"…warm because generally associated with closeness…"
P19	"…warm it gives it more feeling than plane temperature usually people are more wormer…"
P6	"…kisses I want to feel it cold like a shiver down your spine…"
P15	"…temperature of my mother the exact temperature cold or worm… will allow me to understand the other side give me reassurance about the other side if for example if I feel cold and are asked why it is cold or for example I will touch you the forehead and it will understand it's warmed and why it is warm…"
P6	"…passive so the feedback without being actively seeking for it…"
P35	"…active in the sense that I should go to a certain device that would give me the sensation. I don't want it to come to me…"

In the mother relationship, the kissing action usually means kissing the cheek, forehead, head, and hands. This kind of physical interaction was not explored before in RST literature, usually "Kiss" physical interaction is explored for intimate

couples. RST literature explored the use of force as a way to deliver the kissing action. The finding makes notice of other types of haptic feedback associated with kiss other than the force such as temperature, texture, and active feedback. The finding in this section can be used merely as an initial stage for further research in RST and related technologies. It shows there is more to RST than vibration and force feedback.

4.10.3 Replying to Mother's Touch

Social physical touch is bidirectional interaction for that replying to a physical message is part of the communication cycle in remote social touch (RST). Replying is considered as acknowledgment of the received message, in this research the acknowledgment is considered to give some reassurance to the sender and may allow the communication to continue between the sender and the receiver. In this section, participants discussed how they will reply to the physical message they received previously. There are two main points discussed within this section, i) immediacy, and ii) the kind of the reply. Immediacy refers to how immediate one will answer a physical message, this is to see the urgency that touch impose on individuals however, in this section, it was covered briefly and especially related to the mother's hug and kiss physical interaction. The kind of reply refers to how one will reply to the physical message, in this case, hug and kiss physical interactions (PIs). This is to explore whether RST should always be reciprocating with touch or with other sensor modality, similarly to social touch where one could touch back, move away, or say something for example.

First of all, 11 out of 23 participants mentioned that they will reply immediately to the RST message [P17] especially if it was a symbolic way of messaging [P18]. This is because they already had the choice to answer it in case of an explicit way of communication [P16], or it will show the true reaction to the message [P24]. On the other hand, 6 out of 23 participants preferred to reply as soon as they can [P22], and 6 out of 23 participants preferred replying when they are available depending on their

time or activity [P19]. It also depends on the type of the device, if it is easy to reply and fast i.e. portable, or need to be in someplace to reply [P25]. Another way to reply is by using an automatic response when one is busy the device automatically sends a pre-recorded reply [P6].

Table 4.33 Replying to mother's touch (immediacy)

P17	"…I will reply immediately at the same time…"
P18	"…I will reply as immediate as I can if I don't have anything to do … because if I reply also would reply symbolically so it will not take that much of time like I will squeeze button or something…"
P16	"…immediately because I already had the choice to accept or reject so if I am not available to do the action I will not pick up …"
P24	"…it is depending probably immediately sometimes my reaction would be honest as it would be but I will respond always /made my reaction intensity depend on the truthiness of my reaction but it would be an immediate reaction…"
P22	"…I will try to reply as soon as possible if I'm busy I'll reply when I finish…"
P19	"…it depends on my state if I'm busy or not maybe I am in a meeting the class exam or I'm outside so I reply when I am available…"
P25	"…it depends on the method if I'm outside and she send me a message and I have the ability to reply back I will reply immediately but if the method (the device) is not with me as soon as I go home I'll reply…"
P6	"…I think it should be automatic response for example if at my class and she send me a hug she may be also want to receive a hug so maybe a customizable message can be done to be sent as an automatic response or she customize it for herself so the settings can be programmed…"

The responses suggest that concerning reply when a physical touch shifts from being face-to-face interaction to mediated touch communication it will gain the attributes of other communication media. These attributes found here are i) the person has control over the communication, ii) letting the communication medium take over, and iii) current communication product and technology limitation. Such attributes may or may not be advantages for RST depending on the context and the individuals. For example, automatic response to a touch message can be used by touch avoiders however the receiver of such message may feel it is disrespectful.

Additionally, participants discussed in which way one will reply to a mother's touch. This includes the type of physical interaction participants would like to reply back to their mother with and if they would like to attach other sensor modalities with the message such as a smell or visual. Table 4.34 shows for the hug most 19 out of 23 participants would like to send back a hug to their mother, and 8 of 23 participants

would like only to send touch messages back not including other sensor modalities. For replying to a kiss from a mother, 4 of 10 participants would like to send a kiss back, and 3 participants only to send a touch message back. Refer to Table 4.34 for all the other choices.

Table 4.34 Replying to a mother's hug and kiss with the frequency mentioning by the participants

	Reply with	Senses to attach with the reply
Hug **23** **participants**	19 hug 1 hug or shaking hand 2 call back 1 sight/ visual	8 only touch 2 only visual (e.g. video or picture) 1 only audio (e.g. phone call) 2 audio and smell 2 touch and smell 3 touch, visual and audio 1 visual and audio (e.g. video call) 3 touch, visual, audio, and smell 1 all the senses
Kiss* **10** **participants**	4 kiss 2 Kiss and/or hug 1 hug 1 kiss and/or shaking hand 2 sight	3 only touch 2 only visual (e.g. video or picture) 1 audio and smell 1 touch and audio 1 touch, visual and audio 1 touch, visual, audio, and smell 1 All the senses

* there are 13 participants however here it shows 10 who miss the "kiss" interaction with mother, this is because 3 participants want to send as first not receiving thus, they were not included here.

Participants who choose to reply back with a physical interaction did so because one reply in a similar way to the received message [P6], touch could give real feeling [P25], and maybe the other side reason to send touch is that they needed to feel touch [P34]. In addition to touch, participants did choose to attach other sensor modalities to their reply [P31] such as adding visual and audio [P25], adding the sound of the person and the surrounding [P15], or also adding smell [P16]. However, participants who did not want to reply with a touch and only reply with a visual, audio, or smell message did so because to show the mother that one is happy receiving her hug [P17] and see one's reaction to the hug [P24]. Another way to reply is by using an automatic way, a pre-recorded message [P3]. This suggests that in RST communication reciprocating with touch is not always the case though it is preferable

depending on the PI and relationship, in this case, a mother's hug and kiss. This result may vary depending on the relationship and the PI. If one is designing for RST one needs to consider the way the receiver will reply to a physical message.

Table 4.35 Replying to mother's touch (the kind of the reply)

P6	"…when I'm receiving a physical contact I should also be able to reply to with physical contact so if I need it she would need it…"
P25	"…touch will give her the real feeling that I really miss her and I want to touch her…"
P34	"…because she, give send me something with touch I would assume that she actually wants the touch so I'm just sending it because I know she would need it…"
P31	"…I would like to have all except the taste I mean sight be able to see, I mean facial or some other emotions are just seeing and the person is good at hearing, I mean, hearing and seeing is going to enhance the experience so is going to make it more natural. and for the touch and smell I guess it's more important in terms of the sound making it more do I mean so, all four are important in terms of to feel it actually to smell, the smell the odor or to feel the actual presence and touches obviously physical touch the texture to feel the person physically…"
P25	"…a video could be a video message me of telling her that I'm happy feeling her hug or maybe an image of someone happy or a video of being happy because my mom is a sighted person, she has to see something it will maximize the feeling…"
P15	"…hearing maybe like a voice message sight maybe depends on the situation … hearing is important for realistic touch if I do not hear from you the realistic part is gone voice is like a the breathing of the other person shooting the other person doing the action also talking if she's talking I'm also hearing what is humming on the other end…"
P16	"…smell I believe part of the hug is that smell of the person you are hugging…"
P17	"…how I look at her being happy …."
P24	"…my mother generally like to see my reaction to understand my expression and how I am feeling it would be useful for her to see that…"
P3	"…I just say send hug (the message code is already recorded then just sweep to send it again) sending it as simple as possible maybe just a press a button swipes up swipe away automatically will send a hug or something…"

4.10.4 Sending a Physical Interaction to a Mother

The first point discussed was the communication characteristics for sending a mother's touch. These are simulated/symbolic, synchronous/asynchronous, and implicit/explicit. both ways were discussed. Table 4.36 shows the characteristics with the number of participants choosing each.

Table 4.36 Communication characteristics of sending a hug/a kiss to a mother with the frequency mentioning by the participants

	P*	Hug**	P	Kiss**
communication characteristics	13	Sim	5	Sim
	9	Sym	4	Sym
	1	Sim/Sym	1	Sim/Sym
	17	Syn	6	Syn
	3	Async	2	Asyn
	3	Syn /Async	2	Syn /Async
	11	Imp	4	Imp
	11	Exp	5	Exp
	1	Imp/Exp	1	Imp/Exp

* Number of participants choosing the specific answer, for the hug out of 23 and for kiss out of 10

** Sim = Simulated / Sym = Symbolic / Syn = Synchronous / Async = Asynchronous / Imp = Implicit / Exp = Explicit

There are a few reasons why participants selected the simulated way. Since it is physical interaction one needs to feel that the action is being done [P31]. Also, while doing the action one will feel supported, and by doing the action the other side can feel one's feelings through nonverbal ways [P30]. On the other hand, a symbolic way of sending a message is chosen because it is an easier way to send a message [P34], and since they are sending it, they are not feeling the physical interaction [P29]. Also, one can use a symbolic way when one needs to ask the other side to send a certain PI (e.g. sleeping on the arm) [P35]. One would use a symbolic way not to alert the other side about one's feelings, or in case the other side is the usual giver of the PI (e.g. a mother usually the kiss giver) one will send it as a symbolic way [P24]. Additionally, if one is a touch avoider will prefer sending it symbolically [P3]. Yet symbolic way may carry no effect and no meaning that is why some may choose simulated over it [P6].

Table 4.37 Sending a touch to a mother (Simulated vs. symbolic)

P31	"…I guess simulated because I want to actually perform the action so that I feel like I actually did it. rather than sending some messages. I mean a solely because it's, it represents some physical activity and social remote feelings…"
P30	"…simulated I just have to give this thing doesn't mean anything for me so just give it back … I will hug her back because when I need a feel to cry, I will hug her so that's, I feel I hug someone so that she feels what I'm feeling … express how I am appreciating her, or I'm really very, very thankful for her to raise me. I will kiss her hand and forehead…"
P34	"…it looks like it's easier because they require not much doing physical things, just like pressing with hand or something…"
P29	"…because when I send for example a hug I don't feel it I am the one who sending it for me sending it as a code as long as I think it is benefit it will be interpreted as a hug for me all right with it…"
P35	"…symbolic... because I would like to give her code that, you know, I'm feeling the need for her love…."
P24	"…symbolically because I don't want her to know my feeling, I don't want her to know the intensity my feeling if I have to ask for it… I don't feel like I need to ask for it but I get it can be symbolic because she usually do it…"
P3	"…I will just send a symbolic message just sent something that presents me saying there there I would expect that my mother would like something sophisticated more simulated and related to a hug so she will receive it as she wants to,,,"
P6	"…symbolic does not make sense it will not have an effect that's like a vibration message on WhatsApp…"

In relation to synchronous (Sync) and asynchronous (Async)**,** sync seems more preferable however both were chosen. Synchronous will feed the immediate need for attention[P24], the need to feel the physical interaction (PI) because of a certain situation [P29]. Sync is a live connection [P32] and helps with the feeling of presence [P31]. It feels more respectful to have Sync PI communication [P30]. Moreover, if the loved one is more emotional, sync communication is seen as a way to suit this context [P34]. Even though sync will allow one to feel the response at the moment and be in the moment yet one may need the option to save the message otherwise it will be lost [P6]. However, async communication fits the symbolic way of interaction [P22], or in the case of sending a gift like an interaction product [P7].

Table 4.38 Sending a touch to a mother (synchronous vs. asynchronous)

P24	"…because I immediately need attention…"
P29	"…because when I want to send something I would like to feel the immediate feedback of it because that's the reason I'm sending it to feel it at that specific situation because I'm used to not having it so when I am sending it I really needing the feedback for that specific situation…"
P32	"…I want to create live connection I want to receive it at the same time …"
P31	"…I want to know that actually someone is receiving it right now. I mean I guess it's important…"
P30	"…I have to give it right now. I don't think I will record that I think because it is not like it is not respectful…"
P34	"…I feel like my mom is very emotional type. so I don't think she would actually care if it's any time to actually take it …"
P6	"…sync but saving because maybe the device will not be there but I like the live link because as soon as I send a message will expect a response because like the message when you send a message if they don't reply and you start getting busy with something else you lose your tempo you lose the moment not having a life link will not give the same feeling…"
P22	"…for symbolic async…"
P7	"…thinking of her gift … for special occasion like mother day I am a sand one of these physical interaction … because I really would like to plan the gift plan it for a special memory associate with a memory …"

In relation to implicit vs explicit way of interaction. Individuals who chose an implicit way did so because it is a more natural way of interaction [P4]. One will feel the communication interaction immediately [P29] without interruption [P32]. However explicit seen as a way to have control over the communication [P21], it will allow avoiding mistakes [P14]. it will allow to take initiative over the communication even in a symbolic way [P3].

Table 4.39 Sending a touch to a mother (implicit vs. explicit)

P4	"…send automatically it would be more natural…"
P29	"…because when I wanted to happen immediately…"
P32	"…directly without interruption…"
P21	"…I want to control sending message as much as controlling the receiving message…"
P14	"…because if I cannot delete is problem maybe I will send the wrong message…"
P3	"…explicit because I will take initiative click something or swipe something to send the message…"

The second point discussed was about the notification that is commonly used in the applications the participants use in their daily communication such as WhatsApp. In

RST, the notification means that the other side received the message (the device is working) and the other person opened the message (felt the touch message). 16 out of 23 the participants preferred to have notification when the other side received and opened the message. This is because one will feel worried if they did not get a reply [P18], or they feel sad [P14]. But others do not mind if the loved ones open and felt the message but did not reply [P19]. A notification will provide ease of mind that their loved one felt their message [P6], or just an indication if the other side busy or not [P17]. Having both notifications, the message reached and felt by the loved ones, bring about human interaction, however one may wonder why the other side did not reply [P21]. One participant only wanted to be notified if the loved ones received the message and no notification about the loved one feeling it. The participant did so because open and felt the message notification brings about some negative feeling [P34]. 6 out of 23 participants did not want notification because they will feel frustrating [P3], anxiety [P7], or negatively if they saw the loved ones felt their message and did not reply, so for them their loved one's reply is the notification [P15]. The relationship also matters if one will feel negative or not by not getting a reply after seen the loved one felt their message [P8].

Table 4.40 Sending a touch to a mother (notification)

P18	"…if I saw it she got it but there's no reply it will matter for me but of course it depends on after how long she will reply she reply after 3 day I will but if she replies after 3 4 hours probably she's busy…"
P14	"…I wanted to be notified both that they received and felt even if I do not get reply maybe I will feel bit sad but I want to know if they received and felt it…"
P19	"…I wouldn't mind if she opened it but she did not reply maybe there is a reason and I fully understand…"
P6	"…I would like to know as soon as I send it, they received it and also I would like to know if they open the message because I would expect a reply to know how they felt…"
P17	"…no problem if she did not reply and I saw she felt it … she will reply she's busy…"
P21	"…yes I want to be notified both receiving and filed a message it will bring more human interaction or better dimension on my messaging even with WhatsApp if the other person have the gray tick that's will be boring to have communication with but if the blue tick it will be more interesting to communicate with… it's might matter if she received it and felt it and I did not get a reply I will start wondering why…"
P34	"…I would like to know if they received it, but I wouldn't care about if they opened it or not same for my WhatsApp I don't usually care if someone opened it's not to feel offended or something when some like reply late, so I don't care…"
P3	"…it will be additional thinking not healthy for the communication it'll be frustrating…"

Table 4.40 (continued)

P7	"…I don't want to be notified both the technology or they opened it because it's cause anxiety…"
P15	"…I don't want notification but if I'm doing something action and the next person is there then they will reply in a certain manner I will feel it at the same time and this is notification for me … let's say I hug a person and the person did not hug me back also I can see they opened it and they felt it then it will be disappointing and worse so that's why I don't want it…"
P8	"…I am close with my mother it is okay but if it is a close friend and I seen they did not reply even after they felt it that I may feel like they did not like me or something…"

The third point discussed was about the haptic feedback quality which is important to set the tone of the message. The participants discussed this point concerning the intensity, duration, and frequency of the message. For sending a physical touch to a mother, the intensity and duration of the haptic feedback sent is important to express the feeling [P25]. It may vary depending on the mood [P8]; the duration can be longer if the mood was bad [P29], or it can be sent the same way it was received [P4]. Also, it can have similar qualities as real physical interaction [P31]. Participants would like to have control over the feedback quality in case they do not want to worry about the other side about them [P24].

Table 4.41 Sending a touch to a mother (haptic feedback quality)

P25	"…the intensity is important is how you express your mother you miss her or love by giving her a strong hug and also the duration matter for me I have been away for more than 4 year so I just natural will give her the feeling how I miss her…"
P8	"…duration intensity and frequency depend on my mood or for example someone send me that something bad happened they are sad that maybe the traditional intensity will be more also my mood if I'm sad or not the intensity and duration will be more…"
P29	"…it depending on how my day is going if it was not that bad maybe it will be fast or no message sending but my day is very very very bad the duration will be longer the frequency always one but the important is duration depending on the day how's it going…"
P4	"…for the hug the intensity should be the same as I received it I should send it the same way…"
P31	"…the actual physical. I mean, the force that I applied, so I'm not sure what exactly the intensity in the time. so I mean, I can yeah, most people I should control and apply the same force that would that I would apply if it was the real hug, duration. also, some kind of physical attachment. so most probably set some fixed time but whatever time that I think that's appropriate would be or I need for that …"
P24	"…I don't want to give away what I'm feeling … depending on the context…"

The fourth point discussed was whether the participants want to exchange some kind of message with their loved ones before the remote social touch communication is going to happen. This message can be considered as a warning message to tell "I am going to send you a physical interaction message please go/wear the device to activate it". 14 out of 23 participants decided to have no warning message before ahead to have more spontaneous and sudden communication [P18]. Having a warning message is seen as not similar to real-life interaction [P14], not a natural way [P24]. However, 9 out of 23 participants who preferred to have a warning message did so because the kind of interaction is simulated or synchronous, they need to be in a certain safe place to experience it, to manage the time [P21], or arrange it later [P31].

Table 4.42 Sending a touch to a mother (warning message)

P18	"…I wanted to be spontaneous no warning messages…"
P14	"…I don't want to have warning message that she will send a hug or I will send a hug because in real life if someone is passing by you don't say I will hug you wait let me prepare myself…"
P24	"…I don't want warning because it is too stimulated we didn't feel so natural …"
P21	"…yes, I want warning message before sending or receiving because it is stimulated experience so I can go to safe place received a message then I go back do whatever I'm doing or maybe I can tell her that I can do this later…"
P31	"…synchronous you have to somehow arrange it…"

The fifth point discussed was concerning establishing the communication or receiving the PI message in public, 13 out 23 participants wanted to use RST only in private places, not public settings, and 10 out 23 participants did not mind the use in public. The device's appearance is a factor if people will use it in public or not [P19]. Also, the way of the communication simulated or symbolic is another factor, if it was a symbolic way of communication or subtle way then use in public [P18][P34], but more simulated real action then use in private [P8]. More intimate physical interactions are seen to be appropriate if it is done in a private place [P31]. If this kind of communication is common between people a participant did not mind using RST in public, it is seen as a positive way to remind others to send a message to their loved ones [P14].

Table 4.43 Sending a touch to a mother (public vs private)

P19	"…private or public it depend on the device how it look … if something that I can feel it without people knowing that shouldn't be a problem… depend on how practical the device is it doesn't make sense you are walking with a big thing … if nobody is looking or knowing about the device that will be no problem to do the action in public…"
P18	"…because it is symbolic it's okay to do it in public…"
P34	"…I do not mind doing outside because when sending it is symbolic people will not pay intention…"
P8	"…do the real action only in private but in public I'll do it in more subtle way or I will delay it…"
P31	"…it's still some more intimate and some personal stuff. and maybe, I mean, I would be more comfortable doing it on myself. alone…"
P14	"…it's going be a positive energy she's hugging her mother also let me send a hug for my mother too or loved one…"

4.11 Saving Physical Interaction

In this research saving touch is considered as a frequency of emotional event that can impact emotional wellbeing (Diener et al., 2009), in addition to the continuous cycle of bidirectional remote social touch (RST). The frequency one experiences pleasant emotions is associated with judgments of happiness (Lucas et al., 2009). Thus, one of the main points in this research is to understand the concept of saving touch from the user's point of view. Additionally, based on two theories, the Top-Down theory which is the collection of small pleasures provides happiness, and the Associations theory which is an association network based on certain events provides a tendency to happiness (Diener, 2009); as in associating the saved message with a certain memory.

The participants in this research were introduced to the idea of saving touch (the possibility of having a loved one social touch saved forever). 30 out of 36 participants wanted to save the RST message, and 6 out of 36 participants did not want to save the RST message. This section will discuss, the usage scenarios, emotional impact, and concerns related to the saving touch concept from the participant's point of view. Also, discussion on whether participants are interested in manipulating the touch message qualities such as intensity, duration, and frequency

after saving it. Also, participants discussed if they would like to attach other sensor modality with the touch and save it as a whole experience.

4.11.1 Saving Touch Scenarios

After introducing the concept of saving a loved one's touch forever even after death, participants discussed how they will be using such a feature, where, and when. Table 4.44 shows various keywords mentioned by the participants related to usage scenarios for saving RST messages.

Table 4.44 Saving touch scenarios usage with the frequency mentioning by the participants

F	Usages	F	Emotional usage
12	Missing and memory	8	8 When depressed
7	For emotional	3	3 To left the spirt
2	Future generations and education	4	4 Feeling comforted and happy
2	Motivation		
1	Behavior change		
3	Similar situation as when received		

* F = frequency mentioning by the participants

The first scenario is related to emotional wellbeing, such as stressful moments [P29], emotional situations [P3], when feeling happy or sad [P25], or just in need of support [P19]. When an emotional situation arises but nobody around to help rather than be quiet about it, one can use the save feature [P6]. One could use it when feeling depression or stress and not be able to reach the loved one however if the PI played over all the time it may lower the value of it [P1]. Additionally, it could be used as encouragement and give motivation [P22], or as a reminder not to do something one shouldn't do [P7].

Table 4.45 Saving PI emotional wellbeing usage scenarios proposed by the participants

P29	"…the stress is it playing a big role because me being living away from my family studying here during exam during stressful week I will use it…"
P3	"…if I am emotional when I'm older or something…"
P25	"…I will use it when I am extremely happy when something good happened or when I achieve goals in my life when I'm feeling down or miserable or something terrible happened so either extremely happy or depressed then I would play the message again and again…"
P19	"…maybe one scenario if I'm feeling sick and I need some kind of support a hug … but my mother is sleeping so I can just use the one saved from another time…"
P6	"…sometimes when I have bad day or exam and I don't have anybody to talk to or share because sometimes you feel it is just a small thing it will go when you have an emotional feeling and you don't want to bother people around you so this will help the thing as you said because the person will not be bothered by my emotions because it is just a machine…"
P1	"…maybe it's can be a good thing if you are very depressed or you are far away and you cannot communicate with your loved one at that time for example I'm feeling very bad because something bad happen and I am calling my wife but I cannot reach her at the moment maybe to be relaxed and get out of stress I can open a hug or a kiss but in my own opinion it will lower the importance of those one-time action if you can just play it over and over again…"
P22	"…yes it will be great to read the interaction after some time … it can be motivation for me and something to remember…"
P7	"…if I'm going to do something stupid I can't think about my parents and play that message…"

Another scenario to use the save feature is related to remembering the person. One can replay the PI message when missing the person to feel they are around [P2]. It could be used when one feels alone or does activity used to do with the loved one [P5]. It is an additional memory reinforcement medium [P9], it may be used if the person is not living anymore or when they alive [P11]. It could be shared with the loved one as a reminder [P16], or one used it to remember an event [P21]. One could save precious memories with it [P8] to used when the other person is not available or when one needs to feel the PI [P13]. It is a way to link a memory to a point in time [P9].

Table 4.46 Saving PI remembering usage scenarios proposed by the participants

P2	"…on the day I missed the person so much or the day I want to remind myself of that person video and audio doesn't always do the same thing so seeing the picture yes you remind of that person but feeling the intention behind the action oh yeah this is nice this is something I would like to have…"
P5	"…I walk alone nobody around me … then I can just replay it and feel…"
P9	"…yes, I would like that it's a memory it is like a photo…"
P11	"…I will use it when there are here or even after they are not here…"
P16	"…I will check it later when I cannot access to her anymore or at special days like birthday and collect all these messages in one message then send her to remind her of our good moments…"
P21	"…maybe I live far away from my mother for 4 5 years and something happened that remind me of her maybe I cannot receive the same message then I can open the message and it will make me feel better just like how voice messages or text messages make you feel better …"
P8	"…I think it would be interested when the person died after preserve precious memories…"
P13	"…maybe sometimes you need a hug but he is not in condition to give you or send you a hug so you can open it again and feel it again … maybe I am feeling sad at home and I am missing him maybe he's in a class or doing something then I can open it I feel it…"
P9	"…it's a memory it's reminds me of a point of time just like a photo … I'm not sure how it will affect my life but I think it is just like a photo when we see pic I remember a memory it saves the same purpose…"

There are a few other scenarios to use the save feature. For example, on special occasions [P14], depending on the mood [P11], or in distress at night [P6]. It could be used in a similar situation to the real PI used to be done [P15]. The save PI could be passed on to the next generation, for example, to feel one's grandparent PI [P35] or a mother teaching something to her kid [P1]. Finally, saving RST may help to save the presence feeling of the loved one [P5].

Table 4.47 Saving PI various other usage scenarios proposed by the participants

P14	"…for example, I use it on mother day or I will use it in birthday good days and bad days…"
P11	"…scenario to use it I go home I am alone and she's there like she used to be there when I go home come back after school so I will do that I use it when I'm missing the old days … maybe I'll use it depending on mood…"
P6	"…when I'm alone and when I'm trying to sleep when I have restless night hard when I have difficult time…"
P15	"…for example like me if I have a bad day I can just go home and hug my mom at the same time this is not mean she is here it is just a simulation … maybe before doing something really important or before making a choice I will grab her hand because she used to grab my hand before I go to exam then I start to grab her hand later…"
P35	"…I will also be able to make my children feel the same touch of their grandmother. so I would want them to know how it feels like hugging their grandmother if she alive. also I can use it for my dad because I'm sure he's going to miss her…"
P1	"…saving the interaction from someone without intimate relationship or love for example your mother teaching you something…"
P5	"…it is not a physical interaction but it is very important for me to be with him feeling the presence of other person not specifically touch…"

Saving a physical interaction to be experienced later has its own emotional impact which is disused by the participants. It could be used in a bad emotional situation [P10], It may help with depression [P25], give a calming experience [P2], and make one feel relaxed and happy [P5]. Saving PI can reduce overthinking of the missing PI which will reduce sadness [P23], and it may help when needing someone to be comforted [P32]. Depending on PI it could be used to lift the spirit [P4], it shows the love from your loved ones [P34]. It may contribute to one's happiness [P14], it could bring comfort when the person is not around[P32].

Table 4.48 Saving PI emotional impact

P10	"…for example, I had a bad day and I want to feel a warm hug from one of my loved one so I can replay it again…"
P25	"…to make a major change in many people life for example if you're depressed and you hear their voice everything will be alright…"
P2	"…sometimes you have a bad day and you would like to just lay there and be with their company it would be calming and also help with depression episode…"
P5	"…I think this will be a positive thing in my life if I don't have this when I'm alone or depressed I don't have someone to go to if I have these physical interactions it will lower possible depression it will make me feel more relaxed and happier…"
P23	"…I am very emotional person I would feel the lack of presence of my family and specifically my father most of the time sometimes I spend quite a lot of time thinking about it overthinking so I would say this will save me from all the hustle of feeling the sadness feeling down that is something it will bring a positive change…"
P32	"…I would use it if something good or bad happen need someone to talk to about it be comforted or when I'm lonely to feel hug or something …"
P4	"…for example, a hug I will use it when I need it for me it's a lot can help left your spirit, I will save all of them … tickling will be less frequent use I will use it when I want to have fun relaxing…"
P34	"…I guess if I have something like this, it shows you the love of parents, like you know that there's someone always there for you. I mean, it's different from the speaking is there's touching in it so you feel your love for your family…"
P14	"…I think this will make me happier sometimes you just want to hear their voices so also you just want to feel that hug…"
P32	"…if god forbid someone you loved passed away and you were comforted when they hug you maybe the hugs you saved will bring comfort later when you are alone, I think it's a nice thing…"

Saving the physical interaction can be considered another layer of memory to represent an action from a person just like a video, audio, or picture message [P17]. It could be used until people meet again [P19]. It could be used to remember how a PI used to feel [P25], one does not know when it is needed [P34]. However, one may choose to delete them or keep it [P31], and for the weak-hearted, that is painful for them to re-live the PI it may automatically dispose of after "X" time [P27]. One could save the intention behind the message too [P2], or the whole conversation including the PI [P35] and other sensory to make it more realistic [P3]. Maybe today's generation will not find it comfortable but the future generation may do [P12]. Finally, one could save the touch of pets too not only people [P35].

Table 4.49 Other issues related to saving PI

P17	"…the way a picture reminds us of the people we love it will be representative an icon it will not be her it is the same with video of her …"
P19	"…saving it would be useful for example time you want to feel it again but she is not available at that time I guess you remember how your mother hugs you so this is the same concept I use it until I will see her again…"
P25	"…if she passed away I can still feel her hugs again with the same feeling and intensity she used to do it wouldn't feel different that I am hugging someone else still basically the hug of my mother … a lot of people miss their family where they pass out so when they have this they still be relieved in a point that they can still remember how their hug felt …"
P34	"…because you never know how long they will stay with you. and it's something you'd actually need after maybe they're gone or you needed some time when you're alone…"
P31	"…I'm not sure if I wanted but, I mean I would prefer to not to have some limited time to feel it. I mean, it's like, you can feel hug only until I mean, in one month and then it disappears. most probably I would have to have as long as I want. so, if I want to delete, I can delete but if I want to keep it, I want to keep it…"
P27	"…it should be like this I received it maybe after a few days it disappears by itself because I don't have the courage to delete them like the stories in Instagram…quite painful to carry things with you I don't have the courage to delete them or throw them away so it can delete by itself of course I'm remembering the person I don't want to carry this thing with me like a luggage…"
P2	"…would like attach the intention with the physical…"
P35	"…I would like that it saves the entire conversation that we had. so I would like to feel it what I did and what she did later on in life, because god forbid if something bad happens, I would want to that's …to be with me even after she's not there, I could feel it. she doesn't have to do it in person, but I have saved it in the memory so I can feel the same thing all over again…"
P3	"…I believe or I think that should be attached another sensory when communication… if you have a virtual environment where you can feel the reaction of my action it will be recorded and I can experience it later to know how they reacted it will not be as in the original hug but realistic enough.."
P12	"…I can imagine this technology become a common thing maybe the generation born right now they will be comfortable with it later receiving touch through digital medium…"
P35	"… [other people to save their PI] … I don't have a pet right now. but if I had a pet then my pet like a puppy…"

4.11.2 Concerns Related to Saving Remote Social Touch Messages

There are some concerns related to saving a physical interaction that the participants discussed. Table 4.50 shows various keywords mentioned by the participants related to what worrying them about saving remote social touch messages.

Table 4.50 Concerns related to saving remote social touch messages

F	Concerns
6	The other person
6	Devalue
3	Unpleasant experience
8	Emotional side
2	Ethics and Privacy

* F = frequency mentioning by the participants

First of all, it may cause an unpleasant experience, the novelty of it may feel uncomfortable [P12], unnatural [P28], or unpleasant i.e. experiencing a PI that happened at the time and point all over again [P1]. Another concern is the devaluing of the real PI, over time the physical interaction may lose its value and memory [P13], or make missing the real interaction less [P20]. Feeling the PI lose its intimacy over time [P1] and increasing the frequency of feeling the experience can ruin the feeling [P2]. It may get misused [P7], If it is misused could devalue the PI i.e. better to say I love you to one's face than send heart emoji [P6].

Table 4.51 Saving PI concerns

P12	"…example if I watch a video of my pet or a person for me that video is the pet not fake or something but for the touch it will feel fake to me … I want to experience it at the moment sent but I don't want to record it because it will not feel real to me it will feel awkward, I will feel creeped out I feel like I'm having a zombie …"
P28	"…it just feels like an unnatural kind of support or some kind of replacement that just won't be adequate. that will just be a mockery of the real thing. I just feel like it's not. okay, you're cool. you're young, you're having this thing. you're having a relationship. you're sending each other virtual hugs, which are a thing now, but on a serious note, no, I mean, if it just ruined things…"
P1	"…my first respond I think it is creepy because people not have experienced before for example feeling the first kiss all over again whenever you want if you feel bad and open the message and feel like being kissed…"
P13	"…over time maybe the feeling goes less the memory fades away because that hug ended at the exact time not all the hugs mean the same maybe on a different point, he saying a different feeling not the exact…"
P20	"…I think I will take for example hugging for granted I will not miss it anymore right now I miss it I think it will make me feel better if I can hug him frequently because I miss him…"
P1	"…if you can do it any moment you want it, it will stop being intimate…"
P2	"…play that feeling not so often I think because it will ruin the feeling just like when you listen to a song too many time I'd get boring after some time might be like that maybe save it for special occasion…"
P7	"…I think people will miss use it…"
P6	"…it will devalue your family member for example if you have a hug message from your mom how you going to access or use it I think it will be taken for granted like for example right now we have emojis someone that is not laughing sending you laughing emoji or even someone doesn't love you but send you love emoji make the volume of the heart goes down when you say to his face I love you it has a value more than sending a heart the heart can be misused for the people who have seen misused of that heart they will not believe in that person…"

Moreover, participants discussed some emotional related concerns. Feeling the PI over and over may induce sadness and painfulness [P11]. Saving RST could make it hard to move on after a loss, this is because it may give a false sense of the other person after death [P13]. It could be addictive [P18], for that this side effect should be researched further [P8].

Table 4.52 Saving PI emotional related concerns

P11	"…for example if you see a picture one time you miss the person but if you keep seeing the picture over and over you will miss the person even more similarly if you keep feeling the hug over and over to feel a closer may make the person feels even away…"
P13	"…it would make something harder someone died you need to be able to move on if you have these messages you can play it again and again it will make it more harder for you to move on with your life you will know that person is not here anymore you can manipulate reality with these messages impact yourself with this messaging give you the feeling they still around but they are not…"
P18	"…addiction to the touch it will make it harder to understand. the person is not here it will cause a lot of problem this technology will not help you to fully realize the person is not here anymore…"
P8	"…if such product exist I don't know the impact of it on society…"

Additionally, there are concerns related to the other person whom one is saving their PI. It will feel like forcing the other person to give the PI [P12], and may impact the real interactions [P31]. This means there is an ethical issue with consent, maybe later in life the person does not want to give the PI anymore [P13] and thus it could be exploited [P28]. Other concerns were mentioned such as privacy issues when it falls in the wrong hands [P13].

Table 4.53 Saving PI concerns about the loved one

P12	"…for me feeling the touch digitally to create this I feel like I'm forcing them to touch it's like I'm forcing my mother to hug me but she is not hugging me the meaning of the hug is my mom protecting me but my mom cannot protect me because she's dead and I am forcing her to pretend to protect me so I don't want that for any physical interaction for any relation…"
P31	"…I mean in terms of some technology and how it's going to affect actually, it's exciting, but I can't really I'm not really sure how exactly it's going to change the life or how it's going to affect it if it will affect to the real interaction or not…"
P13	"…I like to save it but if the other person doesn't it will be concerned … after so many years I don't know if it would be acceptable because at some point he or she want to send it but maybe at another time she doesn't and me receiving it again and again it would be disturbing … today maybe he or she wants me to hug tomorrow maybe she will not … at one point of time that person decided not make the message accessible…"
P28	"…it's going to take something that is humanistic individual, and it's going to turn into a commodity that you can exploited anytime for your own, you know, benefit, and it just takes away from the specialness of it just ruins it…"
P13	"…first my thoughts go to a privacy because if someone sends you a voicemail someone else can hear it so if someone sends you a hug or something else it is more private cuz it is physical I don't want someone else to feel it…"

4.11.3 Manipulating the Remote Social Touch Message

When one saves a physical interaction message, one either able to manipulate its intensity, duration, and frequency or keep it as it is. 19 out of 30 did not want to manipulate the RST message and 11 did want to have the ability to manipulate. Table 4.54 shows various keywords mentioned by the participant related to why not to manipulate the remote social touch message.

Table 4.54 Why not to manipulate the remote social touch message

	Manipulation
5	Losing meaning and value
10	Unnatural / Not from the sender
8	Changing it depending on the mood

* F = frequency mentioning by the participants

For the participants who chose not to manipulate the message, did so because the message could lose its meaning [P2] and value [P21]. Ethically questionable, it may lose its initial sender intention [P18]. Manipulating a message may make it unnatural, i.e. someone says something they did not say [P5], or you are sending it to yourself [P8]. Manipulating the message could encourage a bad habit to give false feelings [P7]. On the other hand, some participants who choose to manipulate the PI message had some conditions. Customizing the message after saving it while preserving the original but with the condition still feels like it is original in case the emotional situation requires that [P6]. The message will be manipulated depending on the situation or mood at that time when replaying it [P23]. But the original must stay intact [P24].

Table 4.55 Manipulating saved PI

P2	"…I don't think so I would like to be able to change it if I am able to change something it will lose it is meaning if I am able to change the feeling of a message from a person then I don't really need the message from that person because I can make the feeling myself it wouldn't be the same as receiving from that person…"
P21	"…I will not manipulate it keep it as it is … that message is information and those parameters (intensity duration frequency) extra information from that person who sending the message it is receiving a text message from someone then after 40 years change the message it will lose its value …"
P18	"…ethically and personally for me it will not be good to manipulate the message … if I am tired of the message that I think that it makes me depressed I'll just stop feeling it but not changing it / it will not be interesting I guess the initial intention the way she made it would be perfect…"
P5	"…I don't want to change anything because it will feel unnatural it is like you make someone say something to you they didn't say…"
P8	"…it would be very artificial if you can manipulate it … it will not be the same message that the first person initiated it just like doing it to yourself…"
P7	"…maybe I like to change the intensity but I believe I shouldn't do that but I like that I'm afraid it will make me rely on it I think it would be best for me…"
P6	"…first I would like to be able to change the qualities of the haptic feedback for example sometimes I feel like having a tighter hug or lights a pat on the shoulder I think I should be able to customize it, about the original haptic feedback should be the same but you have the ability to make a new one customize and save so you can go back to the original if you want … I want to have the origin with me all the time but have the ability to customize as I want however it should feel like original for example if I change the intensity I would like to feel like the same person sending me the haptic feedback again in real time so I can't forget they are not here…"
P23	"…yes I would like to manipulate the message because it depends on the situation to situation maybe you are feeling really down you want it to be longer and more intensity … manipulating according to the situation … for example if you fail in an exam you really want someone to be there not just being alone in your dorm room I would say I will increase the intensity then …"
P24	"…I would like to manipulated but without changing the original message I could have multiple copy but the original will stay as original …"

4.11.4 Adding Other Sensory Modalities to RST Message

Physical interaction is a multisensorial experience thus additional sensor modality can be integrated with the touch message. Participants discussed this point while talking about receiving and saving a physical interaction message. Table 4.56 shows some keywords participants mentioned related to attaching other sensor modalities to the remote social touch messages.

Table 4.56 Adding other sensor modalities to remote social touch message

F	Adding other sensors	F	Kind of sensor modalities to attach with the touch sense
3	Help with memory	8	Audio, visual, and smell
5	Realistic and immersive	5	Smell and audio
		4	Audio and visual
		3	Smell
		2	Multi-sensorial
		1	Audio
		1	Only touch
		1	Taste, audio, and visual
		10	N/A

* F = frequency mentioning by the participants

Integrating other senses could enhance the memory that the message wants to recall [P13]. Saving audio messages with physical interaction (PI) could help to understand the thought behind the PI message [P2]. Saving video and audio with the PI may help with the memory especially if it is a special day [P6]. It could make it more immersive. i.e. sound of laughter, a rhyme, or a scent [P4], become more realistic [P8], and natural [P9]. Adding smell will enhance the experience [P15] and enhance the feeling of presence [P20]. Speech from the person while doing the PI [P29], or the surrounded sound can be added to the PI message [P30]. Also, each PI can be presented by taste [P28]. Additionally, all the senses can be integrated to recreate the environment setting when the PI is happened [P21], even the taste especially if it is not available in the future [P14].

Table 4.57 Adding other sensor modality to the saved PI

P13	"…probably if I attach hearing or sight to it it will mean more the message. she recorded with it it will bring back more memory as well I think touch will not pull that much memory message recording would be more strong to bring back memories … at this point I would like to attached smell too it is strong reminder add specific things it may bring good memory maybe send me a hug from a holiday place you can smell the beach…"
P2	"…maybe placing an audio in that feeling while the person is sending they could say something for the receiver in especial occasion happen birthday or a death then send it with audio then when the occasion happen the receiver can hear what you are thinking of as well…"
P6	"…I would like also attach audio or video message with the original haptic feedback so I can see for example the face of the person sending me at the hug and save it forever with the feedback beside that time and the day it could remind of a special day…"
P4	"…maybe attached smell or scent with the message it stimulate other parts make the experience more immersive maybe also a sound can be attached for example for tickling a laughter sound from me or from my mother or conversation for sleeping on mother lap if you can attach another physical interaction for example playing with my hair because she do that to be nice she also sing some nursery rhyme…"
P8	"…I would like attached a video message and audio message with it it's become more real…"
P9	"…the more information attached the better image or something else are audio messages temperature so multi-sensory it will have more natural effect…"
P15	"…I prefer to attach the smell to the touch too I remember she had a shawl that has a woody smell to it she used to give me when I am cold I would love to have that to smell attached to the touch … smell going to make it more realistic it is very hard to recall a smell that's why it is good to attach it…"
P20	"…I would like to smell my brother's scent or hear him with the touch it will give the message more presence as if he here…"
P29	"…hearing and touch and smell to feel really the situation … hearing her voice being able to talk during the hug…"
P30	"…I need to hear her voice message yes like a real one like she speaks about something anything doesn't matter what she speaks about even cooking or something she speaks in the phone with her friends I need to hear voice…"
P28	"…you know, a sweet aftertaste or something in your mouth, but that's just an idea maybe … different tastes for all of them… a hug maybe tastes like caramel macchiato or you have holding hands like something sunny and happy some nice taste everything would have a different taste or smell…"
P21	"…for example, it is morning my mother is cooking breakfast maybe I kind of smell or taste the breakfast listen to her talking about the breakfast also visualize her cooking that breakfast then the hug happened this is whole memory … I can save it as combine package …"
P14	"…yes, I would like to attach all the sensory maybe also that taste it's just something my mother like maybe after 40 year I can test it if it does not exist in this world anymore…"

4.11.5 Saving RST Message Final Remarks

In literature the concept of saving touch is not widely topic to research, these findings, however, suggest a wide area where a deep investigation is required to have a solid understanding of the impact of saving touch on human beings. As the findings suggest that participants perceived such a concept may impact their emotional wellbeing either positively or negatively depending on the context and relationship. Additionally, they have various concerns such as devaluing the PIs, the emotional impact toward the loved on, and ethical concerns. However, they may want to use it to remember a loved one, to uplift their emotional wellbeing, and for motivation. Participants of this research suggested attaching other sensor modalities to enrich the experience such as adding audio of the loved ones or their smell. Concerning the saved message some participants wanted to be able to change some of its qualities for example depending on the mood, such as increasing the intensity of the haptic feedback or the duration of the message, yet some preferred not to do that to keep it authentic. Saving the touch message can be another added characteristic to the RST product, as mentioned above there are certain issues that need to be considered before implementing it in a RST product, and these need to be reflected in the proposed RST framework.

4.12 Product Characteristics for Remote Social Touch

This section explains the remote social touch (RST) product described by the participants of this research and its characteristics. The detailed information in this section should not be treated as how the final product should be, this is because there are various perceived needs from the participants which may hard to combine in one product. However, the information will give a general feel about each characteristic mentioned if implemented within a RST product. The findings show a few themes may increase the chances that similar users to this research participants will desire to in a RST product. The themes commonly mentioned are wearability, portability,

and attachability, familiarity to current products (e.g. a wearable product such as a watch), used anytime, not attention seeker, integrated with current communication products, and customizable. Moreover, a theme interpreted from the participants' answers is that a product can impact users' behavior and user behavior in communication could impact product characteristics. For example, if the product is big and not wearable then the product will only be used in a certain place which impacts one's communication by not having it anytime and anywhere, however, if the person likes to comminate continuously at anytime and anywhere then wearability and attachability seem a characteristic for remote social touch product. Also, participants used products and objects they own to illustrate their points such as a wristwatch, neckless, bracelet, shirt, ring, wristband, and scarf.

This section is going to expand on two points. The first point that is going to be discussed is whether the product should consist of one part that performs the communication cycle or multiple parts for each part of the cycle (send, reply, receive, and save). The second point that is going to be discussed is a remote social touch product's characteristics.

4.12.1 One-Part Versus Multiple Parts Product

Since the product function is to communicate bi-directionally in a cycle (receive, reply, send, and save), the first point discussed was whether the product is as one part that offers the full cycle or one part for each (i.e. a part for receiving, another part for send, etc.). The majority (28 out of 35[7] participants) preferred having only one product that provides a full cycle of communication. There are few reasons for that, individuals may have already a lot of electronics [P2], it is more convenient [P9], and could be easy to use for communication [P5]. Also, having only one

[7] The information from 35 out of 36 participant, one participant rejected the idea of remote social touch thus the discussion with him was only about what sees wrong in RST excluding the discussion about product characteristics.

product especially if it is standalone, can feel the symbolic meaning and value behind it [P25]. It could be easy to travel with [P21], and setup [P12]. On the other hand, 6 out if 35 participants preferred the product to consist of multiple parts, they pointed out that the sender should be separated from the receiver [P1], the saving should be in a different part [P18], or the feeling part (the one providing the haptic feedback) should be separated [P17] because it can be safer this way [P25]. Another view is to separate the controller from the product physical object [P4], or separating the symbolic way of messaging part from the simulated messaging part [P2]. Also, if the product can render various sensor modalities other than touch these can be separated [P14]. In relation to having only one product that contains everything is the possibility of being lost, one will lose everything unless the data saved digitally somewhere [P23]. The product can be situational depending on context one can take it apart to use either wear it, attach it, or just keep it somewhere [P25].

Table 4.58 One-part product vs. multiple parts

P2	"…one product all because too much electronics…"
P9	"…one product for all better and it is more convenient 3 or more product can be difficult to handle…"
P5	"…one product for everything because it will be compact like how smartphone and it will be easy to carry around for example he sent me a message and I am caring for example only the receiver so I if I want to send him back I cannot because I'm only carrying the receiving that's why I like to have all together…"
P25	"…stand-alone because it gives you the feeling that this is something special for example this is used only for special occasion valuable express to your feeling it is for a specific purpose you cannot buy it with money it has a value and this choice only for my mother and father if there's other people I will choose something else…"
P21	"…because I travel a lot so I don't want to carry a lot of stuff if I'm carrying this object with me…"
P12	"…one for each seem difficult to set up…"
P1	"…maybe it can be separate if I want to send it with one part of my body and receive it in another part…"
P18	"…I will go for one product for sending and receiving that will be symbolic … and another product that I will have at home full-size simulation and that's for saving…"
P17	"…maybe the product is one a place but feeling it in another place like it's a bracelet but I can feel it where I need to feel it…"
P25	"…you can have single device that do the sending and receiving and another device that do save a message when you want to play it you play it on that device the saving device for example you attach your laptop to it and you play the message I wanted to be separate because if something happened to the machine the saving one will stay as a backup will not be lost…"
P4	"…maybe the physical thing is with me however the controllers are on the phone…"

Table 4.58 (continued)

P2	"…receiving should be symbolic but sending should be simulated … maybe we can attach it to a clothing then you can have it simulated like a hugging yourself apparently I need to separate sending and receiving the necklace could be for receiving kissing …"
P14	"…product for all but you can send separately touch smell all that…"
P23	"…but if your break the device out or lose it you will end up losing everything I would say in different devices even though it is not feasible but at least if you have one is it broken I can still receive or reply … if you lose your reply device you will not lose the saving data…"
P25	"…I will leave it at home but I can still take something the product with me attach it to my phone and see the message … also a wearable for example I cannot have my phone when I'm taking shower but I can wear my watch because its water resistance …"

4.12.2 Remote Social Touch Product's Characteristics

The participants discussed the characteristics of a remote social touch product based on the cards shown to them. The cards include standalone product, attachable, added to a functional product, non-wearable, wearable, portable, accessories, cloth, and decorative. The participant may also include other characteristics not included in the cards. A detailed explanation about these cards can be found in Chapter 3 Section 3.7.2. Figure 4.13 illustrates the frequency of each characteristic mentioned by the participants and the relationship the participants were thinking of while discussing remote social touch.

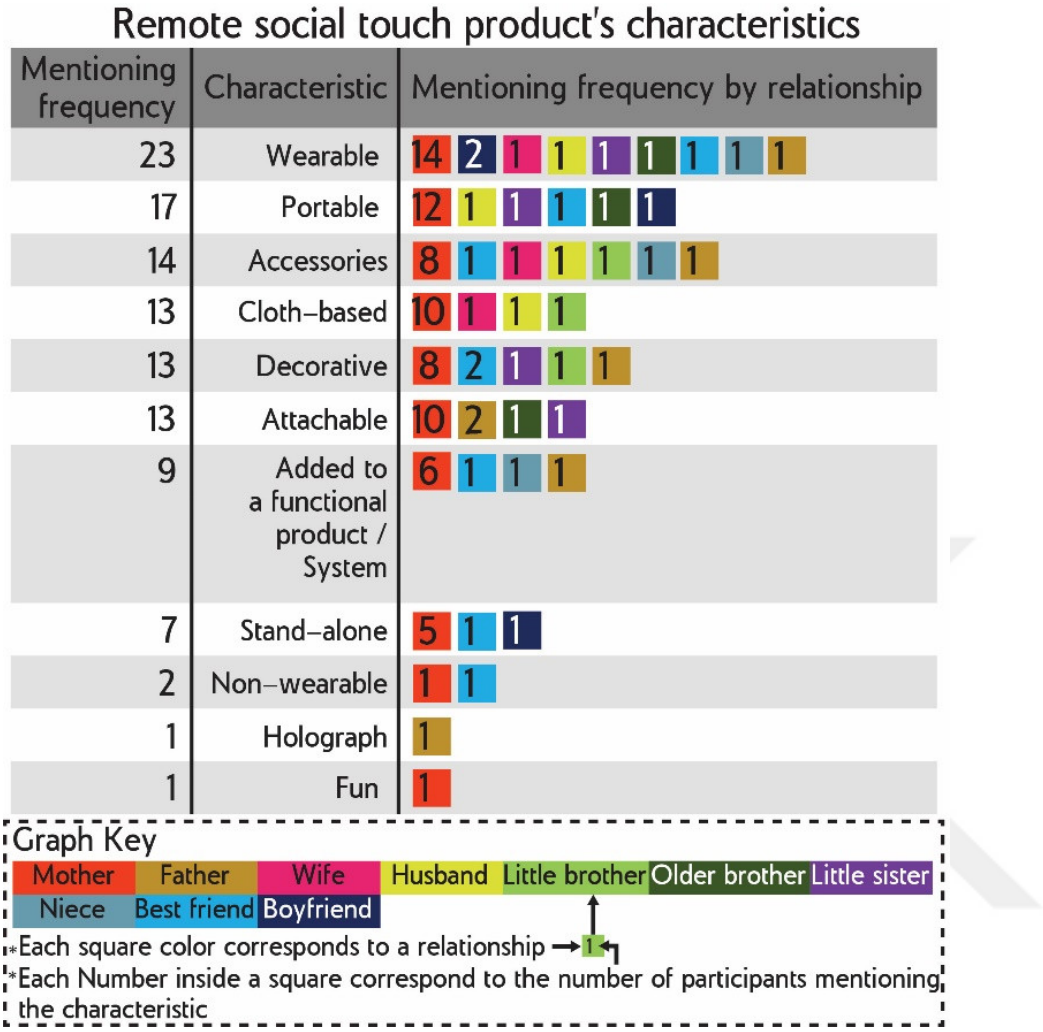


Figure 4.13. Remote social touch product's characteristics

In relation to the characteristic of RST product, the first one and the most reoccurring characteristic mentioned by the participants is wearability (23 times mentioned) and portability (27 times mentioned). Participants are looking for an object that is to be always on oneself [P2][P7]. This is could be because physical interaction (PI) communication can be anytime [P4], it may happen outside [P5], better for synchronous communication [P8], and familiarity to current wearables products [P22]. Portable or wearable can be with the person all the time, if people already have a lot of things to carry they choose a wearable feature [P3], one will not know when the product is needed [P34]. However, others feel wearing something only as a communication device is not practical because other things to wear or it will be

forgotten unless integrated with another wearable device [P12]. The product should be decorative or fashionable [P12], and place on the body where it is accessible anytime [P33].

Table 4.59 Wearability and portability (A)

P2	"…I think it should be wearable and accessory should be always with you because you could think of something you could think about that person at the moment and you don't have the mean to send a message it will not mean anything it won't be useful at that scenario it's good to be added to a functional product for example we are using our phone attachable phone case portable same idea clothing if you couldn't attach it and they attach it…"
P7	"…portable because I wanted to be small not a huge, I can put it in my pocket and maybe something I can attach it to something functional I use like my lighter…"
P4	"…should be portable because you don't know when you will need it … maybe decorative and portable something fun I can play with like a widget decorative as in sense of entertainment attachable I can attach it to my laptop or phone…"
P5	"…for holding a hand PI I think wearable accessories attachable I can use it more cuz I have it on me I can't touch it or hold it for sending and receiving so when I'm going to walk I can hold my hand…"
P8	"…I want to carry it all the time if I wanted to be synchronous …"
P22	"…I like the idea of wearable product like a wrist watch because I wear that most of the time…"
P3	"…portable will not be nice I have to carry this and I have to get my laptop non wearable or decorative product also it will be terrible … stand-alone I may forget it …that it should be always integrated with something to use all the time … so it should be wearable clothes item attachable to a functional product…"
P34	"…it's really something you can actually go around like it's with you everywhere so you can use it whenever you receive … what time you want…"
P12	"…I don't think I will wear a bracelet because it's vibrate of touch of someone … but if I have a Fitbit I would like to install software that do that thing messaging so added to another factional products it make more sense … but if the product do everything that I would prefer portable stand-alone maybe wearable maybe attachable to phone…"
P12	"…Maybe a comfortable clothing item like a jacket but it's also fashionable Then also can act like a touch sender receiver… I would like to make something portable tiny and decorative like JUUL the vaping device Very fashionable…"
P33	"…It could be on the wrest where it's accessible anytime. You can send it anytime it could be around the neck in the shape of maybe like a necklace or something. You can touch it, you transmit the thing Also it could be around the heart area. something like something keep your hand [put the hand on the heart] and it just transmit to feel like …"

It can be fabric-based [P10], such as clothing items used depending on the occasion [P14]. Being a clothing item one can perform various PI on it [P3], and it can render the haptic feedback on a larger surface of the body [P15]. The product can be portable for the people who do not like wearing things [P4], put on when needed [P20], or

keep it somewhere presentable [P11]. It should be light to carry, not occupy space, and last longer if charging [P4] yet big enough to feel realistic touch [P35]. Another way to carry it is to attach to things already worn by individuals such as cloth [P24]. Finally, it should look familiar and inconspicuous such as be similar to decorative objects currently they used [P5].

Table 4.60 Wearability and portability (B)

P10	"…it can also be a cloth it's got to be a fabric base but it doesn't need to be a real piece of cloth…"
P14	"…clothing can be for a specific occasion maybe I feel depression or I feel so bad maybe I can wear it…"
P3	"...clothing thing is most logical because you can implement changes to make it more realistic…"
P15	"…clothing if I wear a shirt on I get a hug I can get that feeling nobody will know that it is moving it is only me I will know … if it is an added function to my shirt I'm sure I will wear the shirt because it keep me connected … shirt it covers most part of my body"
P4	"…not wearable because I hate wearing anything like watches or accessories…"
P20	"…on my back something I can get it out and use it not something stuck on me all the time so I can take it out wear it and use it then put it out again…"
P11	"…I can hold it take it with me it's a practical to have it but still it is something itself it is something special to me that's why I don't want it to be inside the phone but maybe something attached to the phone I can attach it to my bag too and if it is portable I can put it into my pocket it is wearable so I can also wear it take it off and wear it like a watch or necklace and decorative because it's going to be wearable…"
P4	"…something is small can be put in a bag or a jacket does not occupy space it should last for long over time if it is on batteries…"
P35	"…well I think it should be decorated piece of art because I would want it to be big enough so that I can feel like you know, it's realistic. but it should also be portable. not so heavy. I can carry it if I want it should be not that big that I can't carry it outside. it should fit in my bag…"
P24	"…maybe attachable to clothing or something I wear it underneath attachment that goes with every cloth like a clip-on / in respective to the fabric it is fluid form could be shoulder extension that latches to the clothes or textile friendly…"
P5	"…decorative for example cactus plant I really like them I can put it on my desk maybe a stand for the plant and in the same time I can do the messaging… attaching to sunglasses stand so I can just hold the stand and it is in my room or maybe the glass case I can hold it and I carry it all the time with me…"

The second product characteristic mentioned by the participants is attachability (22 times mentioned) with objects or products they own [P4], used daily to be on the person all the time [P6]. Additionally, it can be integrated or attached to an object that carries value to the participant such as a ring from a loved one [P5]. The product can be attached to the person or an object [P19], this is because will help make it less forgotten [P23]. It can also be pairable with electronics they already use such as

smartphones [P21]. A product that can be used in a various way it can be attachable one time then it can be by itself as a decorative object, also easy to carry not and extra thing to worry about [P5].

Table 4.61 Attachability

P4	"…attachable if it is compatible with the things I use that would be great it's going to be attached to my phone or pairable with my phone…"
P6	"…I think the best one is adding it to a functional product so you will not need an extra thing to carry it is like there is no chance to forget your phone so if it is added to your phone then you'll have it with you all the time but if it is not with your phone then you have an extra one thing to have maybe also attached to our clothes but clothes need to be change so maybe is attachable to cloth because clothes you have to wear it all the time…"
P5	"…I'm wearing a ring from my father I really like it so if it has a button to contact my father it will be nice more special…"
P19	"…maybe attachable either to you or to something you wear but not a specific type of clothing the device is not the clothes…"
P23	"…I want attach it to my phone because it is always with you, you do not need to rush back to get it if you forget it…"
P21	"…it can be standalone something small like a pen pen-drive can send or receive the message also it can connect to a phone so I can hear the notification and also can have clothing so I can feel the whole interaction throughout…"
P5	"…also I would like it to be maybe both attachable like a cover of my phone and maybe decorative…"

Additionally, the participants mentioned that the product should be unobtrusive (2 times mentioned), hidden (7 times mentioned), multisensorial (2 times mentioned), and integrated with current communication media (1 time mentioned). The product could have shifting/transformability (4 times mentioned), and entertainment features (1 time mentioned). It can be like accessories (14 times mentioned) allow wear and forget no need to be constantly aware of it [P1], or A system you can install and forget about it [P28]. Some participants pointed out the importance of it being hidden or not noticeable by others for privacy and intimacy reasons [P13]. Any characteristics that make it stand out will draw some questions which are against the privacy it should have [P1]. It can look normal or fashionable [P19], underneath the cloth hidden [P21], not attention seekers accessories [P27], or be in place not visible like around the neck or shoulder [P1].

Table 4.62 Unobtrusive, Hidden, multisensorial, and integrated with current communication (A)

P1	"…something like accessories for example wearable accessory and clothes otherwise I really need to be aware of that object I am holding it is it with me is it at home is it in my bag where is it but if it is wearable I can wear it and forget about it when message come I can always feel it…"
P28	"…maybe like, you know, you install some device for the internet. it's like in some kind of cupboard in your house. so, you just put it there and sort of installing, don't bother with it again…"
P13	"…one can we use more privately and one can be use at all point … private can be clothing and decorative … the other thing for the public can be accessory a wristband a watch it look good and do the faction you can keep it on you always it can fool people it's a watch but it is not can use for sending or receiving…"
P1	"…it should not be very visible otherwise other people can see it, it is against the intimacy of the message if someone send me a kiss and other people can notice it either through sound or look or color light, I wouldn't want it I wanted to be as invisible as possible…"
P19	"…I don't mind being shown to the public if it does the job but still look normal but I don't think that's important as to fashionable…"
P21	"…so, I can than wear it okay now I can feel the experience and I prefer this clothing to be underneath my clothes nobody can see it…"
P27	"…accessories lock necklace or something you can wear on your wrist something it does not look so different from the thing that I am wearing I even don't want it to look like something like fitness thing … it can be quiet simple like a robe you can attach it to your wrist so I can feel some kind of stuff with it it won't be visible to everybody does just a piece of accessory not attention seeker…"
P1	"…I think it should be something included with the clothing not visible event for a kiss or holding hand so maybe on the neck part two people still kiss on the neck no problem also a hug or cuddle can be felt around that area and maybe it can be extended to the shoulder so we can feel sitting side by side…"

Additionally, RST products can give a multisensorial experience [P3] which can be customizable [P13]. It can be an entertainment object that does the communication [P4]. The product can have shifting or transformability features, it can manipulate by hand small but can become big to simulate the action [P20], to be easy to carry around [P8]. A product that can shift from being something to be the communicator to be also hidden [P7]. The physical interaction that the product trying to communicate can impact the product characteristics [P5]. For example, active PI such as physical play can be with a stationary product but passive PI such as a kiss can be with a portable product [P27]. Also, the place to use the product depends on the PI how it naturally done; indoor, outdoor, portable, or standalone [P24].

Table 4.63 Unobtrusive, Hidden, multisensorial, and integrated with current communication (B)

P3	"…for me touch alone it's a limited experience I would include that experience for more comprehensive communication to me video or audio calling and sharing it is more meaningful than just a touch communication especially if it is just a symbolic unless you are a blind touch is not the man driving of your memory and it is not the main communication you use I don't see a system which is only based on that I see it on top of other system…"
P13	"…I would like to customize it or changing it like for this message I can use taste and smell but the other one not I can change things but the product is one…"
P4	"…maybe decorative and portable something fun I can play with like a widget decorative as in sense of entertainment…"
P20	"…some kind of object that I can manipulate with my hand … something portable that I can open then hug or fighting as in punch then send then put it back…"
P8	"…something you can put inside the necklace then open it then become bigger so someone can simulate a hug on it on the same with linking arms…"
P7	"…it is decorative but I can press on something than something happened…"
P5	"…maybe sending putting my head on the shoulder can be a decorative at that time I will be in my room kind of relax then I will put my head on something…"
P27	"…I would love them all to be together maybe I can separate these two devices sending active messages playing around and doing things together that can be a stationary kind of thing staying at home not carrying around with me on the hugging and tickling maybe some kind of more passive and symbolic kind of thing so I can carry that around and I would like carry around I would like to receive this message from her during the daytime I said have some kind of messages…"
P24	"…for hug and kiss I want to feel natural I want to carry it around for other it is very contextual experience so when I am in my house I want to feel that not when I'm outside so stand-alone can be used when I am at the moment I go to that thing then I interacted with that just like how I go to my mother and interact with her it could be a decorative or stand-alone product just specifically for that purpose maybe go and shaking it literally asking for attention maybe it has a leaver or a hand grab on a press on to just like how I do it with her literally simulating the actual experience somehow … hug and kiss I like to getting them but I don't ask for to receive them that's the element of surprise is important for me so just carrying it with me and experiencing it out of the blue is good…"

There are a few other various product characteristics mentioned by the participants. It should be convenient less expensive to be accessible by most people [P25] and less maintenance required [P6]. The product itself has symbolic value [P18] and can be gifted, recording the PI on it then sent to the loved one [P7]. The visual look of the product can be customizable by the user [P33]. Instead of the product record the PI, it can be a central system where buyers record presets in the store then take only the sender-receiver part [P28]. Moreover, the product can present a holograph

representative of the other person to interact with physically [P23]. Finally, the material choice of the product should be pleasant to interact with [P4].

Table 4.64 Other various product characteristics

P25	"…it shouldn't be exclusive to certain amount of people it should be available to every single person in need of remote social touch for example of there is a device going to be built and sell to people it shouldn't be that expensive so for example student in different country with low budges cannot afford it … it should to be available for all the classes of the society is going to help a lot…"
P6	"…definitely one for all because one for each require space and also my need a lot of maintenance I may be more expensive to carry and if you have too many it may lose its value or maybe lose one of them…"
P18	"…I will go with wearable bracelet because I love bracelet if it is something symbolic I will wear it all the time so I had this kind of experience before…"
P17	"…so basically, I would like to have a product that I record the message on then I will send this product to my mother the object itself the same thing my mother will have a different object she will record and message on it then we'll send that object to me…"
P33	"…I mean and if it's possible so that I can design my own device. so, everyone should have to make it in his own way and also so that this shape is belongs to me and another person…"
P28	"…the center is where I'm buying this thing that I feel like it would not be possible to put this technology in every home or for every buyer so if you want to buy it, you get your screen you get your little data thingy, whatever it is, you go to the store and you record all the things you want on their machines, you put that data in your machine, you put your patch on and you come home. so if you want new interactions, you go to store and record again…"
P23	"…I would say I want holograph type of thing that you can see the person in front of you … I will interact with a real hug…"
P4	"…the interaction should be friendly the material should be nice to interact with…"

4.12.3 Interacting with The Artefact

To understand how the participants will interact with a Future RST product to send the physical interaction (PI), they asked by the researcher to act out the preferable gestures for the simulated and symbolic way of messaging if an artefact exist. The hug PI, the kiss PI, sleeping on PI, and patting PI were commonly discussed by the participants of this research concerning a "Mother" relationship, thus this section will further explain these physical interactions as special cases. Figure 4.14 shows various interaction styles to send mother's hug PI, Figure 4.15 for mother's kiss PI, Figure 4.16 for mother's "sleeping on" PI, and Figure 4.17 for mother's patting PI.

Depending on the way of the communication, in simulated way participants tend to act out a gesture similar to the physical interaction (PI) action. For example, for a hug, they will act out the hug action either by hugging the object or hugging the air (can substitute the air by cross touching the shoulders, see Figure 4.14), similarly with the kiss they can either kiss the object, the air or do flying kiss action (see Figure 4.15). However, in a symbolic way, the gestures tend to be unnoticeable by others people to keep the communication private and intimate, for that participant tends to:

1. Act the essence of the action, for example, the hug has a squeezing feeling thus the gesture of squeezing acted out, and the kiss action has a pressing feeling or deforming of the lips thus the gesture represents a pressing or putting the fingers in a way similar to the lip,
2. Acting a familiar way of interaction with current electronic gadgets such as pressing or swapping,
3. The other symbolic ways to send a PI is by texting the PI or just thinking of it.

In the light of this findings, the method of allowing the user to act out the interaction style can elicit various way a designer can incorporate in the product especially if the product specialize for one PI, additionally, a researcher can use this method to find behaviors of touch related to RST and how it correlates to the actual physical interaction. RST framework should take notice of these findings by making obvious the importance of interacting style to the PI one trying to communicate.

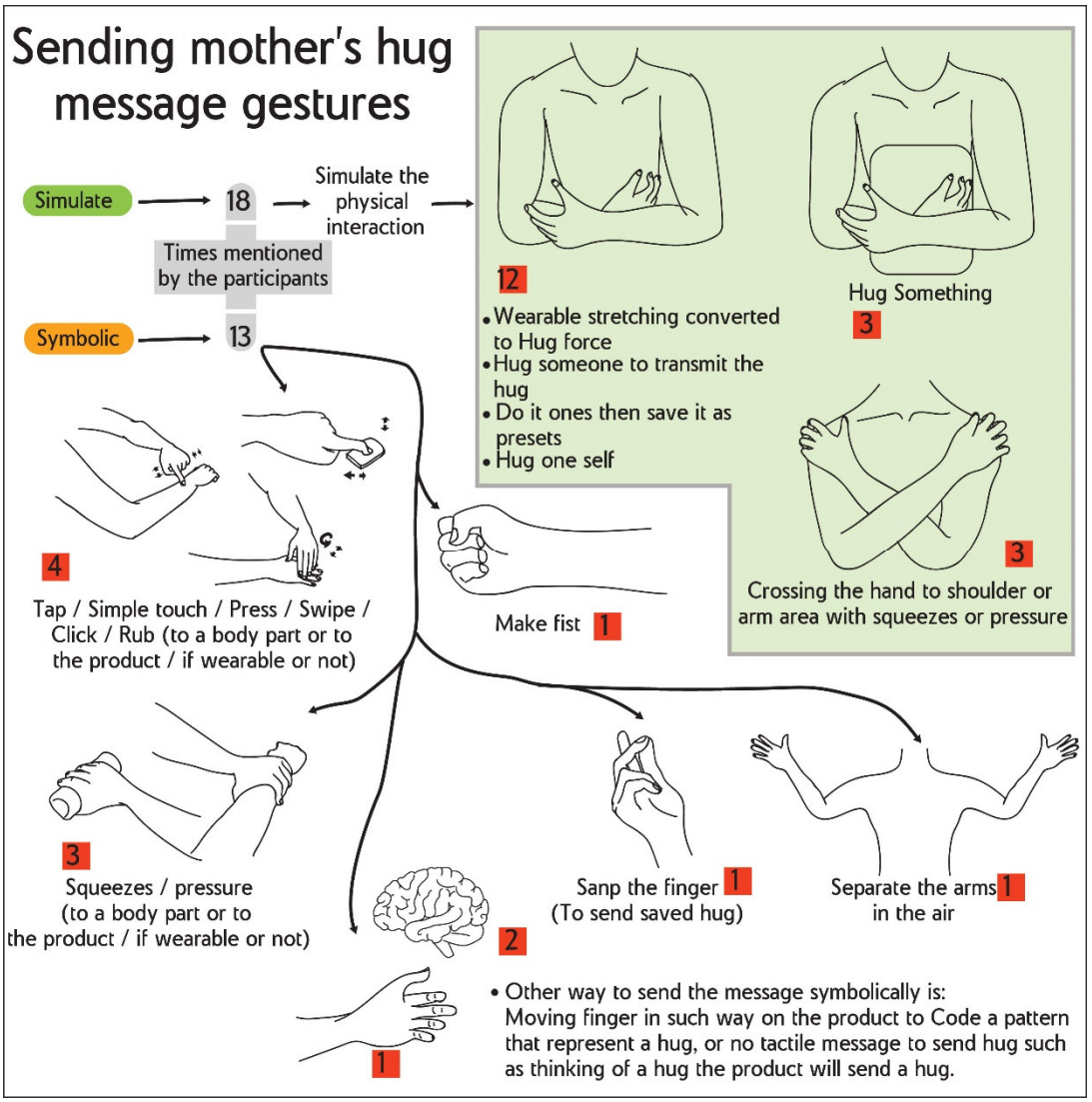


Figure 4.14. Interaction style to send a “Hug” physical interaction message, simulated and symbolic ways

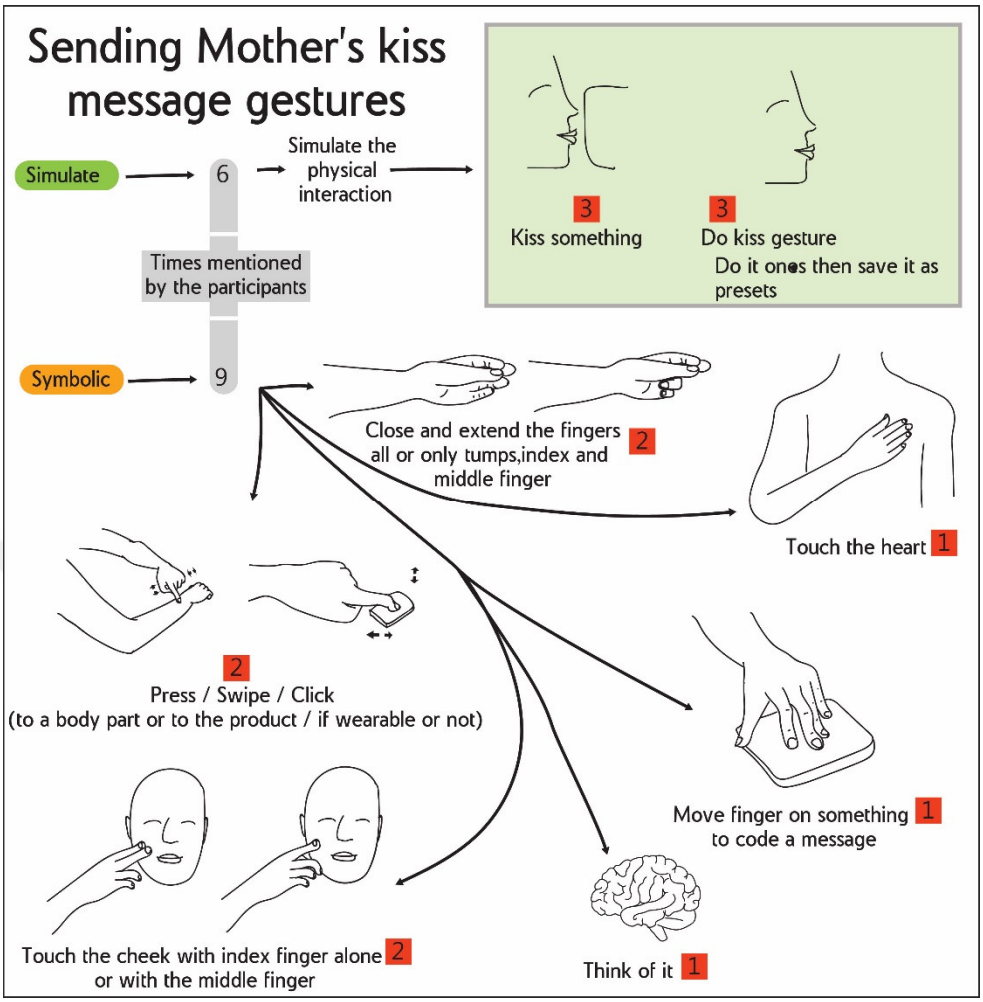


Figure 4.15. Interaction style to send a “Kiss” physical interaction message, simulated and symbolic ways

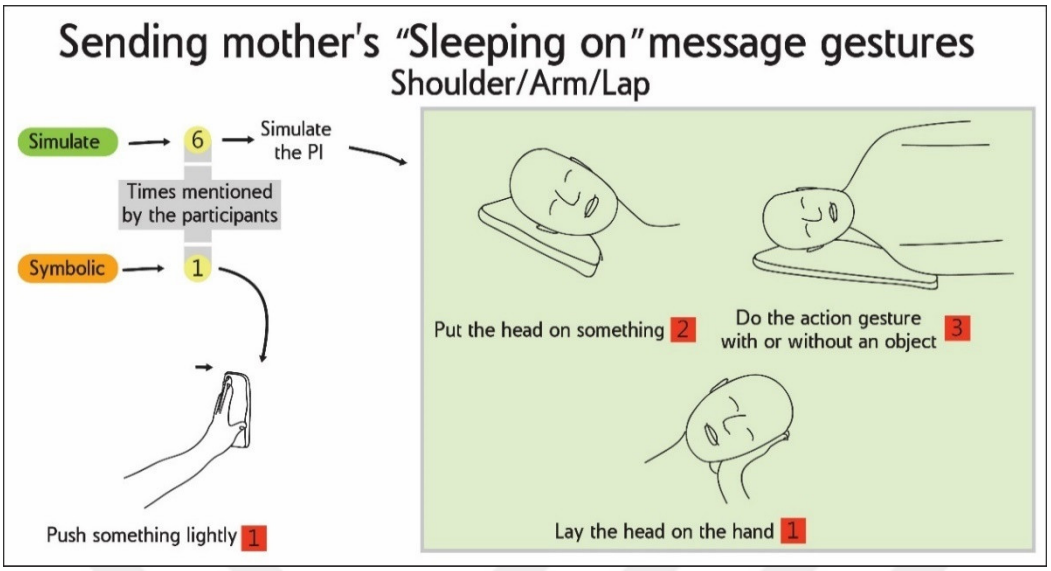


Figure 4.16. Interaction style to send a mother's "sleeping on" physical interaction message, simulated and symbolic ways

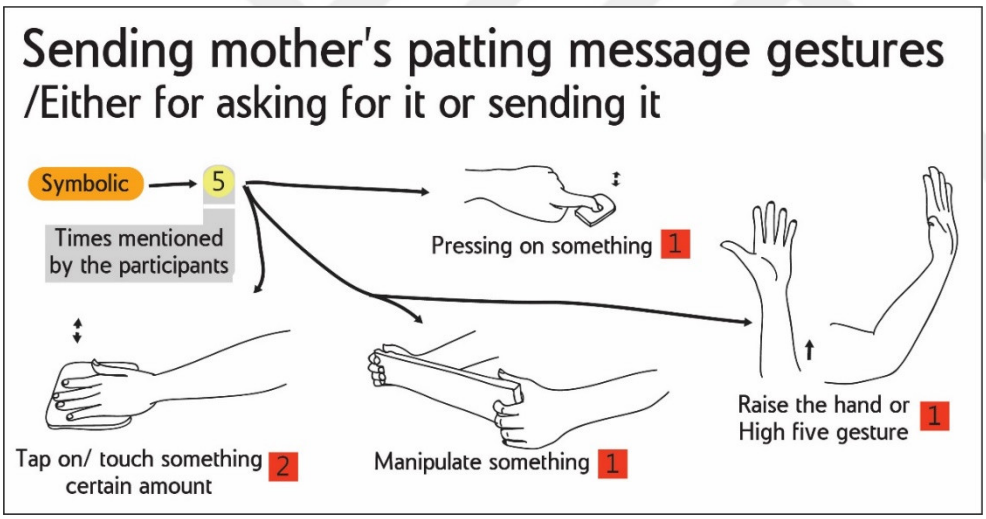


Figure 4.17. Interaction style to send a mother's "Patting" physical interaction message, simulated and symbolic ways

4.12.4 Location of The Product and The Haptic Feedback on The Body

Similar to Jones and Yarbrough (1985), adopting their style establishing area for non-vulnerable body parts (NVBP) and vulnerable body parts (VBP), in this research human figure was used (refer to chapter 3 section 3.7.2). The human figure can show heat map-like areas by collecting all the locations mentioned by the participants regards to a certain physical interaction (PI). This makes it easier to assess the major body locations where a PI has an impact and where a possible future product can live on the body. The figure can describe where people would like to feel a certain PI through remote social touch (RST). This section will discuss further some physical interactions related to the "Mother" relationship as a special case since they were commonly discussed among the participants of this research.

Participants may choose multiple locations; each location is a general place it can represent the whole location or a point in that location. Figure 4.18 shows the locations where the participants want to feel the haptic feedback when receiving mother's hug PI, Figure 4.19 for mother's kiss (Kisses' kinds: General kiss, Kiss on the cheek, kiss on the forehead, kissing the hands). For mother's "sleeping on" PI, and for mother's patting PI, Figure 4.20 for mother's "sleeping on" PI, and Figure 4.21 for mother's patting PI.

As evident from Figure 4.18 whether people choose to receive the hug in a simulated or a symbolic way that the hug action is more related to the upper body location, mostly around the arm-shoulder and chest location. Similarly, for the kiss, Figure 4.19 shows that participants associate the head location with the kiss however forearm and hand location were chosen for a symbolic way to receive the kiss message. Additionally, the figures show that for these two PIs (Hug and Kiss), the locations are almost similar to where the real PIs do happen. However other PIs elicited in this research, the location to feel them may differ.

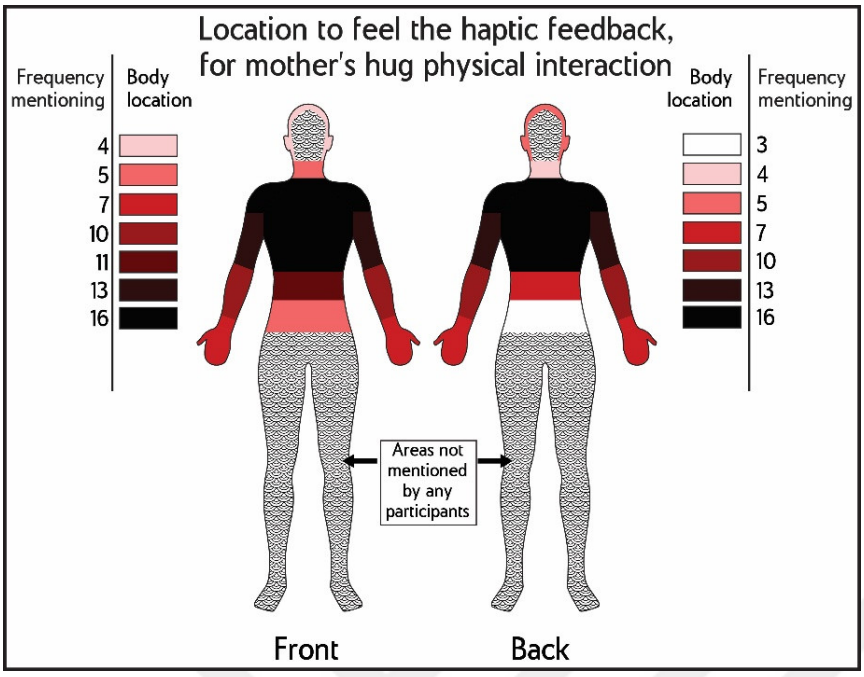


Figure 4.18. The body locations where participants want to feel the haptic feedback for the mother's hug physical interaction

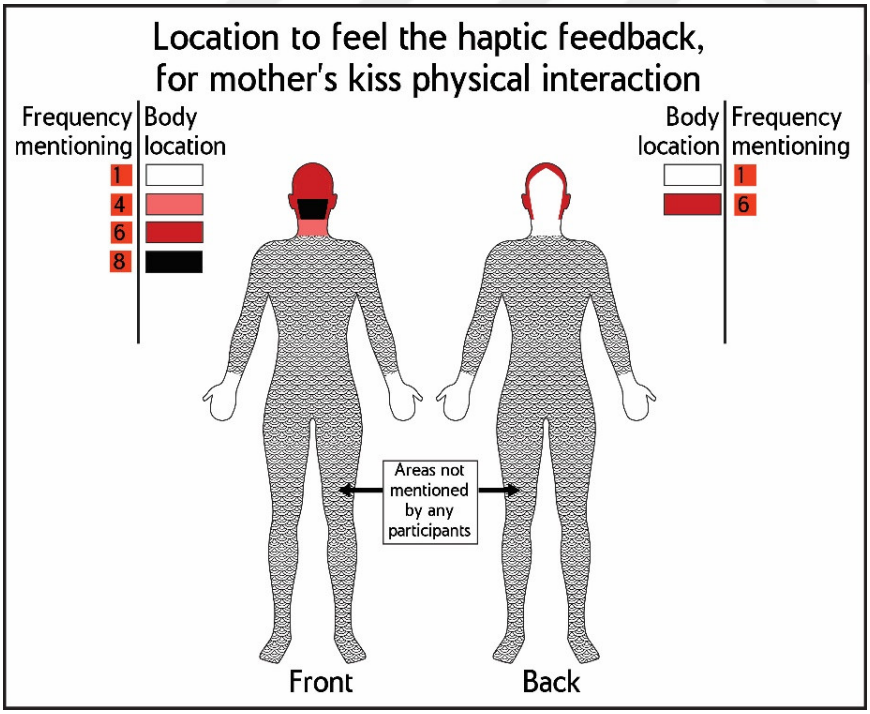


Figure 4.19. The body locations where participants want to feel the haptic feedback for the mother's kiss physical interaction

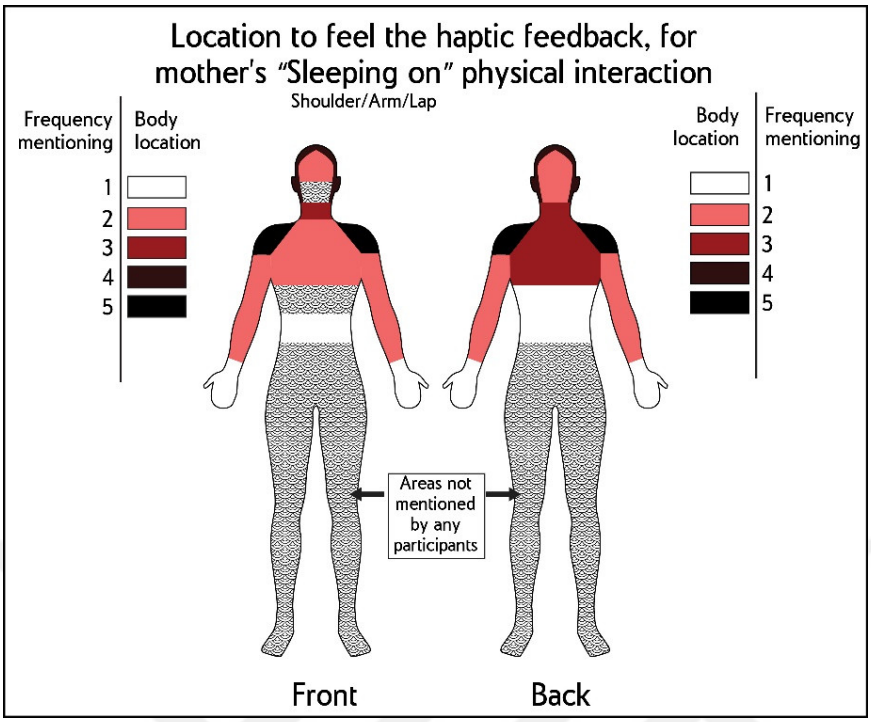


Figure 4.20. The body locations where participants want to feel the haptic feedback for the mother's "sleeping on" physical interaction

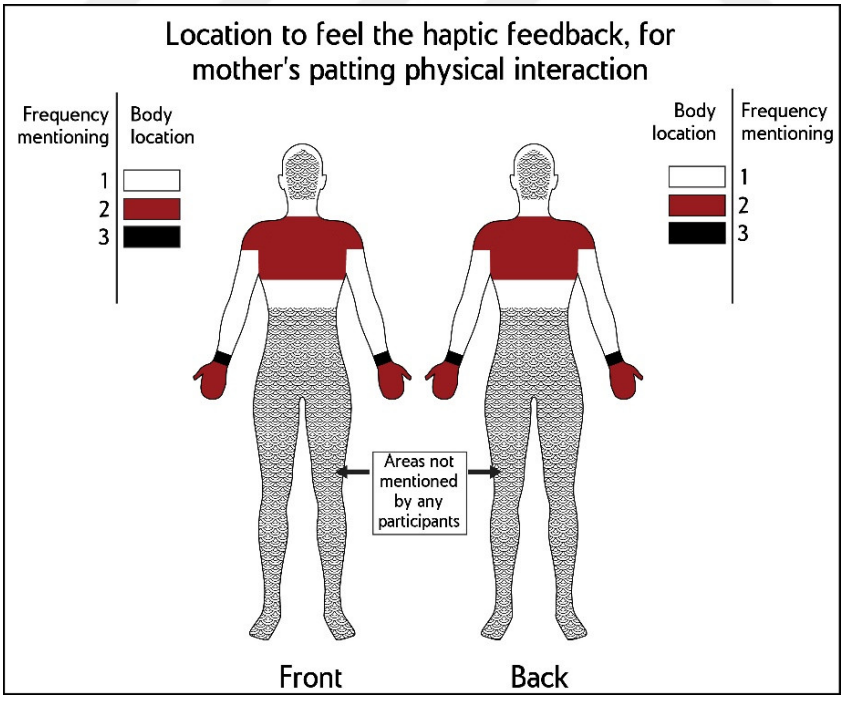


Figure 4.21. The body locations where participants want to feel the haptic feedback for the mother's patting physical interaction

Similarly, the human figure was used to explore the preferable location on the body where participants would like to have the product on them in case if it is a wearable product. Figure 4.22 only shows the case of mother's hug PI, Figure 4.23 for mother's kiss PI, Figure 4.24 for mother's "sleeping on" PI, and Figure 4.25 for mother's patting PI. Participants may choose various locations for the same PI, and the location could represent that the product can either cover the whole location or somewhere in the location.

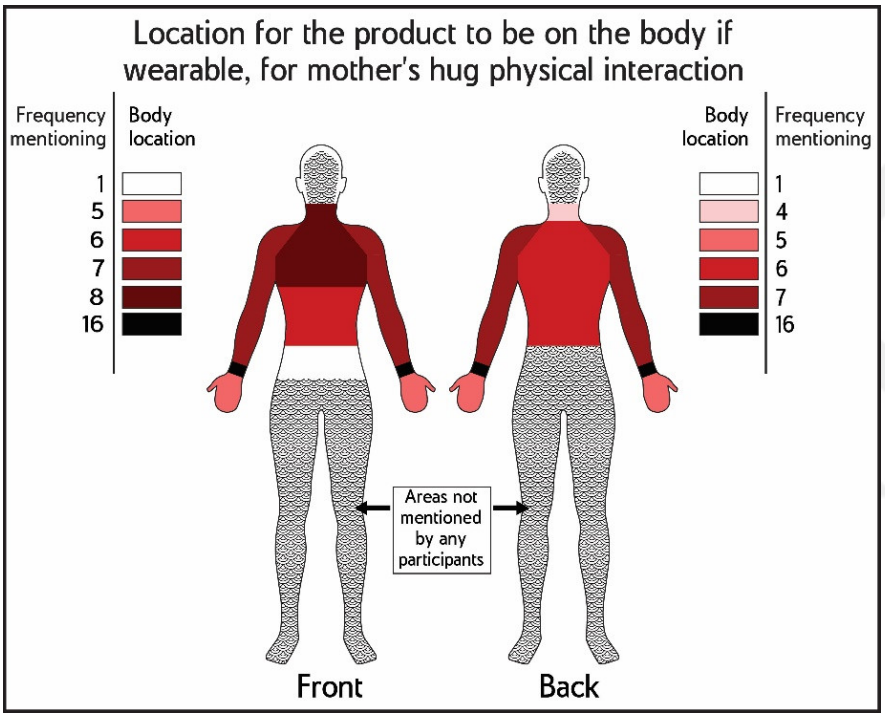


Figure 4.22. The body locations where participants want the product to be for mother's "Hug" physical interaction

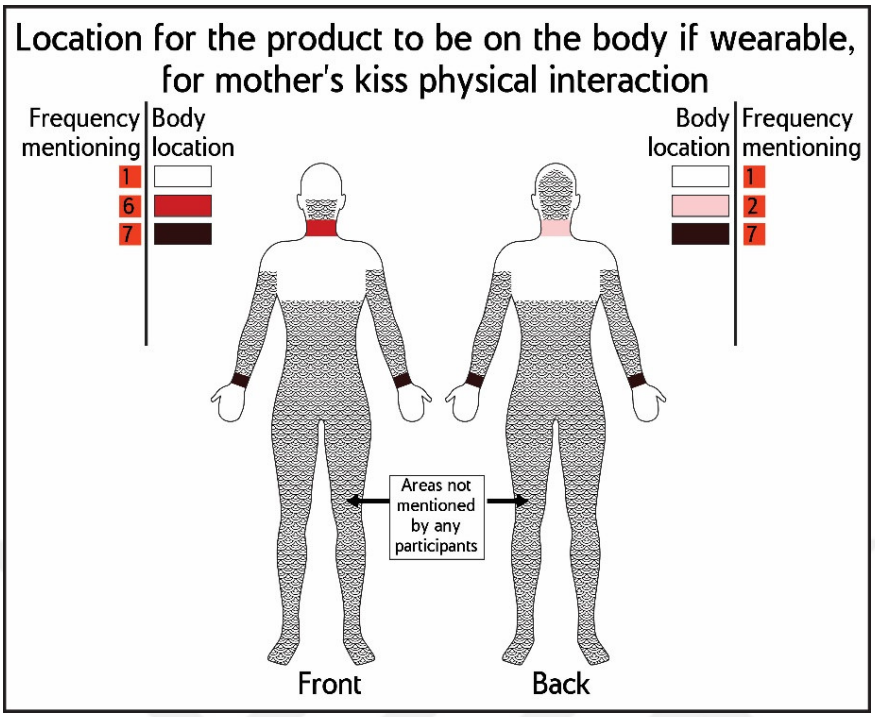


Figure 4.23. The body locations where participants want the product to be for mother's "Kiss" physical interaction

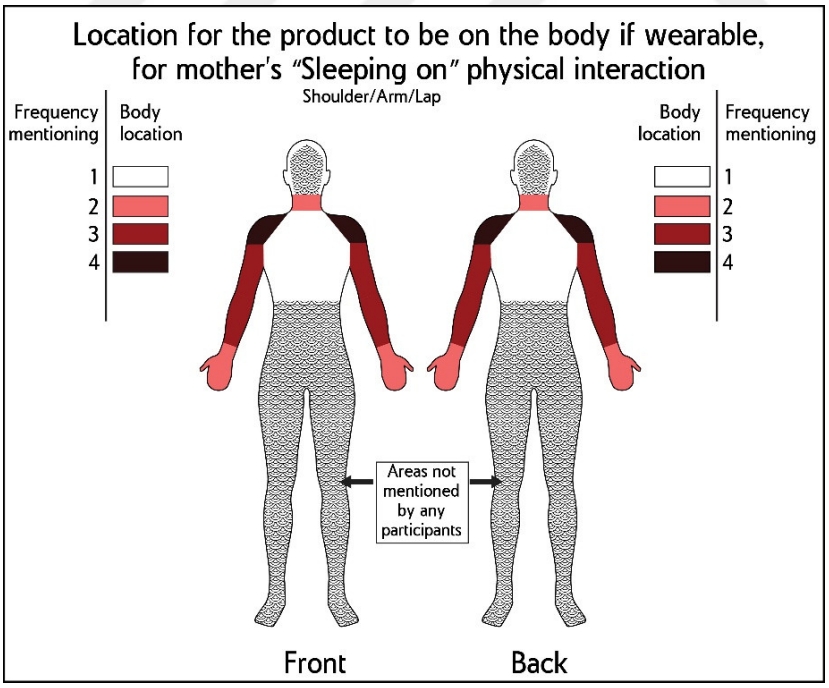


Figure 4.24. The body locations where participants want the product to be for mother's "sleeping on" physical interaction

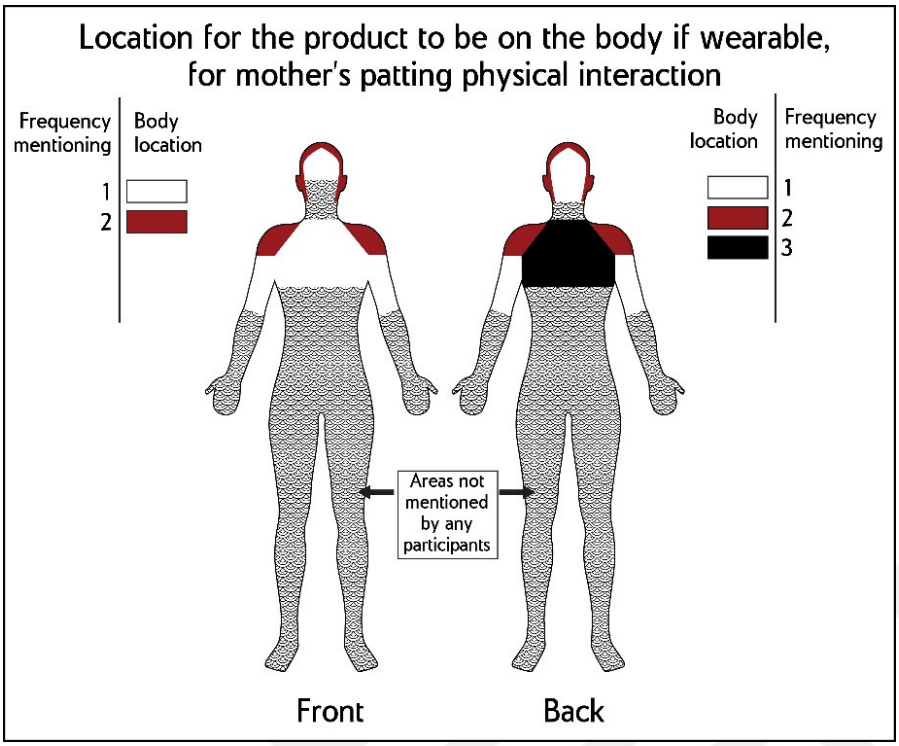


Figure 4.25. The body locations where participants want the product to be for mother's "Patting" physical interaction

The common locations for the wearable product especially if it was for a symbolic way of messaging are the forearm, wrist, and hands this is because of participants familiar with wearable technology such as smartwatches and accessories wearable on the hands. other reasons such locations more common are they are easy to access and not drawing attention. However other locations also mentioned by the participants that the product can live on, for the hug location around the shoulder the chest, and for the kiss the neck and the head. Additionally, if the product will send and receive a hug and kiss then it may live on the upper body location where one can feel both the hug and a symbolic way of the kiss such as around the heart location.

These figures can be used individually for each PI or combine with other PIs to find the best suitable place for a product. A comparison between the Figure 4.18 to Figure 4.25, reveals that the location the product can live on is almost similar to the locations where individuals want to feel the haptic feedback for the PI especially if it was a simulated way of messaging. Using this way, the human figures, to elicit information

on the location of the feedback and the product related to certain PI can be beneficial for future RST research or product design. A future RST framework should consider these findings, body location is an important part of RST and general social touch and it should be obvious that the body should not be neglected when designing or researching for RST.

4.13 Touch-related Behavior Patterns and Personas

While researching remote social touch (RST) three main types of touch-persona surfaced in the literature as well from the participants of this PhD research, these are i) Touch avoider, ii) Touch deprived, and iii) Touch-neutral. Additionally, the participants showed three types of interest in the subject of RST i) interested in using RST, ii) hesitant to use RST, and iii) against using RST (Figure 4.26). This section is going to discuss these points further. These three interest groups were extracted based on how many advantages or disadvantages points in using RST a participant discusses.

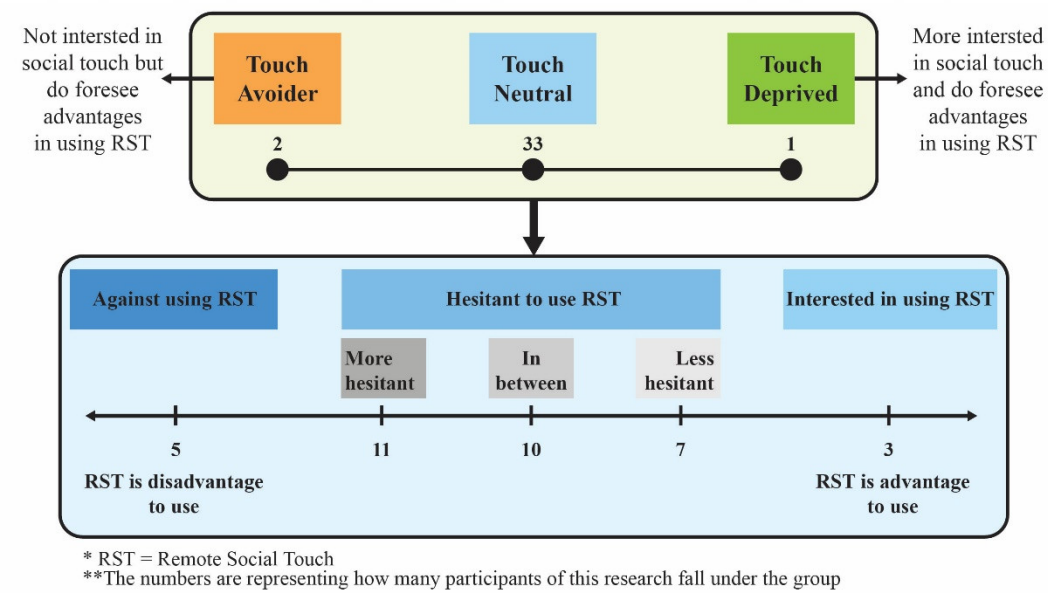


Figure 4.26. Extracted individual persona and behavior toward remote social touch from this PhD research.

First of all, type of touch persona:

a. Touch avoider

Those individuals are not interested in engaging in social touch or physical interaction with other individuals (Johansson, 2013). Individuals might feel unpleasant or disgusted by touch for many reasons including feeling insecure about initiate the touch or sharing an emotion through it (Lenselink, 2016). For this group of individuals, RST might seem an advantage for them. For example, participant [3] thinks that one scenario to use RST is allowing the other side to express their love or affection physically which is good for the loved one (the sender) emotional health, but the touch avoiders (the receiver) could choose to "On" or "Off" receiving the physical interaction on their side as they are not very interested in physical touch, "*... it will be used to disable the interaction from my side if I don't want it and let the other side used it when the social context requires to do social touch…*" [P3]. RST can also allow the manipulation of the characteristics and qualities of the communication to suit best the touch avoider, for example having an automatic response when a loved one sends to the touch avoider or lowering the intensity of the haptic feedback.

b. Touch deprived

individuals who need, want, or are interested in a social touch but lack physical contact for some reason (refer to Tiffany Field (2014, p. chapter 4) for further information). Being deprived of social touch could impact mood states negatively (Tiffany Field et al., 2020). In this PhD research, one participant whose mother tries to give less physical affection wanted to have the ability to change the feedback qualities such as increasing the duration or intensity of the haptic feedback, such ability could be one of the advantages of RST for touch deprivation. For example, for participant 14, her loved one tries to prepare her for the life of independence thus the loved one used to

initiate physical touch less frequently in general even if the participant initiates the physical interaction more than the loved one and feels the need for more touch interaction. In such case, in RST the ability to manipulate the haptic feedback qualities can be an advantage in RST, "*depending on the situation I am in for example if she sends me a light hug then after that I want to replay it and I change the intensity to be more because oh I wish she was here*" [P14].

c. **Touch-neutral**

It is a term given by this PhD researcher to any individual who does not fall under the "Touch avoider" and "Touch deprived" group. Individual who does not restrain from social touch and receive enough physical contact fall under "Touch-neutral" group. Most of this research's participants fall under this group. However, in relation to RST their aspirations, concerns, needs, and the way to use RST vary among them. Among them, individuals could have a vast interest in using RST, a hesitant to use RST, and against using RST. Following explaining each of three interest

Second of all, individuals group based on the interest in using RST. These groups established based on how many advantages or disadvantages points a participant mentioned about RST, these groups as follow:

I. Interest in using RST

In this category, the participants perceived RST as an advantage addition to their lives with no disadvantages. They did not mind the idea of receiving or sending a physical message over digital media or mediated by an object. Some of the advantages they foresee, for example, RST can help with feeling less alone, "…*This can help with mental stability Evan that person far away from you know they are thinking of you and initiating physical touch with you…*" [P2]. Also, RST is seen as a way to increases the feeling of presence,

"*…You can tackle the problem of isolation Being alone and away from your family so you can feel they are still with me…*" [P23].

II. Against using RST

In this category, the participants perceived RST as disadvantage addition to their lives with no advantages. The participants spoke against the idea of transmitting touch over digital media or mediated through an object. The participants are more interested in real touch even if they miss it when they are away from their loved ones the participants do not want to replace the real person with something else. Some of the disadvantages they foresee, for example, RST will be misused by the people "*...it is bit concerning it may take over the real touch people will tend to these devices more than they tend to the real physical touch ...it may be misused depending on the relationship context…*" [P7]. Also, being away and miss physical interaction is a benefit for one's emotion and that is way a participant did not see RST useful "*…not being a close to your family it's a good thing sometime it will help you to grow get experience with your feelings and emotions to be mature sometimes you need some distance or space from your family i think this thing remote social touch are not useful at al…l*" [P9].

III. Hesitant to use RST

This category is divided into three subcategories, i) some of the participants less hesitant and more toward using RST, ii) either between interested in using RST and not interested in using RST, and iii) hesitant to use RST and more toward not using it. In this category, individuals foresee both some advantages and disadvantages of using RST. For example, some participants foresee that RST could enhance the sense of connectedness, "*… it gives the feeling of being there ... for me physical interaction is important for me to feel the love of loved ones closeness to feel better and to feel care …*" [P11]. Another group of participants foresee that RST could be mixed with current

communication media to enhance it "… *because of the globalized life we are living away from our loved one it is good to have another layer of communication to keep in touch* …" [P1]. On the other hand, some participants discussed the disadvantages of using RST. Some participants foresee that using RST could devalue the actual real social touch "… *growing distance from people maybe it will turn like Instagram everybody sending hug to each other or touching each other but no one really touching anymore digital closeness bring about physical distance* …" [P12]. Others, foresee that RST could raise addiction issues which could impact emotional wellbeing negatively "… *let's say somebody will go for real simulation of the physical interaction for example of a robot that stimulate their mom or dad's or partner will be an addiction to it ... it is not going to be good for people not very strong psychologically* …" [P].

Approaching these groups with the help of HCI and product design theories

Finally, understanding these personas and behaviors towards RST can be used in conjunction with some theories in human-computer interactions (HCI) and product design mentioned in Chapter 2 Section 2.8. Based on HCI and product design theories each group mentioned in this section should be approached differently while introducing RST to them. The "Technology Acceptance Model" and the "Innovation Diffusion Theory" do insist on the information used to propagate the knowledge about a new innovative product should be tailored to the targeted user group. The extracted groups in this PhD research do depend on the participants' selection, however, it is still relevant in some way to considered while preparing the methods for introducing RST. Additionally, these theories can be used to understanding these groups further by utilizing them in conducting further research.

4.14 Results and Analysis Chapter Summary

- In the fieldwork, 42 participated in the online diary and 36 in the interview sessions. Most of the participants are undergraduate students between the ages of 17-26.

- One of the findings of the online diary There are four types of reasons behind one's communication with loved ones, "complex communication", "simple communication", "sharing communication", and "one be among others".

- Current communication media have a certain limitation that prevents individuals from establishing a communication when needed such as when technology fails or when unable to know about the other side availability to establish the communication.

- There many physical interactions individuals may miss interacting with their loved ones, some relationships may have few physical interactions other can be common such as a hug or a kiss. Among the participants of this research "Mother" relationship was the most discussed and "Hug" was the most physical interaction missed.

- To understand the importance of social touch among individuals, people can talk about how they feel while engaging in physical interaction and while missing the physical interaction with a loved one. Also, the importance of social touch can be interpreted from the individuals' discussions about the frequency of engaging in physical interaction with the loved one. This approach was used in this research to elicit the importance of social touch.

- The participant of this research discussed some perceived benefit from RST related to emotional wellbeing, connectedness, and enhancing current communications media,

- The participant of this research discussed some perceived concerns from RST related to negatively impacting emotional wellbeing, the impact on real-life physical interaction, and concerns about the communication or product itself. The most common keywords mentioned related to this issue are privacy, safety, devalue the real physical interaction, not able to move on, not tending to the real person, not authentic, and emotional concerns.

- The participant of this research discussed some perceived usage scenarios from RST related to emotional, motivational, support, daily general messaging, and other various scenarios.

- In relation to the cycle of RST, the participant discussed how they would be sending, receiving, and reply touch message. Some physical interactions (PI)s only receiving some only sending. Also, the reply will depend on the direction (from which relationship to another) and/or the kind of PI. The meaning of the same PI could be different between the relationship depending on who will send it and who will receive it. Additionally, one would reply to a PI with the same PI received or replying with a different PI from the PI received or even with a different sensor modality. Remote social touch (RST) characteristics are driven based on context, mood, and usual physical touch behavior among individuals. Also, a participant could pick feedback close to how the real PI usually feels. individuals may incline to choose something more toward a realistic manner to social touch to communicate the physical touch within the cycle of communication.

- In this research saving touch is considered as a frequency of emotional event that can impact emotions. Most of the participant wanted to save a physical interaction message in contrast with few did not. however, participants of this research discussed some concerns with saving the message such as devaluing of the physical interaction, impact on the other person, emotional concerns, and concerns related to ethics and privacy. Moreover, most of the participants did not want to manipulate the saved message because the meaning and the

value of the message could be lost and the altered message could feel unnatural. Also, participants discussed attaching other sensor modalities to the saved touch message.

- RST products can have various characteristics such as being a one-part product, wearable, attachable, decorative. However, there are a few characteristics that were commonly discussed by the participants of this research there are wearable, attachable, portable, and accessory-like. To interact with such a product one can either use a simulated way of interaction, using the essence of physical interaction or using a familiar way of interaction with current electronic gadgets. Additionally, the placement of a product on the body can be similar to where an actual physical interaction is felt on the body if the intended use to similarly feels and send a physical interaction. However, if a symbolic way was intended for the use of RST product a more familiar location on the body with the current electronic gadget can be used such as a wrist.

CHAPTER 5

PROPOSED REMOTE SOCIAL TOUCH FRAMEWORK

5.1 Introduction

Researching and designing Remote Social Touch (RST) is a complex task due to many elements involved in the RST experience. This Chapter describes the early framework proposed to guide a novice RST researcher and/or designer around the RST related issues. The framework highlights several important considerations that should be taken into account when researching or designing RST, (e.g. the actors involved in the communication, the product, and the nature of communication), and provides a formalized and comprehensive background including the process and the principles of RST.

Researchers can use it as a reference to generate research materials and to bring into focus various considerations, for example, highlight the emotional impact of a certain way to deliver the physical interaction (PI) remotely. Researchers may use the framework to investigate a specific dimension of touch such as 'the duration of touch impact on users' emotional wellbeing'. Designers could also use the framework to bring into focus certain considerations, such as the PI message concerning certain PI, user group, and relationship.

This chapter sum the results from the literature survey, the online diary, and the interviews into the early proposed remote social touch formwork. The chapter is going to explains the framework based on the results noted in Chapter 4 and in addition to what was explained earlier in Chapter 3.5 -initial remote social touch framework-. The following sections explain the proposed framework in further detail, the explanation is divided by each of the three main elements of the framework: "Actor", "Product", and "Communication".

5.2 The Basic Layout of The Proposed Remote Social Touch Framework

The first iteration "Version 1" of the proposed RST framework (Chapter 3 Section 3.5) developed after surveying literature related to communication, remote communication, social touch, models, and frameworks. In this section, the second iteration "Version 2" is going to be explained. The second iteration combines the results and the discussion presented in Chapter 4 with the first iteration of the framework (Chapter 3 Section 3.5). Figure 5.1 illustrates the main elements and their dimensions taken into account of the proposed Remote Social Touch framework. Also, Figure 5.2 shows the process for remote social touch communication with the relevant main elements and dimensions of the framework, refer to appendix N for higher resolution.

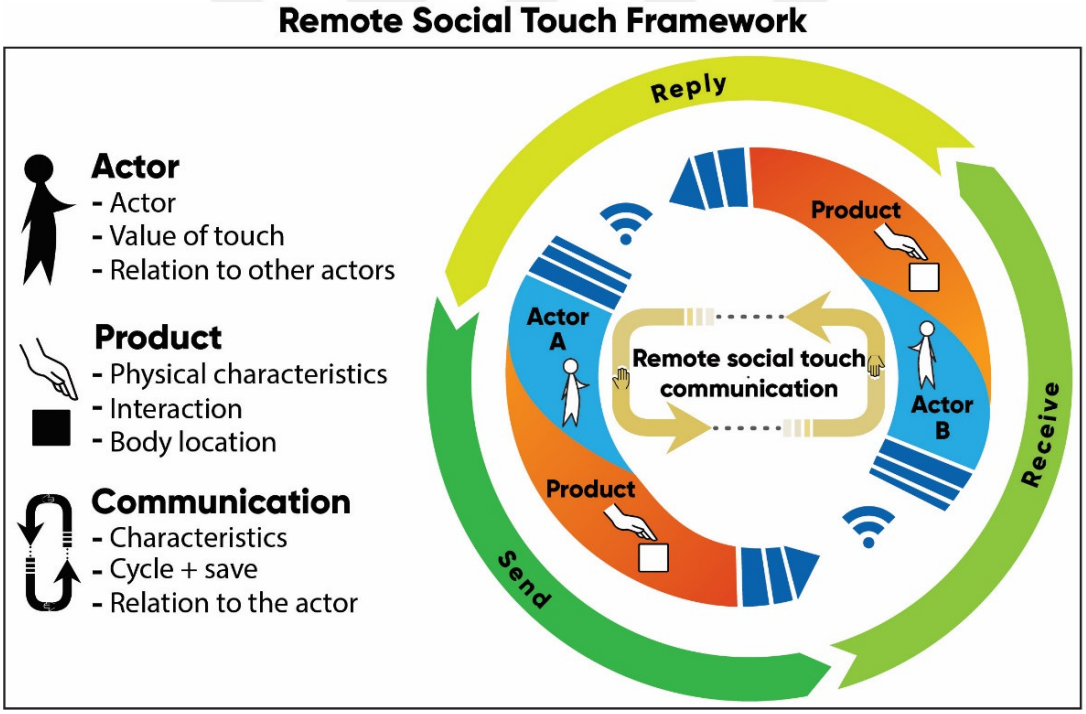


Figure 5.1. The proposed Remote Social Touch framework

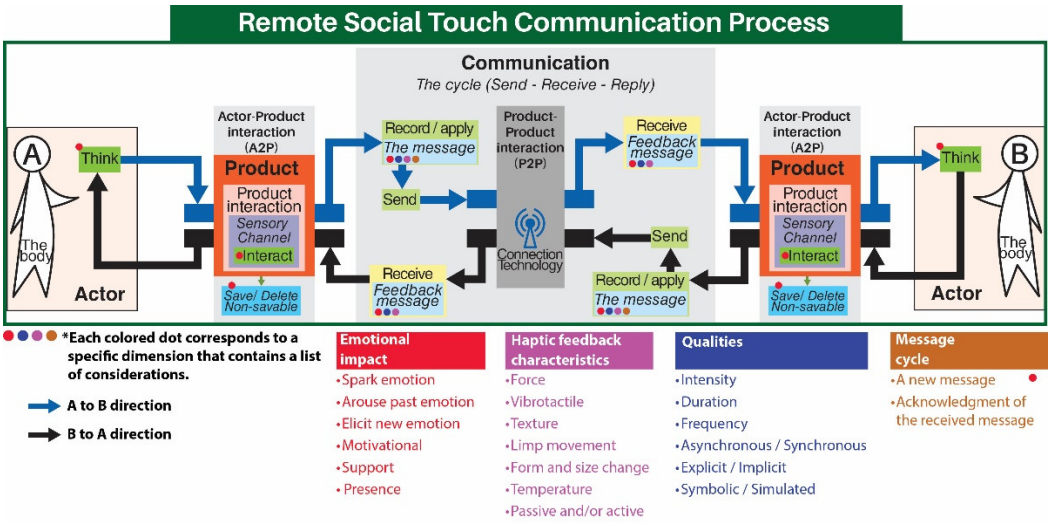


Figure 5.2. Remote social touch communication process, refer to appendix O for higher resolution.

Remote social touch (RST) in this framework is realized through a cycle of communication back and forth between the actors. The cycle can be described as follows:

Sending a message from A to B;

- B receives A's message; and, B replies to A's message;
- then, A receives B's message, and A replies to B's message.

Such a cycle would continue unless one of the actors decides not to send or reply to a message. Table 5.1 lists the various dimensions related to each element of the cycle and it is complementary to the RST framework illustrated in Figure 5.1 and Figure 5.2.

Table 5.1 Remote social touch elements and dimensions

Remote social touch communication			
Elements	**Dimensions**		
	Main considerations	**Sub-considerations**	**Details**
Actor	Actor type	Human *	
		Robot *	
		Pet *+	
		Digital virtual avatar *	
	Value of touch	Emotional reaction to touch *+	
		Frequency engaging social touch +	
		Type of touch-persona *+	[Touch avoider /Touch deprived / Touch-neutral]
	Relation to other actors	Relationship *+	[Kind /power]
		Gender *	
		Age *	
		Cultural background *	
		Type of social touch exchanged *+	
Product	Physical characteristics	Single / Multi-parts +	
		Characteristics +	
		User's ownership of it +	[Customization /Creativity /Personality]
		Visible / Hidden +	
		Materials use *+	
		Symbolic meaning to the Actor +	
	Interaction type	Simulated *	
		Symbolic *	
		Other means +	
		Gesture style +	
		Familiarity +	
	Location on the body	Product location +	
		Haptic feedback location +	
		Physical interaction location +	

Table 5.1 (continued)

Communication	Characteristics	Haptic feedback characteristics *	[e.g. force, vibrotactile,...]
		Haptic feedback qualities *	[Intensity /Duration /Frequency]
		Communication qualities *	[Symbolic /Simulated and Asynchronous and Synchronous /Explicit and Implicit]
		Direction of the message *	[one-to-one /Many-to-one /One-to-many]
		Sensory Channel *	[Visual /Auditory /Haptics /Olfactory /Gustatory]
		Notification +	
		Warning message +	
		Relation to current media +	[Combine /Replace /Enhance /Familiarity /Access /Commonality]
	Cycle	Send / Receive	Emotional impact *+
			Communication qualities *
			Haptic feedback characteristics *
		Reply	Type of reply [similar physical interaction /different physical interaction /other sensory modalities] +
			Urgency [immediate /soon /when available] +
			Control over it [by the receiver or the product i.e. auto replies] +
		Save	Ethical concerns +
			Emotional impact +
			Manipulation +
			Multisensorial +
		Message	Kind of message [Complex /Simple /Sharing /Be among other] +
			Relationship power [e.g. Mother-child] +
			Direction send-receive (Person A to Person B / B to A) [Meaning change /Only send / Only receive / both] +
			Message characteristics *
			Manipulation +
			Situation and context *+
	Relation to actor	Reason to use +	
		Positive impact *+	on Person A / on Person B / on AB relationship
		Negative impact *+	on Person A / on Person B / on AB relationship
		Ethics *+	[Consent /Privacy /Ownership /Safety]
		Private / public +	[Product appearance /Simulated or Symbolic /Commonality /The physical interaction /The context]
		Temporality +	[Frequency to interact with the product /Frequency to send receive]
		Emotional impact *+	[Spark emotion /Arouse past emotion /Elicit new emotion /Motivational /Support /Presence]

Every "*" star symbol on the sub-considerations and the details columns mean it was extracted from literature, and "+" plus symbol means it resulted from the present research.

5.3 'Actor' in the Remote Social Touch Framework

This element "Actor" in this proposed remote social touch framework is the initiator(s) of the communication and the receiver(s) involved. This element consists of certain dimensions as presented in Table 5.2 which this section going to discuss.

Table 5.2 'Actor' element of RST framework and its dimensions

Actor type	Human *	
	Robot *	
	Pet *+	
	Digital virtual avatar *	
Value of touch	Emotional reaction to touch *+	
	Frequency engaging social touch +	
	Type of touch-persona *+	[Touch avoider /Touch deprived / Touch-neutral]
Relation to other actors	Relationship *+	[Kind /power]
	Gender *	
	Age *	
	Cultural background *	
	Type of social touch exchanged *+	

Every "*" star symbol on the sub-considerations and the details columns mean it was extracted from literature, and "+" plus symbol means it resulted from the present research.

5.3.1 The Actor

The actor in RST is the main catalyst for communication. In this research human to human communication was the focus, however other kinds of actors could also be engaged in such communication. Therefore, the actor can be a human, a digital virtual avatar, a robot, or even a pet. For example, human-robot interaction research focuses on eliciting affective responses in humans and encouraging affective communication with humans. Jewitt et al. (2020) classify interaction as i) robot-initiated, such as a robot caring for a human (Mukai et al., 2010) (Figure 5.3a); ii) human-initiated, such as a human stroking a pet robot (Yohanan & MacLean, 2012) (Figure 5.3b); or iii) cooperative touch, a human and a robot are engaged in a physical contact (e.g. shaking hands (Shiomi et al., 2006) (Figure 5.3c)).

Figure 5.3. a. Nursing robot by Mukai et al. (2010, p. 6001), b. Pet robot by Yohanan and MacLean (2012, p. 168), and c. Shaking hand with a robot (Shiomi et al., 2006, p. 308)

In such an interaction scenario with robots, robots should be able to convey emotions and interpret emotions through touch, i.e. understand the meaning behind the touch (Jewitt et al., 2020). Empathic communication is an important factor to motivate human engagement with digital agents and robots (social agents), and touch can mediate empathy (Van Erp & Toet, 2015). Engaging with a robot through touch can have an impact on wellbeing as it can help to reduce stress and depression while for example stroking, petting, and hugging a pet robot (Yohanan & MacLean, 2011). the actor can be also a digital agent, in this way human-digital agent can interact through touch. This can add an extra layer of human-likeness to achieve an interaction experience that closely resembles human-to-human interaction (Hoppe et al., 2020). For example, while a person is using virtual reality applications, stimulating the touch sense by virtual agents could increase the feeling of co-presence with the virtual agent (Ahmed et al., 2016).

Similarly, the participants of this research also mentioned such scenarios, where remote social touch could be used for example with their pet. For example, one participant while talking about saving the touch message through remote social touch, mentioned saving a pet touch *"... I don't have a pet right now but if I had a pet then my pet like a puppy..."* (P35). The actors outside humans were not within the scope of this research, however, the proposed framework opens up a potential route for further research through which other actors can engage with humans.

5.3.2 The Value of The Touch

Value of touch may vary among individuals living away from their loved ones, and some may miss social touch more than others. In this research, some of the findings from the online diary are

i) More than half of the entries indicated missing touch from ones a week to the whole week,

ii) Only 5 out of 42 participants mentioned that they did not miss touch at all (refer to chapter 4.6 for further detail), and

iii) Some indicated that they feel sad, frustrated, or try to "hide the emotions" when not able to receive touch.

Additionally, some of the findings from the interview sessions, when talking about physical interaction with a "mother" relationship, while engaging in a hug action with a mother, participants talked about happiness, joy, warmth, satisfaction, and comfort. On the other hand, the participants talked about sadness, and that they felt bothered, and lonely when they were not able to access a mother hug (refer to chapter 4.6.1 for further details).

People using a RST product may represent different personas on the basis of their relation with 'touch', accordingly, they could be i) touch avoiders - individuals who rather stay away from engaging in social touch (Johansson, 2013), ii) touch-deprivers

- individuals who need, want, or interested in a social touch but they lack physical contact for some reason, refer to Tiffany Field (2014, p. chapter 4) for additional detail about this touch type group, or iii) touch-neutral - an individual who does not restrain from social touch and receive enough physical contact.

5.3.3 Relation to Other Actors

There are certain dimensions concerning the actors invalided in RST, these are the relationship, gender, age, cultural background, and the type of social touch exchanged. In this research, one of the findings that impact the exchange of physical interaction messages in RST is relationship power (e.g. mother-child), and the direction sending (from what relationship to what relationship) can change the meaning or the content of the message. For example, a patting on the shoulder message from a parent to a child can mean "well done", however, a similar message sent from a child to a parent can mean "do not be sad", or a child send "kissing hand" physical interaction to a parent but the parent will not send a similar message.

The type of social touch exchanged in RST is related to the relationship among the actors. The physical interaction message can be dependent on the missed physical interaction one needs from the other side of the RST communication. Missed physical interaction can be a usual kind of social touch (e.g. a hug) or specific to a relationship (e.g. sleeping on mother's lap), also some relationships can have a few diverse missed physical interactions. The message content can depend on the context and situation where the messaging is undertaken. Each message has its technical characteristics that depend on haptic feedback characteristics, the feedback qualities, the communication characteristics, and whether the message is the first time or is a reply to a previously sent message. All in all, the message itself has an emotional impact on the actors.

5.4 The Product in Remote Social Touch

This element "Product" in this proposed remote social touch framework is the object that the initiator(s) interact with to establish or receive the communication. This element consists of certain dimensions as presented in Table 5.3 which this section going to discuss.

Table 5.3 "Product" element of RST framework and its dimensions

Physical characteristics	Single / Multi-parts +	
	Characteristics +	
	User's ownership of it +	[Customization /Creativity /Personality]
	Visible / Hidden +	
	Materials use *+	
	Symbolic meaning to the Actor +	
Interaction type	Simulated *	
	Symbolic *	
	Other means +	
	Gesture style +	
	Familiarity +	
Location on the body	Product location +	
	Haptic feedback location +	
	Physical interaction location +	

Every "*" star symbol on the sub-considerations and the details columns mean it was extracted from literature, and "+" plus symbol means it resulted from the present research.

5.4.1 Characteristics of A Remote Social Touch Product

In this research, various characteristics of RST are explored to understand the preferences for future RST users. Based on the findings, an RST product can be a one-piece object or consist of multiple parts, for instance, the sending part can be separate from the receiving part. PI messages can be saved/stored digitally somewhere (e.g. in the cloud) or stored on a separate physical object in a safe place. As the results of the research pointed out, a preferred RST product should have certain characteristics some of which are commonly desirable including wearable, portable, attachable, decorative, fashionable, and familiar. Some characteristics may not be so commonly desired such as, entertaining, and transformable (e.g. the shape

could change, or transform from being wearable to non-wearable depending on the usage scenario). Moreover, the private and intimate nature of the social touch can be translated into RST products as being unnoticeable, hidden, and not attention-seeking features that would be more preferable among RST users.

The material that the product is made of is important to consider especially if the product involves users' touch-based interaction to send a message. Materials are known to evoke certain emotions (positive or negative) that is by itself a wide research field (Karana et al., 2015). Touching a product can arise certain affect, the material could impact jugging the product and may/may not provide a positive experience (Crippa et al., 2012; Peck & Childers, 2003). For example, soft texture like animal fur could be inviting to touch or hug.

Additionally, the product can either be attached to an object that carries a symbolic value to the users (e.g. a ring gifted from the loved one), or the product itself can carry a symbolic value to the users especially if personalization and customization are applied to the product. For example, a product can be gifted with the recorded physical interaction message to the loved one on a special occasion such as a birthday.

Certain things may help users to feel ownership over the RST product. For example, being able to customize and/or personalize the haptic feedback characteristics or the appearance of the product. The design of RST product can influence its usage and the use of the product can influence its design. For example, if the product is small and portable, allowing on-the-go communication, individuals may use it more often and publicly. In the opposite scenario, individuals may prefer to use it in a more private place, which will affect their daily communication ritual.

Designing a product for RST also echoes the philosophy behind Pieter Desmet and Pohlmeyer (2013) positive design formwork. Positive design is “intend to increase people’s subjective well-being and, hence, increase an enduring appreciation of their lives” (Pieter Desmet & Pohlmeyer, 2013, p. 7). Their framework consists of design

for pleasure, design for personal significance, and design for virtue. A remote social touch product could induce positive affect and reduce negative affect, this approach is associated with improving wellbeing hence a positive design approach as proposed by Pieter Desmet and Pohlmeyer (2013).

5.4.2 Interaction with a Remote Social Touch Product

Interacting with the RST product to send a message can be through a simulated or symbolic way (Figure 5.4). Simulated interaction is performing the exact physical interaction to send the message, for example hugging the air or an object to send a hug (Figure 5.4a). Symbolic interaction can be achieved by: i) a familiar gesture to a current electronic gadget, such as swipe (Figure 5.4b1); ii) a close proximate to the essence of the physical interaction intended to be sent such as squeezing for sending a hug (i.e. hug has squeezing action) (Figure 5.4b2); and iii) through other means, such as texting or the product can understand the user's thoughts (Figure 5.4b3).

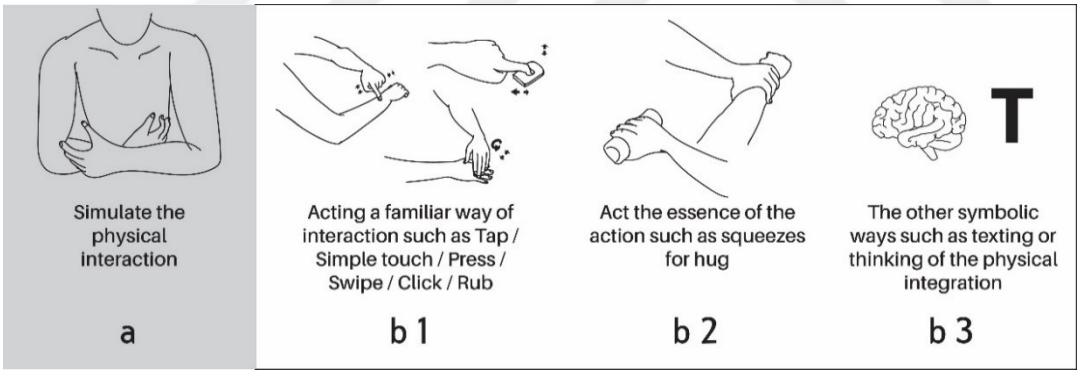


Figure 5.4. Four different interaction styles resulted from this research interview sessions

The proposed RST framework suggests two types of interaction: i) actor-to-product, and ii) product-to-product. Actor-to-product interaction may involve various dimensions as explained by this chapter. Product-to-product interaction refers to the technology behind connecting the RST products together, such as the internet, Bluetooth, or any technology concerns with connectivity. However, two main considerations related to connectivity are i) availability and ii) reliability to provide

RST communication when the user needs it, this is can be considered as factors to reduce the failure of the RST communication.

5.4.3 Body Location of a Remote Social Touch Product

Concerning the body of the user, three main considerations are relevant to remote social touch: i) the product location on the body (whether it is wearable or attachable to the body, such as a product worn on the wrist), ii) the haptic feedback location in the location where the user will feel the touch message such feeling a hug on the upper body location, and iii) the physical interaction body location such as shaking hands includes the hands or the kiss include the lips. In a social touch context, there are non-vulnerable body parts (NVBP) and vulnerable body parts (VBP) (Jones & Yarbrough, 1985), this can be translated to remote social touch especially when relationship, gender, and age are taken into consideration while communicating touch remotely. One of the findings of this research is that the body location where a product can be located is almost identical to the locations where individuals want to feel the haptic feedback, especially if it was a simulated messaging. However, for symbolic messaging a more familiar body location utilized by current technology (e.g. smartwatch) could be preferred such as on the wrist.

As an example, communicating a mother's hug remotely (see Figure 5.5 and Figure 5.6) show that the body location chosen by the participants are related to the locations that the participants choose to feel the real hug. In the case of a mother's hug, the hug action is more related to the upper body location, mostly around the arm-shoulder and chest, and the locations are almost similar to where the real physical interaction does happen. The results show that forearm, wrist, and hands chosen for symbolic messaging, this is could be due to the familiarity with wearable technology such as smartwatches and other accessories worn on the hands. Shoulder and the chest locations are chosen to resample the real location for the hug to send or restive mother's hug. Additionally, the product could separate the message sending part from the message receiving part thus the body location of the product could be

separated. For example, a product for a hug can be on the upper body location however feeling the received message can be only on the lower back of the users but the physical interaction can be sent through touching the shoulders.

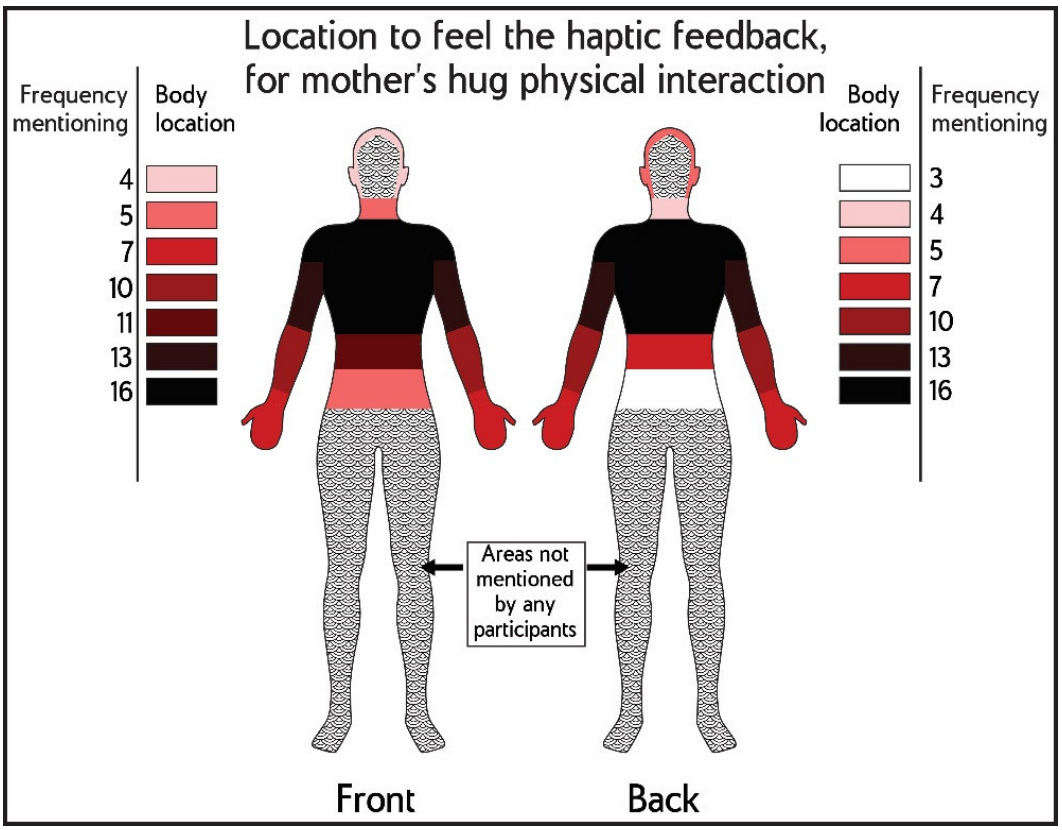


Figure 5.5. Mother's hug: haptic feedback body location, refer to Chapter 4 Section 4.12.4 for further details

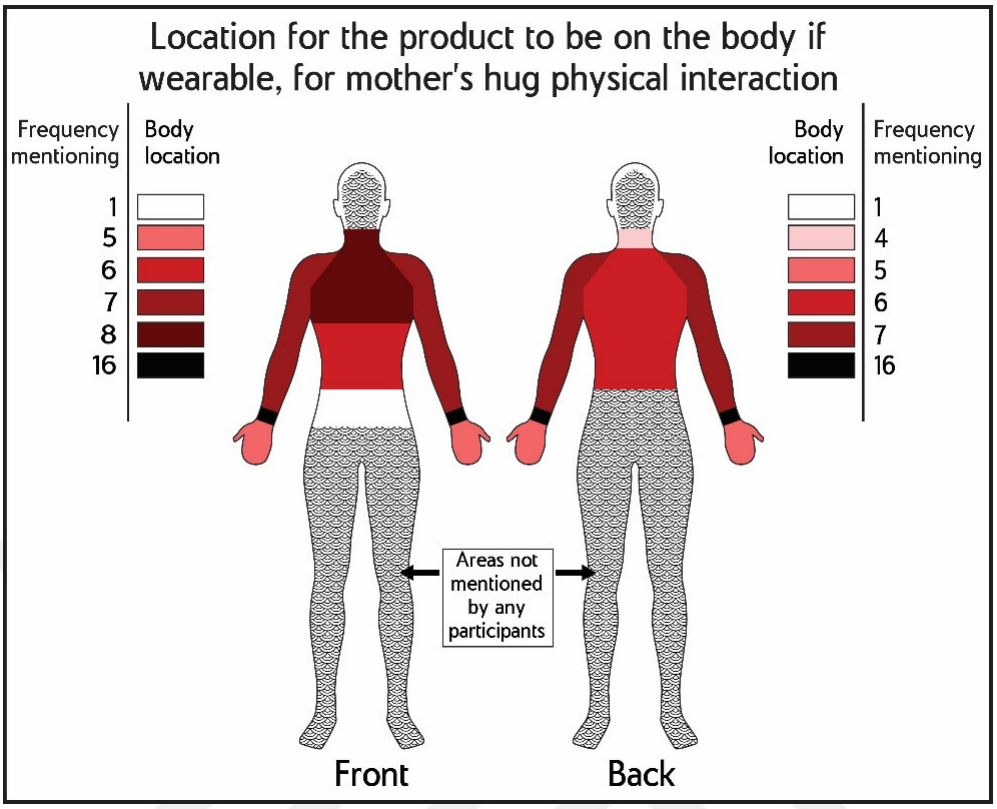


Figure 5.6. Mother's hug: product placement body location, refer to Chapter 4 Section 4.12.4 for further details

5.5 The Communication in Remote Social Touch

The element "Communication" in this proposed remote social touch framework highlights certain dimensions related to sending or receiving a touch message among the actors. Table 5.4 present these dimensions which this section going to discuss.

Table 5.4 “Communication” element of RST framework and its dimensions

Characteristics	Haptic feedback characteristics *	[e.g. force, vibrotactile,...]
	Haptic feedback qualities *	[Intensity /Duration /Frequency]
	Communication qualities *	[Symbolic /Simulated and Asynchronous and Synchronous /Explicit and Implicit]
	Direction of the message *	[one-to-one /Many-to-one /One-to-many]
	Sensory Channel *	[Visual /Auditory /Haptics /Olfactory /Gustatory]
	Notification +	
	Warning message +	
	Relation to current media +	[Combine /Replace /Enhance /Familiarity /Access /Commonality]
Cycle	Send / Receive	Emotional impact *+
		Communication qualities *
		Haptic feedback characteristics *
	Reply	Type of reply [similar physical interaction /different physical interaction /other sensory modalities] +
		Urgency [immediate /soon /when available] +
		Control over it [by the receiver or the product i.e. auto replies] +
	Save	Ethical concerns +
		Emotional impact +
		Manipulation +
		Multisensorial +
	Message	Kind of message [Complex /Simple /Sharing /Be among other] +
		Relationship power [e.g. Mother-child] +
		Direction send-receive (Person A to Person B / B to A) [Meaning change /Only send / Only receive / both] +
		Message characteristics *
		Manipulation +
		Situation and context *+
Relation to actor	Reason to use +	
	Positive impact *+	on Person A / on Person B / on AB relationship
	Negative impact *+	on Person A / on Person B / on AB relationship
	Ethics *+	[Consent /Privacy /Ownership /Safety]
	Private / public +	[Product appearance /Simulated or Symbolic /Commonality /The physical interaction /The context]
	Temporality +	[Frequency to interact with the product /Frequency to send receive]
	Emotional impact *+	[Spark emotion /Arouse past emotion /Elicit new emotion /Motivational /Support /Presence]

Every “*” star symbol on the sub-considerations and the details columns mean it was extracted from literature, and “+” plus symbol means it resulted from the present research.

5.5.1 Remote Social Touch Communication Characteristics

Communicating social touch remotely has certain characteristics and qualities that may have an impact on the usage scenario, including the meaning intended in the message, and user behavior. The Following explains the main considerations.

- Qualities of communication include *simulated and/or symbolic* (acting out the exact physical interactions 'PI' and/or substitute the PI with code), *synchronous and/or asynchronous* (live link, when one press something the other side feels it immediately and/or record the message then send it, can be saved and reply any time), *implicit and/or explicit* (one will feel the message without the need to interact with the product and/or one need to interact with the product to start feeling the message).

- Qualities of the haptic feedback include the *intensity* of the feedback (e.g. how strong the hug feels), *duration* (how long the hug lasts), and *frequency* (how many hugs does the message contains). Some individuals may prefer certain qualities over others or consider one as more important than the others within the communication.

- Haptic feedback characteristics can include force, vibrotactile, texture, limp movement, form and size change, passive and active, and temperature change. These characteristics depend on the technologies that able to give the sense of touch feedback. Some new technologies may develop in the future specially to fit certain remote social touch (RST) scenarios or other technologies may develop in other fields able to be utilized in RST.

- The direction of the message hence communication can be "one-to-one" (RST only between two actors), "many-to-one", or "one-to-many" directions. However, for the present research, only the "one-to-one" direction was within the scope, thus other directions are not discussed in detail and they require further investigation.

- Social touch is a multisensorial experience, similarly, RST could carry a multisensorial experience. For example, one may want to see and smell her mother while feeling her hug; or a friend may want to hear his friend's laughter while tickling him. For that, RST may include other sensory modalities to complement the touch sense.

- Some features of current communication media can translate to RST communication such as notification (alerting the sender if the message was sent and if the message was opened and felt by the receiver), and warning message (actors can inform each other if one wants to establish a communication with the other before sending a message).

- Individuals also may compare RST communication to current communication media such as video calling or social media. Ease of use, the cost of the medium, the commonality of the medium among peers and loved ones, familiarity with the medium, or ease of access to the medium, are some areas people may use to compare RST to the current communication media. Also, individuals may use RST in conjunction with the current communication media to enhance it instead of replacing it, for example, hugging someone while talking on the phone.

5.5.2 Remote Social Touch Communication

Acknowledgement and frequency. Remote social touch (RST) communication consists of a cycle that promotes acknowledgment and frequency of events (Figure 5.7). *Acknowledgment* gives some reassurance to the sender about the other side of the communication and may allow the communication to continue between the sender and the receiver. *Frequency* in the communication is achieved by i) allowing the communication to continue back and forth, and ii) allowing saving the physical interaction message to be accessed any time as one desires. The frequency that one does encounter an event has a higher chance to impact on emotional wellbeing

(Diener et al., 2009). The cycle of communication consists of sending, receiving, and replying to a message.

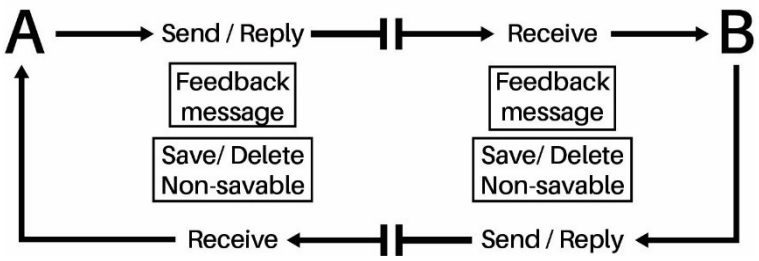


Figure 5.7.The remote social touch communication cycle as found and proposed by this research

Sending, receiving, and replying a touch message. There are certain considerations related to the cycle (Sending, receiving, replying), these are: the emotional impact of the message, communication qualities and characteristics (see Section 5.5.1), and whether the message is new to start a cycle or an acknowledgment to continue the cycle. A reply to a message in the RST cycle can be: i) a similar physical interaction (PI) message as the one sent, ii) different PI, iii) in addition to the PI can contain other sensor modalities, or iv) no PI but only other sensory modalities. For example, if one sends a hug message, the receiver either sends a hug back, a kiss, or just a video message. Also, the urgency in replaying can be divided into an immediate reply, replying as soon as possible, or reply when one available to reply. Replying to the RST message can be either by the receiver taking control over the reply and send something back or the product takes control over the reply such as sending an automatic reply based on a pre-recorded message.

Saving a touch message. With such a concept there are few ethical concerns such as consent, privacy, and the impact on the person whose message was saved. Additionally, saving or deleting a message has its emotional impact on the individuals. The message that is saved can be kept as it is or the user can manipulate it. For example, one can change the duration of a hug message to have it last longer than the original message sent. Moreover, the saved message can be multisensorial

if the user chooses to save other sensory modalities attached to the original message, such as a video or voice of the sender (visual and auditory).

Touch-based messages. “A message” in RST communication can take on various kinds of touch messages. It can be a message that is meant to deliver a physical interaction (PI) such as a hug, or it can be a touch message with no link to a PI such as vibration with the meaning of, for example, “I am thinking of you”. Additionally, there are many reasons why individuals stay in contact with their loved ones which will impact the type of message. RST message can be a simple message to say “Thinking of you”, or it can be used to enhance “complicated”, “sharing”, or “be among other” type of messages by attaching a nonverbal channel (the touch) to it. For example, while one is talking on the phone with her mother, she can feel her mother’s hand stroking her hand (enhance complex type communication), or one can feel the texture of her pet photo sent from her brother as a supplement message (enhance sharing type communication).

5.5.3 Remote Social Touch Communication and The Actor

This section discusses certain issues related to remote social touch communication (RST) with the actor, these are RST messages, ethics, and the use of RST in a private or a public place. These issues are the result of the interview sessions conducted with this research participants. These issues are mentioned in this section due to the lack of mentioning them in literature. The importance of these issues may depend on the context one is researching or design about. However, these issues give general information on considerations that could impact the actors involved in RST communication.

RST messaging. Two main points should be highlighted in relation to messaging in RST, the impact of the message on the actors, and the intended purpose behind the message:

- Messaging in remote social touch communication could impact the actor in certain ways. Messages in RST communication can carry various types of tactile feeling that can be translated to a certain meaning understood only by the actors involved in the communication. The message could resemble a real physical touch (simulated touch, e.g. the feeling of someone's hug), or a very basic tactile message (symbolic touch, e.g. a light vibration). In RST, to send a message, the actor engages physically with an object, not a living thing, e.g. not a human or not a pet. The object is responsible for delivering a message from the living thing, e.g. a human or a pet. However, the received message is not going to give a true experience of real-life social physical touch as if touching a real living thing. In this situation, the actor's imagination should make him/her believe as if they are really engaging physically with the other actor. As a result, this could have a positive or a negative impact on each user and the relationship between the users. Using RST may develop a certain impact on the actual social touch between the users when they meet after being separated, yet an investigation still needs to be done considering this point.
- The intended purpose behind establishing RST communication could also be considered. There are various scenarios for someone to use RST such as, emotional support, motivation, daily ritual messaging, used to enhance audio/video communication, forced separation (e.g. COVID-19 case), rehabilitation, or to feel a loved one presence. Additionally, a designer or a researcher can explore various other reasons or scenarios why one would utilize RST in their daily life.

Ethics. In relation to the ethics of remote social touch there are few points that need to be highlighted:

- The whole experience of RST is initiating a new type of touch that individuals might never felt before. This means that they need to learn i) the meaning behind the touch message, ii) RST social restrictions, and iii) social-cultural (see social

norms, Jewitt et al. (2020) in Chapter 4) surrounding the use of RST among individuals.

- Further investigation should be carried to establishing an understanding of the ethics related to the utilization of RST among individuals. Ethics related to RST are lacking in the literature. Recently, it was brought into focus by Jewitt et al. (2020, p. Chapter 7), similar to present research ethics surfaced through the discussion with the participants. The main concerns amongst the participants were consent, privacy, ownership, and safety:

    - Consent is especially related to saving a physical interaction message from a loved one. The concern from the participants was as follows: would the loved one still wants someone to feel their touch, for example, a wife sent a kiss to her husband, if they are not together anymore would she still want that message saved by her ex-husband? Another issue related to consent is whether the touch message will be made available and reproduced for other people. This issue will push RST into other areas that are not for "pure social communication tool for separated individuals from their loved ones". Areas such as marketing the physical interaction messages can exploit RST for profit similar to current issues with social media companies selling their user data to gain profit.

    - In RST, privacy becomes an issue, for example, if the product fall in the wrong hands, misused, gets hacked, or someone keeps getting annoying touch messages from someone.

    - This brings the concern of ownership of the information delivered through touch messages, - who owns the data? a system, a person, or a company.

    - The safety of the individuals using the RST product is another concern, this could be physical safety or mental safety. For example, will the product bring harm (e.g. physical, psychological wellbeing) if used incorrectly?

Using RST in a private or a public place. engaging in the communication can be either in a private or public place, this depending on product appearance, a simulated or symbolic way of communication, the commonality of the RST among surrounding people, the physical interaction (PI), and the context. For example, a hidden product underneath the cloth can be used publicly especially a symbolic way of interaction was used, alternatively, if the product is big and decorative and one needs to use a simulated way of interaction to send a message (e.g. hug the device) it may be used privately.

5.6 The Proposed RST Framework and Its Positioning

The proposed RST framework can be considered as an early attempt to respond to the shortcomings of previously mentioned frameworks (see Chapter 2, Section 2.7 for more detail) as it aims to incorporate the following dimensions relevant to RST.

- Model for the design of feeling communication and entertainment systems, by Cheok and Zhang (2019). Their model presents a general view of the main interactions (product-user, user-user) involved in a RST communication. The proposed framework by this research adds to Cheok and Zhang (2019) model by highlighting the user-product interaction and its related considerations, for example, the gesture style, and how interacting with a product could evoke emotion and memory. Additionally, some communication qualities that are missed out in Cheok and Zhang (i.e. synchronous and asynchronous communication, implicit and explicit communication) are included in the proposed framework by this research.

- Model of tactile communication by Hertenstein (2002). Their model presents certain qualities and parameters of social touch and the process of touch communication among individuals. In this research, their model is seen as a possible contribution to RST, however, the proposed framework by this research adds to Hertenstein (2002) model by bringing to the attention that the cycle of

communication can affect both sides of the communication. However, In their model, Hertenstein (2002) focuses on the mother-infant relationship and how the behaviors of the infant after being touch by the mother could change the future mother's physical interaction toward the infant. The proposed framework by this research highlights the impact of RST goes bother direction (on the sender and the receiver) as a cycle of communication and not just behavior alteration. There are certain considerations related to the relationship of the individuals involved in the communication, such as the power of the relationship (e.g. mother-child, friend-friend, etc.) and its impact on the communication not mentioned by Hertenstein (2002) model.

- Research and Design Framework for Digital Touch Communication by Jewitt et al. (2020). It can be used for designing the experience, the device, or the system for digital touch communication. Their model focuses on the general experience and the elements involved in the touch such as the social, and the technical aspects. The proposed framework by this research add to Jewitt et al. (2020) framework by highlighting also the emotional dimension of RST interaction which was not mentioned by their framework in conjunction with the technical dimension of RST communication. This research proposed framework point out which dimension of the framework could impact an individual's emotion.

- Framework for designing wearable technology for tactile communication of emotions by Bordegoni et al. (2012). Their framework focuses on designing wearable technology for tactile communication of emotions. The proposed framework by this research adds to Bordegoni et al. (2012) model by emphasizing the various communication characteristics missed out by Bordegoni et al. (2012) that contribute to delivering the physical interaction message. The communication characteristics and the haptic feedback characteristics are important to consider while designing or researching RST as these could influence an individual's usage behaviors and the characteristics could bring to the communication various emotional implication. Additionally, this research

proposed framework highlights the multi-sensorial dimension of the physical interaction in contrast with other frameworks. Multi-sensorial experience should also be considered while designing or researching RST.

5.7 Utilizing the Proposed Remote Social Touch Framework

In general, for a research or design activity the framework can be utilized in two ways:

i) Help with the process of researching or designing remote social touch

The proposed framework can be used while researching remote social touch, especially in the early stages. It can be used to guide a novice RST researcher about various related issues. The framework highlights several important considerations that should be taken into account when researching RST. The proposed framework elements and dimensions provide formalized and comprehensive background including the process and the principles of RST. This can be used to understand RST before starting the research activity or it can be used to start a path to investigate certain issues related to RST. For example, a researcher interested to explore the impact of RST "Asynchronous" way of communication on the individual way of interacting remotely with each other. In this case, the researcher can see all the various elements and dimensions to keep consistent while keeping the way of communication as a variable to study. Additionally, the researcher can use the proposed RST framework as a reference to generate research materials to use while engaging with the participant for the research.

Designers could also use the proposed RST framework while developing products or applications for RST. Designers using the proposed framework can see all the various considerations (elements and dimensions) at once which allows them to focus on certain considerations that suit their design case. The frameworks can be used at the initial stage while designing for RST to allow various stakeholders to understand RST process. Designers can also use the proposed framework to explain

a RST product concept to other stakeholders by pointing out how the product will tackle each of the framework's elements and their dimensions. Additionally, if a designer while designing RST product focusing on a certain user group, the "Actor" in the proposed framework, he or she can manipulate the other elements and dimensions to find what best fit the user group. For example, if the designer considering children user group, the designer can investigate in detail and explore various outcomes related to dimensions such as product physical characteristics or body location. On the other hand, if the designer focusing on individuals in the working environment, the designer can investigate in detail dimensions such as the relation among the actors, the value of touch, and communication characteristics.

As for product design, the framework adds another dimension where a product design activity is not seen as tangible activities but also branch the design activity to think about the human communication with other humans and objects. Moreover, the proposed framework inspires the idea that a product design also can consider the idea of keeping humans connected. The researcher is hoping that when a product designer learns about this framework, the designer starts to think about how to integrate the element connectedness among humans with everyday product design. Such proposed framework allows the product design to brunch to communication design as well, one thinks about how to allow humans to communicate through the products one design.

ii) Evaluate a current RST prototype or product

Another way to use the proposed framework is to be utilized as an evaluation tool. Existing RST products and prototype designers could use the proposed RST framework to check whether they are tackling the necessary RST considerations related to their user groups. Also, they could use the proposed framework to check if they missed certain dimensions while developing RST product that could impact their output product. Additionally, researchers or designers could use the proposed framework to evaluate an existing product for the addition of new features and to check how the new features could fit with the rest of the product functions. However,

the current iteration of the proposed RST framework needs to be investigated for such usage scenarios for evaluating purposes.

5.8 Chapter Concluding remarks

This chapter described and explained the proposed remote social touch framework with its elements and dimensions. The information used to establish the proposed framework was a result of the literature survey, the online diary, and the interview sessions. The main elements that compose the framework are “Actor”, “Product”, and “Communication”. Each element has certain dimensions that a remote social touch (RST) researcher or designer can consider while undertaking on RST research or design. Additionally, this is an early proposed framework that still needs to be utilized in further research to undergo other iteration, however, the current iteration could still be used to explain the process of RST and its related considerations. This chapter can also be treated as instructions about the framework and how to use it. One can read throughout this chapter to gain the initial information related to RST and its working process.

CHAPTER 6

CONCLUSION

6.1 Introduction

Ill mental states that people experience such as depression, sadness, or anxiety while living separately from their loved ones for a long period of time was the motivation for this PhD research. The researcher was motivated to find ways that design can help reducing or relieving the level of ill mental states for people living remotely away from their loved ones. In literature, efforts can be found that investigate various ways to create an emotion-link to regain the awareness missing between the individuals and provide positive emotion. One of the ways available is Remote Social Touch (RST) which this research is aiming to explore further. This is because the touch sense is underutilized in current communication media, is a sense missed while living away from the loved one, and the touch sense is very important for human development and social development. Moreover, The absence of social touch among loved ones may contribute to the development of stress and impact health (Cocksedge et al., 2013; Ditzen et al., 2007), and jeopardize the development of the relationships (Jewitt et al., 2020). Being away reduces social touch experience and replaces it with verbal and/or visual communication which leads to an accumulation of negative affect that results in the aforementioned negative emotional wellbeing. Thus, enabling social touch remotely among separately loved ones can impact emotional wellbeing positively, increases social awareness, and help with communicating discrete emotions such as love or valance emotions such as positively arouse emotions (Eid & Al Osman, 2016; Huisman, 2017).

Drawing from the literature on the importance of social touch in one's wellbeing and the emotional distress individuals feel when living away from their loved ones, this PhD research aim is to investigate ways to communicate social touch physical

interaction remotely through a product. This is to answer this research main question "How can a product facilitate delivering 'social touch' between people who are geographically apart? "Additionally, it is important to understand the process for such communication, thus this research aims to put forth a scheme of the communication process of remote social touch. This research scop is focusing on the remote social touch process of translating physical interactions among separately living individuals for the sake of providing a sense of connectedness. However, the research scope did not include certain topics, such as i) the detailed explanation of the human body as an instrument to deliver the social touch, ii) a detailed discussion about social norms and culture related to RST, iii) a detailed discussion about the multisensorial side of social touch, iv) spatially replicate the existence of a person in a different location but focusing on the sense of connectedness, and v) discussing the various kinds of meaning behind stimulate the touch sense but focusing only on translating a social touch physical interaction (e.g. a hug).

The PhD research process (Figure 6.1) to achieve the research aim started by answering a set of questions (PhD research questions). First, a literature review was carried out in a few related fields and subjects to understand more about this issue this research is tackling. This is helped to collect information about the issues faced by the target user group, social touch, emotional wellbeing, haptic technologies, and current research in RST.

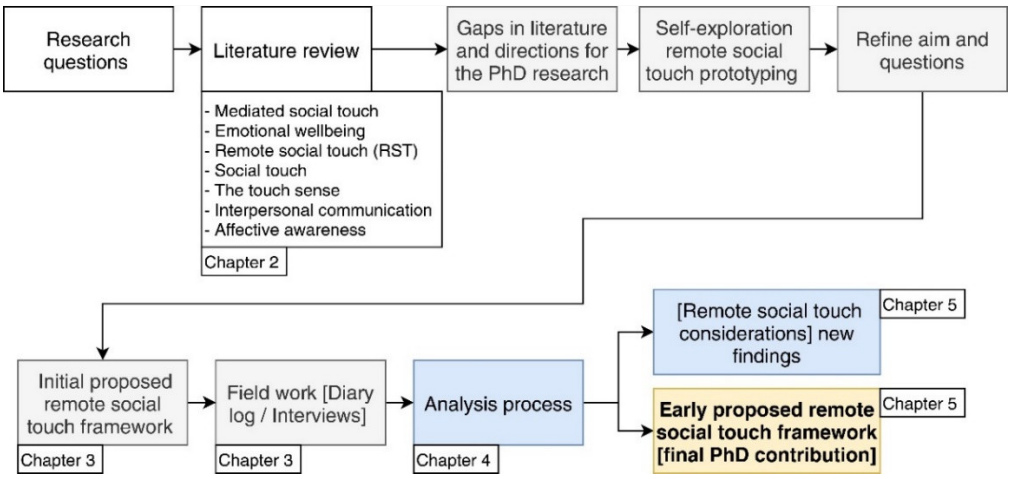


Figure 6.1. The PhD research process

Analyzing and organizing the information from the literature resulted in:

i) Shining the light on certain shortcomings from literature such as do people really miss physical interactions? What is the clear process for transmitting a physical interaction among geographically separated individuals? researching with predefine prototypes and scenarios, not researching the bi-directionality of RST and the asynchronous communication feature of RST.

ii) An initial framework (see Chapter 3 Section 3.5) that encompasses the RST process with the focus on physical interactions and bidirectionality of the communication. As the proposed 'Initial RST Framework' intended to influence the research and the design of RST, it was used to establish the present PhD research process and data collection materials to answers the research questions. This was a step to validate and investigate the initial proposed framework concerning eliciting information related to RST. The RST framework was accompanied by a qualitative research approach in fieldwork to gain information about social touch and remote social touch subjectively from the user's point of view.

To tackle these issues and answer research questions, fieldwork carried out in this PhD research elicited the necessary information. The fieldwork consisted of a 7-days online diary (42 participants) and one-to-one interview sessions (36 participants). The user group participants in the fieldwork are individuals who at the time of the fieldwork living away from their loved ones and mostly university students. The participants of this research discussed issues related to what physical interaction they missed, perceived RST benefits, perceived concerns with RST, RST usage scenarios, information about the RST communication cycle, saving physical interaction, and product characteristics for RST.

After analyzing the resulted data from the fieldwork, the information helped with i) developing the early proposed RST formwork that has three elements with each has certain dimensions, ii) serve as an example of the kind of information could be gain

from the process and material utilized in this PhD research which was developed from the initial proposed RST framework. And iii) to shed some light on issues missed by the previous RST literature.

The information resulted from this PhD research is mainly gained from a qualitative subjective approach from the participants of this research. The participants are a small part of a larger target group of this research. The targeted group by this research are people living away from their loved ones, within that group are the university students, and within that group are the participant of this research. The detailed information resulted from this research represents this nesh group within the context of the research, however, the resulting proposed early RST framework can be further investigated with other user groups and context to understand its relevance to other user groups.

In this chapter, conclusions drawn from the results are highlighted by answering the questions of this PhD research. Then the contributions of this research and the limitation are mentioned. Also, this research revealed few issues not discussed before in literature thus recommendations for future research are highlighted. Finally, a reflection on this research's methods and materials used in the fieldwork are discussed.

6.2 Research Questions Revisited

First revisiting the supporting questions (SQ) then the main question (MQ):

6.2.1 What is the importance of social touch? And What are the most missed physical interactions while living-away from loved ones? (SQ1)

The value of touch

"Social touch" is any kind of physical interaction (e.g. a hug or shaking hand) happening among individuals in a co-located space for any kind of reasons such as greeting or welcoming (Huisman, 2017). It is a need and plays an important role in human development (Tiffany Field, 2014). Touching between people has an impact on emotional and mental wellbeing (Gallace & Spence, 2010). Engaging in social touch relieve stress (Ditzen et al., 2007) and physical discomfort (Huisman, 2017), and maintain and develop relationships (Jewitt et al., 2020). (Jewitt et al., 2020). However, the value of social touch varies among individuals as some may accept it and some may dispraise it. This may also impact how individuals perceive remote social touch. Thus, it was important in this research to investigate the value of social touch for the participants. For that, the online diary and the interviews were used to gain the answer. Analyzing i) how individuals felt about engaging in physical interaction with their loved ones, ii) how they felt about missing the physical interaction with their loved ones, and iii) the frequency of engaging in physical interaction with the loved ones, helped to develop additional information to the importance of social touch.

The online diary indicated most of the participants missed physical interactions, within a week-long at least on average one could miss 2 to 3 times a week. Participants who miss physical interaction felt sad and bored thinking about it and some felt neutral trying to hide their emotions "*it is ok*". Similarly, in the interview,

the participants indicated that while indulging in a physical interaction such as a hug with their loved ones they feel happy, warm, and joyful. For example, a mother's hug gives a feeling of comfort, satisfaction, and safety. However, while being away from a loved one, participants indicated that they were anxious thinking about the physical interaction, lonely, sad, and bothered.

The findings suggest that there can be a link between physical interaction and positive/negative emotional wellbeing. This is obvious by linking the number of times that the participants stated that they missed physical interaction (PI) and the feelings that the participants expressed toward having or missing PI. Another indication of the value of touch can be noticed from asking the participant how frequent he or she engages in social touch with the loved ones, this can show the interest the participant has in social touch.

The combination of three types of information can be important to understand how one values a social touch. These are: i) how many times one misses a physical interaction within a particular time, ii) the feeling about receiving and giving a physical interaction, and iii) in general, the frequency of giving and receiving a physical interaction. The researcher believes this information can be helpful for RST designers to understand the target user group and it can help to prepare the information necessary to introduce RST to the user group. For example, individuals who regard social touch with low value will be approached differently than individuals who have high regard to social touch. Another important information will be also to understand the kind(s) of physical interactions the target user group is missing.

Missed physical interactions

Analyzing the information gained directly by asking the participants in the interview sessions helped to know the physical interaction (PI) individuals miss while being away. In relation to the user group of this research, the research uncovered a wide variety of physical interactions one may miss while living away from a loved one.

One factor that was obvious to impact the kind and quantity of missed PI was the relationship with the loved one.

In this research, the most relationship participants discussed was the "Mother" relationship. Other relationships mentioned are father, best friend, boyfriend, younger sister, younger brother, older brother, niece, husband, and wife. "Mother" had the most missed PI with 14 different missed physical interaction. These are hug, kiss, holding hand, sleeping on mother's lap, patting, tickle, playing with hair, head on the shoulder, sleeping on the arm, physical play, linking arms, eating from the mother's hand, stroking one's body part with an object, and massage. Other missed PI mentioned in relation to other relationships are sitting side by side touching each other, fighting, sex, cuddle, arm around the shoulder, unintentional touch, making things together, fixing loved one's appearance, fixing loved one's facial hair, shaking hands, and hit.

The researcher acknowledges that the participant sampling may have influenced the relationships and missed physical interactions reported in this research. However, the information gained is still valid as it was able to show that individuals do miss specific PIs with loved ones and that these PIs played a role in their relationship with their loved ones. Undergo similar research with a similar user group could uncover similar missed PIs to this research or it could add new ones on top of those mentioned previously. Perhaps a different user group can uncover various other physical interactions one may miss. However, one point to take out of these findings, one needs to first elicit the missed physical interactions of the user group one wanting to research RST or design RST product. This will help to uncover unnoticeable PIs people may need more than other PIs that need special attention from the researcher or the designer.

The information gained related to "the value of touch" and the "type of relationships and physical interactions missed" added to the proposed framework two dimensions in relation to the "Actor" element. This is to show such dimensions are important to consider and pay attention to, especially at the initial stages of RST research or

design. For example, the value of touch and type PI could direct the process for designing of a RST artefact to suit to those, who especially have a vast interest in a specific kind of social touch. Additionally, revealing these two dimensions may help to inspire new technologies to deliver certain missed physical interactions, for example finding a way to render "playing with one's hair" haptic feedback.

6.2.2 How Can These Interactions be Substituted with a Technological Product? (SQ2)

The two terms mentioned in this question need to be clarified: "these interactions" and "technological product". In the previous question [SQ1] "these interactions" described as 'any physical interaction happening among individuals', however, in this one, the focus is more on the social touch, especially the intimate social touch. The research uncovered 25 different physical interactions missed by the individuals. This question was directed at investigating how the physical interactions discovered can be transmitted and substituted with "technological product". Technology can reproduce to a degree the physical interactions, whether it is simple abstract touches or more complex such hug, for an individual who are geographically separated. In this research "technological product" can be identified as any physical object or application that utilizes the technology for stimulating sense of touch, namely "haptic technology". Haptic technologies can: i) sense the touch, and ii) reproduce the sense of touch.

Technology that senses our touch

Touching an object can be detected through certain technologies. Such technologies utilize sensors that can read touch location, duration, and intensity to understand the touch has been applied to it (Huisman, 2017). Many sensors can measure the user's force, grip, touch, and position. Sensors can take various shapes, it can be skin-like, fabric-like, or applied to one's skin. One can incorporate such sensor in remote social touch products to detect a person's touch when is trying to communicate certain

physical interaction and also to help the product to understand what type of gesture one trying to express. Depending on the RST product characteristics these could be manipulated to achieve the desire user experience. However, the placement of such sensors and the way the sensors behave would depend on how individuals like interact with the artefact to communicate physical interactions. This point resulted in the following question [SQ2.2.1] which will be answered later in this Chapter.

Technology that reproduces the sense of touch (stimulating the touch sense)

Reproducing a physical interaction happen through haptic rendering that stimulates one's touch sense. The feeling the technology produces call haptic feedback. Haptic technologies are subdivided into two main categories based on the feedback they provide: 1) tactile such as a display that acts on the skin, and 2) kinaesthetic (proprioception) such as for force feedback (Schneider et al., 2017).

There are various methods to render haptic feedback, the most common one is a vibration which is used broadly in applications for visually impaired people (Pawluk et al., 2015). Other methods to render haptic feedback utilize certain actuators to deliver force feedback such as the use of certain motors to produce force, for example, one can utilize force feedback to reproduce the feeling of being hugged. Warmth and cold (temperature change) also part of the touch sense which can be reproduced by haptic technology to deliver certain temperature associated with certain physical interaction.

Haptic rendering can be done either through direct contact or contactless. In contact haptics, the touch sense receptor will stimulate when in contact, the input and output coincide, thus mutual interactivity between the user and the interface is required. Contactless haptics simulates the touch sense without having direct contact with the body such as using air or ultrasound to deliver force or vibration feedback. Additionally, individuals can make their own language with the haptic feedback "haptic icons" to communicate a certain message.

The various Haptic-render technologies can be arranged in a certain way to deliver the haptic feedback close to how a physical interaction would feel in real life. However, it all depends on the user and how the user wants to feel a certain physical interaction. Some users may want to feel it as close as possible to the physical interaction, e.g. feeling like being hugged. Some others may want to substitute the feeling of the actual physical interaction with a symbolic representation, e.g. a hug represented by for example a vibration sequence instead. Thus, from the point of view of this PhD research, it is important to know first the various characteristics of these technologies, then to introduce them to users so that they can understand how they can replace the physical interactions remotely with these characteristics.

6.2.3 What are the Characteristics of the Technologies that Enable Communicating Physical Interactions between Individuals? (SQ2.1)

The technologies responsible for detecting or rendering a physical interaction have certain characteristics, not only that but, the way that they transmit physical interactions through certain media also have certain characteristics. Initially, the researcher or the designer knowing these characteristics can help to collect suitable information to introduce or design RST for the targeted user group. Moreover, knowing such characteristics could help to link the need of the user in relation to how to feel certain physical interaction with the available haptic technology. These characteristics could impact how the physical interaction messaged carried out, the quality of the message, and the meaning of the message.

Firstly, characteristics related to the technology that represents a social touch or the touch sense are divided into a) haptic feedback qualities and b) haptic feedback characteristics.

- Rendering of the haptic feedback depends on intensity, duration, and frequency qualities. The intensity of the haptic feedback means how strong and pronounce the feedback is (e.g. one will feel a very strong squeeze on the hand). Duration

means how long the feedback one feels (e.g. the squeeze on the hand lasts for 3 minutes). Frequency is how many times each feedback is rendered (e.g. the message contains 3 squeezes feedback rendered on the hand). The participants of this research mostly let the sender have control over these, however, few like to manipulate these qualities depending on mood and it may be an advantage for individuals with touch deprivation and touch avoiders to allow manipulate these qualities. Some people may prefer one feedback quality over other qualities (e.g. intensity over duration).

- Haptic feedback render in a certain way for each message, the characteristics of this feedback are vibrotactile, force, texture, limp movement, form and size change, temperature cold and warm, passive and active, and any technology able to stimulate the human's touch sense. The participants of this research usually pick feedback close to how the real PI usually feels, for example, a hug is associated with force or squeeze.

Secondly, characteristics that are adopted from other communication media are i) simulated or/and symbolic, ii) synchronous or/and asynchronous, and iii) implicit or/and explicit way of interact with the product.

- **Symbolic** such as sending a code (e.g. smartphone vibration). The participants of this research thought it is an easier way to send a message such as "I am thinking of you" and touch avoider maybe prefer it, however, it may not carry the social touch feeling.

- **Simulated** doing or feeling the action (e.g. simulate the hug action while sending or the feeling of being hugged when receiving a message). The participants of this research thought it is similar to the real touch, it feels more personal than a coded message, however, it is robotic, artificial.

- **Synchronous** communication (live communication e.g. phone call) means one can feel the haptic feedback while the other person on the other end is applying it. The participants of this research thought it could be used for physical

interaction that needs to be felt in the moment, it gives the feeling of urgency and the immediate need for attention, it gives the feeling of realism.

- **Asynchronous** (e.g. message), means that one records the touch message then the receiver can feel the haptic feedback of this message anytime later. The participants of this research thought it allows time management, save the message, good for a symbolic way of communications and for gifting a PI, however, it may lose its value

- **Implicit interaction,** one feels the haptic feedback directly without interacting with the product. The participants of this research thought it is similar to the natural way, it provides a surprise element, it allows to feel the interaction immediately.

- **Explicit interaction,** one has to intervene somehow to start feeling the haptic feedback (e.g. pressing a button to start feeling). The participants of this research thought it gives them a choice if they want to feel it or not so it is possible to choose an appropriate time to feel the message and it allows them to avoid mistakes.

All these characteristics, whether they belong to haptic technology or to communication, are responsible for replicating -to a degree- the feel of a physical touch. These characteristics also were dependent on the available (haptic) technologies at the point of this PhD research, hence the characteristics were extracted from the survey carried out in the period of this research. In the future, new technologies may emerge or develop that would point out additional or more advanced characteristics. However, reviewing existing technological possibilities before committing to research/design into RST could help linking users' needs with the technology.

The information gained to answer this question [SQ2.1] helped to develop the initial proposed RST framework by pointing out the main technical considerations that may have an impact on communicating the social touch remotely. The detailed

information is resulted from haptic technology literature and from survey in the available research outputs. The technical information can inform novice RST students, designers, and researcher to form an initial understanding of such technologies. Thus, this could help having a common language with technology experts and other professionals concerning the haptic technology when their expertise is needed.

6.2.4 What are the Characteristics of a Product to Facilitate Remote Social Touch? (SQ2.2)

All the various characteristics related to haptic technology and to communication of Remote Social Touch (RST) answered in the previous question [SQ2.1] fit in a product that facilitate RST. The product can have two types of characteristics, i) the ones related to overall product parts that depend on the communication cycle (send, reply, receive, and save), and ii) the ones that are specific to that product's physical features.

Firstly, the product can be consisting of one part that performs the communication cycle or multiple parts for each part of the cycle (send, reply, receive, and save). Some users may choose to have a one-part product because they already own other electronic products, could be easy to travel with and could be easy to setup. Also, a one-part product may give it a symbolic meaning to the user. However, other users may choose to have a product with multiple parts. This is because one may want to keep the product somewhere but feel the message someplace on one's body, or one may want to keep the messages in one place safe but still able to carry around the communication part.

Secondly, products for RST may have wide varieties of features such as standalone product, attachable, added to a functional product, non-wearable, wearable, portable, accessories-like, clothing based, and decorative. Also, there are few other characteristics mentioned by the participants of this PhD research such as familiarity

with current products (e.g. a wearable product such as a watch), used anytime, integrated with current communication products, and customizable. wearability and portability may allow users to communicate anytime, could be with the person all time, could be better for synchronous communication, and familiar with current wearables products. Attachability also could be on the person all the time, could be attached to an object that has symbolic values to the person, and have the ability to attached from object to another when needed. Additional features such as shape-shifting, transformability, and entertainment are also mentioned by this research participants. Another characteristic that could be important is "not attention seeker product and hidden from other people", this is associated with the private nature of touch; individuals want to indulge in the communication of remote social touch without being noticed by other sounded people.

These product characteristics may be only viable for the participants of this research, however, still, the research uncovered some common themes to already existing research outputs mentioned in the literature. This is to say that these product characteristics could be still discussed by other individuals from different user groups. Nevertheless, RST designer should consider these characteristics and others by conducting an appropriate investigation in relation to the user group in focus. Knowing these characters could help in developing a product close to the popular need. Additionally, knowing these characters will help in picking and manipulate the technology to fit the needed characteristics. Perhaps in the future, there will be new technologies and new product characteristics, however, the data of this research do suggest that "product characteristics" should be considered while developing RST products.

These product characteristics were extracted from the various research outputs available in the literature while conducting this PhD research. They added another element to the initial proposed remote social touch framework, the element of "product". To this element, there are two other dimensions were added that have a tie relation to product characteristics, first the way an individual could interact with

the product, and where the product could situate on the body if it is wearable. Wearability was common among the participant of this research, thus it is important to know where the product will be situated on the user body to feel the haptic feedback and to send a physical message. Thus, the question [SQ2.2.2] "If the Product Is Wearable, Where the Product Would Be Situated on The User's Body?" was put forward for this reason.

6.2.5 How Would the User Interact with the Product? (SQ2.2.1)

The technology that senses our touch may sometimes dominate the way users interact with the product, however, the common technology available and the current research in touch and gesture sensing will allow the technology to be flexible for the product characteristics. In this research, transmitting physical interactions was the driving focus. Therefore, answers to this question are important to build the full understanding of a RST product in conjunction with technology, communication, and product characteristics. Moreover, knowing the way a user may interact with the product to send a physical interaction (interaction style) can help to map out the location of input (on the artefact) which then can be separated from the output (the haptic feedback that has its own characteristics). Additionally, a product designer or human-computer interaction specialist can use such information in developing ways that a product can understand the human behavior and respond accordingly.

Depending on the way of the communication, in a simulated way, users may tend to act out a gesture similar to the physical interaction (PI) action (Figure 6.2a). For example, for a hug, they will act out the hug action either by hugging the object or hugging the air. Acting out the action could dictate certain product characteristics and usage scenarios, for example, the product will be used in private spaces away from others and could be a non-wearable product. Moreover, a user needs to invest the effort to act out the action, this could impact remote social touch communication somehow, for example, impact on the receiver understanding the message by knowing the sender made an effort to send the message.

On the other hand, a symbolic way of communication does not require effort, more private, and could be engaged in private or public surroundings. In a symbolic way, the gestures tend to be not noticeable by others to keep the communication private and intimate, users may tend to:

1. Act the essence of the action, for example, the hug has a squeezing feeling thus the gesture of squeezing acted out, and the kiss action has a pressing feeling or deforming of the lips thus the gesture represents a pressing or putting the fingers in a way similar to the lip (Figure 6.2b1).

2. Acting a familiar way of interaction with current electronic gadgets such as pressing or swapping (Figure 6.2b2).

3. The other symbolic ways to send a PI is by texting the PI, for example, writing a hug to send a hug. Also, just thinking of a PI, for example thinking of a kiss to send a kiss to someone (Figure 6.2b3).

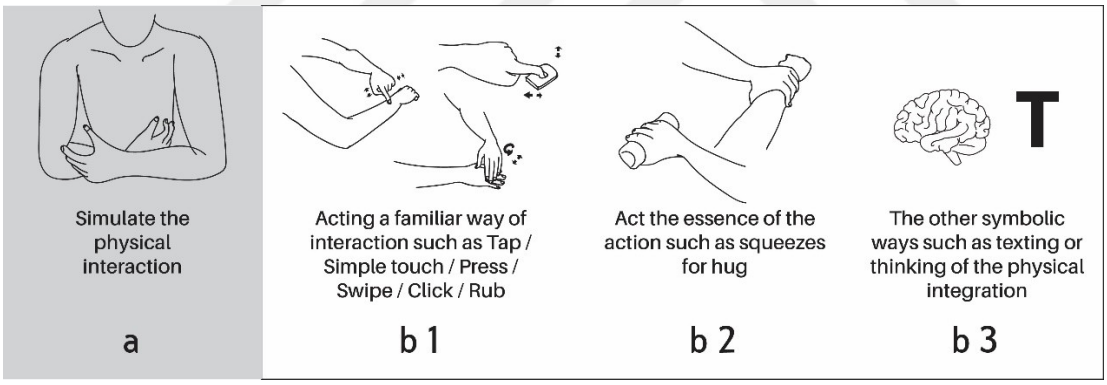


Figure 6.2. Interaction style elicited from participants' interviews

6.2.6 Where the Wearable Product should be Located on the Body? (SQ2.2.2)

As one of the points uncovered in this research, wearability, and attachability (of an artefact) were commonly mentioned by the participants. However, it is also necessary to look at where the product should be located on the user's body to render the received haptic feedback. Individuals may want to communicate certain physical interactions among themselves, whether this would be a factor in determining the location of the product or not is answered within the scope of question [SQ2.2.2]. To find the relevant information about this point, the participants of the research were asked to indicate (by drawing) on a human figure card where a future RST product can be located on the user's body. Following are the main points extracted from the drawings. To understand where a product should be located on user's body it is first important to understand:

i) The user's familiarity with similar products in relation to functionality and characteristics that may dictate where the user likes the product to be worn on the body. For example, if the user is familiar with wearing a smartwatch, then may be more willing to carry RST artefact on a similar place or a nearby position such as the forearm or the wrist. This point was brought up in this research where the participants discussed certain familiar products that they use to explain their needs in a future RST product.

ii) Whether the communication is symbolic or simulated, could also dictate where the product is placed on the body, for example, a symbolic way of communication could allow the product to be on an easily accessed and small area on the body however simulated may require the product to cover a larger surface.

iii) Understand the physical interaction (PI) action and the common place on the body to feel the PI, for example, for the hug the area could be around the shoulder and the chest, and for the kiss the neck and the head. The product

could live on the body almost similar to the areas where individuals want to feel the haptic feedback for the PI especially if it was a simulated way of messaging.

6.2.7 Main Research Question: How Can a Product Facilitate Delivering 'Social Touch' Between People Who Are Geographically Apart? (MQ)

This is the main question asked by this PhD research and was the motivation of this research. The combination of all the answers to the supporting questions [SQ1] [SQ2] helped to reach the conclusion for this question. However, the information relevant to this question was put in a framework proposed by this PhD research. The early proposed remote social touch framework exposes various considerations which able as a whole answer this question.

Firstly, the question focuses on a certain user group, "people who are geographically apart". For this PhD research, it means any individual, who has to live for a certain among of time away from their "loved ones" for a reason such as work, study, etc.. This is because while being away from loved ones a loss of awareness about them could impact emotional wellbeing negatively. One motivation of this research is to a degree try to allow regaining some of the missing "Awareness" through reinforcing the sense of connectedness through one of the available communication media technologies. In this PhD research, the focus is to enhance the sense of connectedness through mediating "social touch" among individuals through certain technologies due to the importance of social touch in our lives and relationships.

Secondly, in this PhD research "Social touch" identifies as any physical interaction individual engaged in such as a hug. However, in this research it is the physical interaction that happens among loved ones "close relationships" is the focus. Such physical interaction can be realized (to a degree) through a digital means through certain technologies "Haptic technologies" that can (digitally) stimulate the touch

sense over a distance. The whole concept and the process for delivering and stimulating the touch sense remotely is what identifies as “Remote social touch” (RST).

Thirdly, the process of delivering social touch remotely could happen through a product. In this research, “the product” in focus is with a tangible property with certain characteristics extracted through the time of conducting this research. However, maybe in the future, a product with non-tangible properties could exist but this point is not the focus of this research. This PhD research investigated various characteristics related to the process of delivering social touch remotely and characteristics related to the product meant for remote social touch. At the end of this research, all the various characteristics mapped into various considerations related to RST.

“Remote social touch” (RST) has certain considerations that should be taken into account while researching RST, or while implementing/designing a new RST product. These considerations are linked with three different elements that co-exist in a RST. These three main elements are “Actor”, “product” and “Communication”. Each element has its dimensions that give further detail on what can be considered or expected from the element.

- The element “actor(s)” in remote social touch is the initiator or the receiver of the physical interaction message. The actor can be a human being, reboot, digital avatar, or a pet. Within the scope of RST, the communication could be one-to-one, one-to-many, or many-to-many. However, the number of actors, certain dimensions should be considered while developing RST products: i) Actor, ii) Value of touch, and iii) Relation to other actors.

- The element “Product” in remote social touch is what contains the RST communication, it could be tangible or not tangible. In this research, the tangible features were investigated, yet it is still possible to take into account the dimensions of this element while developing RST in another format. This

element contains three dimensions, i) physical characteristics, ii) interaction type, and iii) location on the body.

- The element "Communication" in remote social touch exposes certain dimensions in relation to the process of sending, receiving, and saving physical interaction messages. It contains various considerations that should keep in mind while developing RST. The main dimensions are: i) communication characteristics, ii) communication cycle, and iii) the communication in relation to the actor.

The proposed early remote social touch framework illustrates the process for delivering 'Social Touch' between people who are geographically apart which can be utilized by RST researchers and designers. It could be used as a reference to generate research materials and to bring into focus various certain dimensions. Else it can be used to evaluate existing RST prototypes, research outputs, or products to add or remove certain features. In relation to the product design process, the proposed framework can be used in the initial stages to figure out a certain direction for the design by finding the elements or dimensions to focus on more or needed by the targeted user group. Also, the framework can be used in the research stage to develop the research material needed or to know what to use "the information" to approach the targeted user group with. By proposing the early RST framework, it sums the findings of this PhD research and the answers for this research questions.

6.3 Significance and Contributions of this PhD Research

This PhD research aims to contribute to the following:

1. First, adding to the literature about remote social touch (RST). This PhD research shade the light on some issues or areas that are not mentioned or there is a lack in the literature, these are:

- Relationships and PI: this research discovered some relationships missed to physically interact with that there is a lack the discussion about them in literature such as siblings, niece (refer to Chapter 4, Section 4.5 for the full list). Additionally, the most relationship discussed among the participants of this research is mother-son/-daughter relationship which is a rare relationship to find RST literature about. Moreover, most of the missed physical interactions mentioned among the participants of this research not mentioned or tackled before in literature such as patting, linking arm, sleeping on the lap/shoulder/arm (refer to Chapter 4, Section 4.5 for the full list). However, the most discussed physical interaction among the participant is the hug which is very common to finds RST literature about.

- Concerns: This PhD research also uncovered various concerns not discussed before in literature related to RST in general and the saving touch concept. In general, there are various concerns related to the impact on emotional wellbeing, the physical interaction with the other person after an individual is not physically apart anymore, tending to technology more than the real person, and addiction to the technology. In relation to saving the touch concerns discussed are related to emotional wellbeing, not able to move one after death or breakup for example, and consent. Refer to Chapter 4, Section 4.8/4.11.2 for a detailed discussion.

- Ethics came into focus in this PhD research not discussed in RST literature only recently by Jewitt et al. (2020, p. Chapter 7). Ethics discussed by the participants of this research are related to consent, privacy, safety, and ownership.

- Potential Area where RST can serve: one objective of this research is to elicit areas and scenarios from the targeted user where such technology could serve in their lives. This research uncovered various areas and scenarios that RST could serve (refer to Chapter 4, Section 4.9 for the discussion about this point)

- Saving touch concept: one feature of RST is the ability to undergo asynchronous communication which can be saved for later playback to feel the physical interaction message later in life. This PhD research uncovered more about this feature and concept as it was not dissuaded before in literature.

- Potential RST product characteristics: previous RST literature assumes certain characteristics of the product when undergoing a research phase which may lead to limiting the information gained from the users. This can be understandable when researching RST as technology not as a product, however, the product characteristics still vague and not obvious to the future user. Thus, one objective of this PhD research to find out the preferable product characteristics targeted user to like, or at least give hint which features are commonly discussed. For example, in the case of this research, wearability, portability, and attachment were commonly mentioned. Additionally, the research found that there is a link between the kind of communication (simulated/symbolic), usage area (public/ private), and the preferable product. Moreover, this research used a certain method to elicit a potential area on the human body where a product may live on based on user preferences. This helped to understand how individuals may link the product to the type of communication (communicating physical interaction) and link it to currently utilized communication gadgets such as smartwatches/phones and accessories.

- Potential interaction style: this research also elicited various gesture styles to interact with the RST product depending on the physical interaction one wants to send. This can be used directly as interaction style, however, the intended reasons behind eliciting these styles are i) one need to ask the target user before assuming certain style to interact with the product this is because certain physical interaction may require certain interaction style as advent from this research, and ii) understand the background motivation behind

gesturing certain way to replicate the physical interaction for RST. For example, one uses the essence of physical interaction to send it such as squeeze to send hug this is because the hug action has a squeezing feeling to it. Refer to Chapter 4, Section 4.12.3 for a detailed discussion.

- Method and tools: this PhD research showed various ways to tackle eliciting varying information subjectively using certain methods and tools. Future RST research can either utilize similar methods and tools or develop new ones based on the ones used in this research. However, this research illustrated the benefit and the type of information that one can get from combining these tools together which is not commonly combine in such a way in RST literature.

2. Second, enhance or add to other frameworks by proposing an early RST framework that encompasses some previous framework's considerations mentioned in the literature. However, this research identifies new consideration related to RST, these are added together with other previous consideration from literature in an early proposed RST framework.

3. Third, the final contribution of this PhD research is the early RST framework which can help Clarify the RST concept, the principles of RST, and the relation to its various considerations. The framework can assist in researching or designing a product related to RST. This framework highlights three main important elements that should be taken into account when designing or researching RST. This framework can provide a formalized and comprehensive background to identify and consider various issues while designing or researching RST. Researchers and designers may use it to generate research materials and to highlight and bring into focus various RST's dimensions while developing for RST.

6.4 Limitations of the Research

- Self-reporting: One of the limitations of this research is the source of the information used to generate the proposed framework, which was based on self-reporting (of the participants) during the interviews, and online diaries. The responses from the participants were based on the perceived user experience of future technology that the participants had not yet experienced. This may have had an impact on the findings especially in relation to concerns of remote social touch (RST), the way RST can be used, and the areas where RST can be utilized in. As the nature of such a research, which is investigating people's perceived thoughts and impressions about future scenarios, it was necessary to use self-reporting techniques to gain insights about future directions. However, the resulting directions were valuable to gain valuable and relevant information on the research questions.

- The participants: In relation to participant selection, this research and the information gained are related to a certain group of people, university students living away from their loved ones. Thus, the information may differ if this research is made with a different user group. However, the main considerations related to remote social touch (RST) gained from this user group would be still valid s different user groups may propose new considerations for RST or dominant characteristics may shift.

- Cultural dimension: In this research, the participants were from diverse cultural backgrounds and nationalities, however, most of the participants were international students with Middle Eastern and Asian backgrounds. Thus, the degree of the importance (or necessity) of touch, the type of a desired physical touch, being more or less open to engaging in a certain physical interaction may be different for different cultures. The proposed RST framework in this research is not based on a specific culture, but this should be taken into consideration if a research is targeting a specific culture.

- Physical interactions (PI) and relationship: Touching (to someone) and talking about it can inevitably be a sensitive/intimate topic. Therefore, the participants might have purposefully chosen, for example, their mother to talk about rather than for example their boyfriend, girlfriend. Also, may decide to talk about certain physical interaction and over other ones. However, the results are still able to uncover various relationships and physical interaction not mentioned in the literature and add some evidence why certain physical interactions (e.g. hug) are widely common in the literature over other PIs.

- COVID-19 and prototype related: in the mid of the fieldwork COVID-19 pandemic restrictions were implemented which made it impossible and unethical to continue the face-to-face interviews. For that, all the one-to-one sessions moved to be an online interview over skype or zoom. This resulted in participants who join the online interview unable to experiment with the prototype to sense by touch how RST is sent from one digital object and received by another digital object. However, there were no noticeable differences in the quality of the information elicited from the online interviews over the face-to-face interviews.

6.5 Recommendations for Further Research

These are few further research recommendations elicited from the results of this PhD research:

- Testing the framework in design and research activities: related to the proposed early remote social touch (RST) framework, future research can be carried out to test the framework in design activities related to RST product design or researching RST in more focus areas related to its many considerations.

- Investigating the proposed RST framework in relation to the cultural background of the actors involved in the communication. Certain nations or cultures react to social touch differently, thus this proposed RST framework could be studied in various cultural settings. Such study could help to shade some insight into how

remote social touch impacts culture or how culture impact individuals' behavior toward RST.

- The proposed RST framework can also help research areas within i) Artificial Intelligent (AI) based systems to understand social touch and how it can be replicated in digital format, and ii) in virtual reality (VR) systems for gaming and social VR, for example, interacting while stimulating the touch sense with other players and users over VR. The framework can be useful by allowing researchers to focus on elements and dimensions that can serve for their applications and also by introducing various considerations that are intertwined with RST. For example, using the proposed RST process to generate a library for AI systems to learn how to behave similarly to how human behave with other human utilizing the touch sense. AI can learn how each element and dimension may affect the actors involved in the communication.

- The negative effect of remote social touch: There are relatively fewer studies carried out about the negative effects of touch in communication context (Gallace & Spence, 2010), and the present research did not focus on that either. Moreover, participants of this research mentioned some negative outcomes that RST may cause. For example, addiction to replaying/re-feeling of the touch messages, or less caring about the real person and more about the machine/product. Thus, this presents a possible research direction to focus in future studies.

- Touch avoider and RST: Another user group that RST can have an impact on or serve to is "touch avoider", individuals who prefer to stay away from social touch (not liked being touched). Further research can be carried out in this direction to understand more about this user group and whether RST can be directed towards positive implications.

- Physical interactions and relationships: This PhD research uncovered a few physical interactions and type of relationships that are not mentioned or tackled in literature before such as daughter-father, brother-brother, brother-sister, adult-

parents relationships. A further research can focus on one of these relationships and the related missed physical interactions, or focus on one physical interaction and see how technology can help to communicate it.

- Non-intimate remote social touch: this PhD research focused on intimate relationships, however, as future research non-intimate touch and non-intimate relationships can also be potential focus. For example, how remote social touch can alter individuals' behavior who met for the first time remotely? Or perhaps, how RST can be utilized in virtual reality social applications with strangers? In these scenarios RST can be used with non-loved ones, however, further research needs to explore such usage. Additionally, the proposed early RST framework can be helpful to develop such an application by allowing the technology developers to understand the elements and the process for RST.

- Scenarios and areas: This PhD research uncovered various areas and scenarios that RST can be utilized. Future research can be carried out to find out best scenarios that RST can be suitable for integration. Table 6.1 illustrates potential areas and scenarios mentioned by the participants that RST can be further investigated.

Table 6.1 Potential scenarios for the investigation of RST integration

Scenarios to utilize remote social touch (RST) at		
• Elderly retirement houses • Intimate relationship • Parents & children • For general PI e.g. Hug • For habit change • For disabled people	• Children for play • Long-time separation • Medically isolated • Education similar to audiobooks • Military i.e. Privacy • Social rehabilitation	• RST as PI gift • Memory trigger • Remote control things • Cooperative functional work • Space travel • Preventing diseases from spreading

6.6 Reflecting on the Research Methods and Materials Used in the Research

The methods and materials used in this PhD research can be used as they were used to elicit similar information and result as this research or the materials can be used separately depending on what information a researcher or designer wanting to elicit. Below a reflection on some of the methods and materials used in this research.

- Remote social touch eliciting cards: utilizing the cards in the interview believed that they helped to keep the participants focus on the questions related to the card and the cards helped to trigger the response intended from the card. The card helped to provide an easy way for the participant to understand what one needs to talk about without the need to keep reminding or re-asking the question a few times. The cards also served as a focal point while the participants were talking keeping any distraction away, also participants were pointing at the cards while talking. Because of that, some of the questions after the few first interviews moved to be on cards such as Pick-A-Mood characters.

- Human figure: Using the human figures to elicit information on the location of the feedback and the product related to certain physical interactions can be beneficial for future RST research or product design. In this research, it helped to understand the link between where people like to feel certain physical interactions and the area where a product can live on the user's body. However, in future research, sectioning the human figure by body parts with either body part outline or numbers could help in the analysis presider.

- Acting: in this research participants were required to show in a way (acting if possible) how a product can recognize the gesture for sending a physical interaction (i.e. interaction style). The results showed that allowing the user to act out the interaction style can elicit various interaction styles a designer can incorporate in the product especially if the product specializes for one PI and understand participant motivation behind the gesture style. Additionally, a

researcher can use this method to find behaviors of touch related to RST and how it correlates to the actual physical interaction.

- Early low fidelity Working- Prototype: in this PhD research the prototype made in such a way that looks like a tool rather than a finished product, that is important not to limit the imagination of the participants (i.e. fixate on the look and feel of the product instead of the idea trying to deliver). The prototype was made for the reason to make participants understand the principles of remote social touch (RST) and let them feel by touch how RST works. However, due to COVID-19 only half of the participants were able to experience the prototype the other half had to watch a video made by the researcher explaining the prototype. The prototype design helped in delivering the visual explanation because of the noticeable visual change while sending RST message and that is one benefit of not using vibrotactile actuators as it is hard to see the change of vibration in contrast to deformable haptic feedback (i.e. force feedback) that is possible to feel by touch and visually noticeable for online interview application. As most RST literature utilizing prototype in the research stage helped with eliciting information instead of explaining to the participant how the concept work and letting them imagine it.

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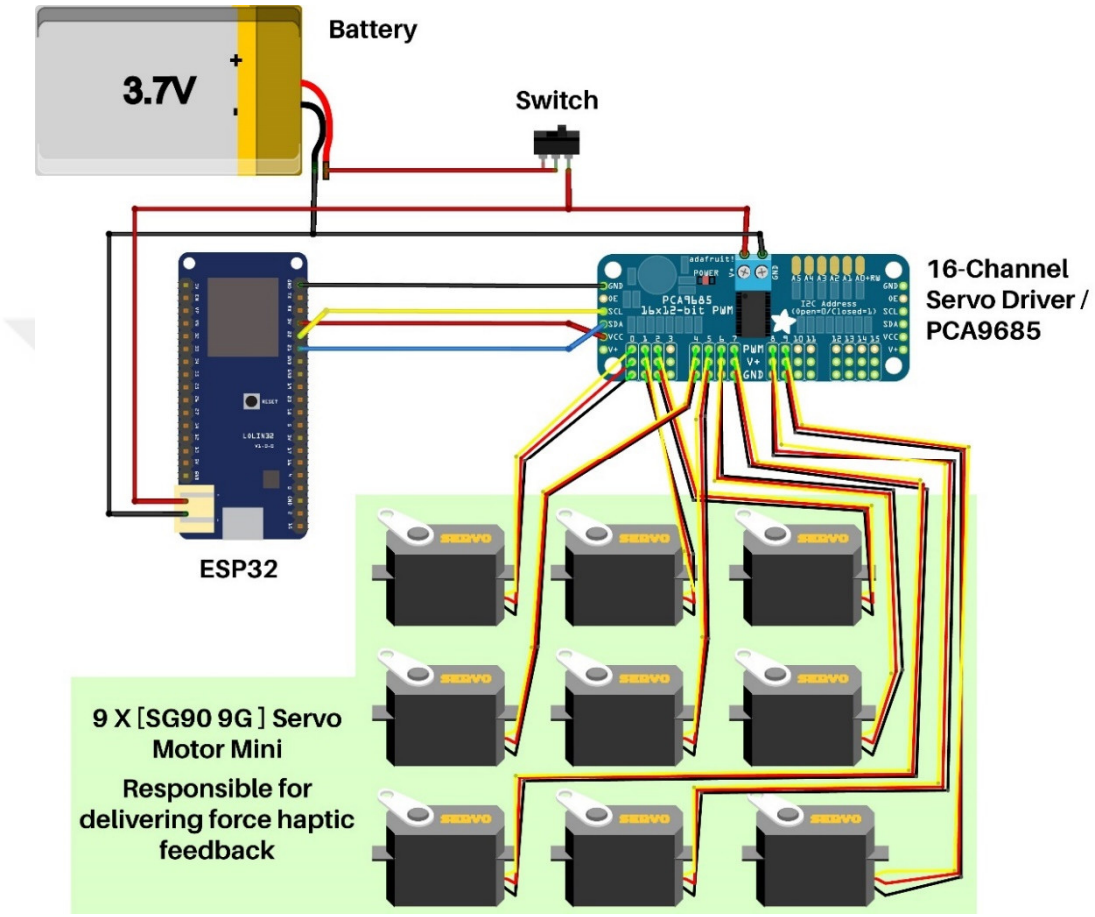
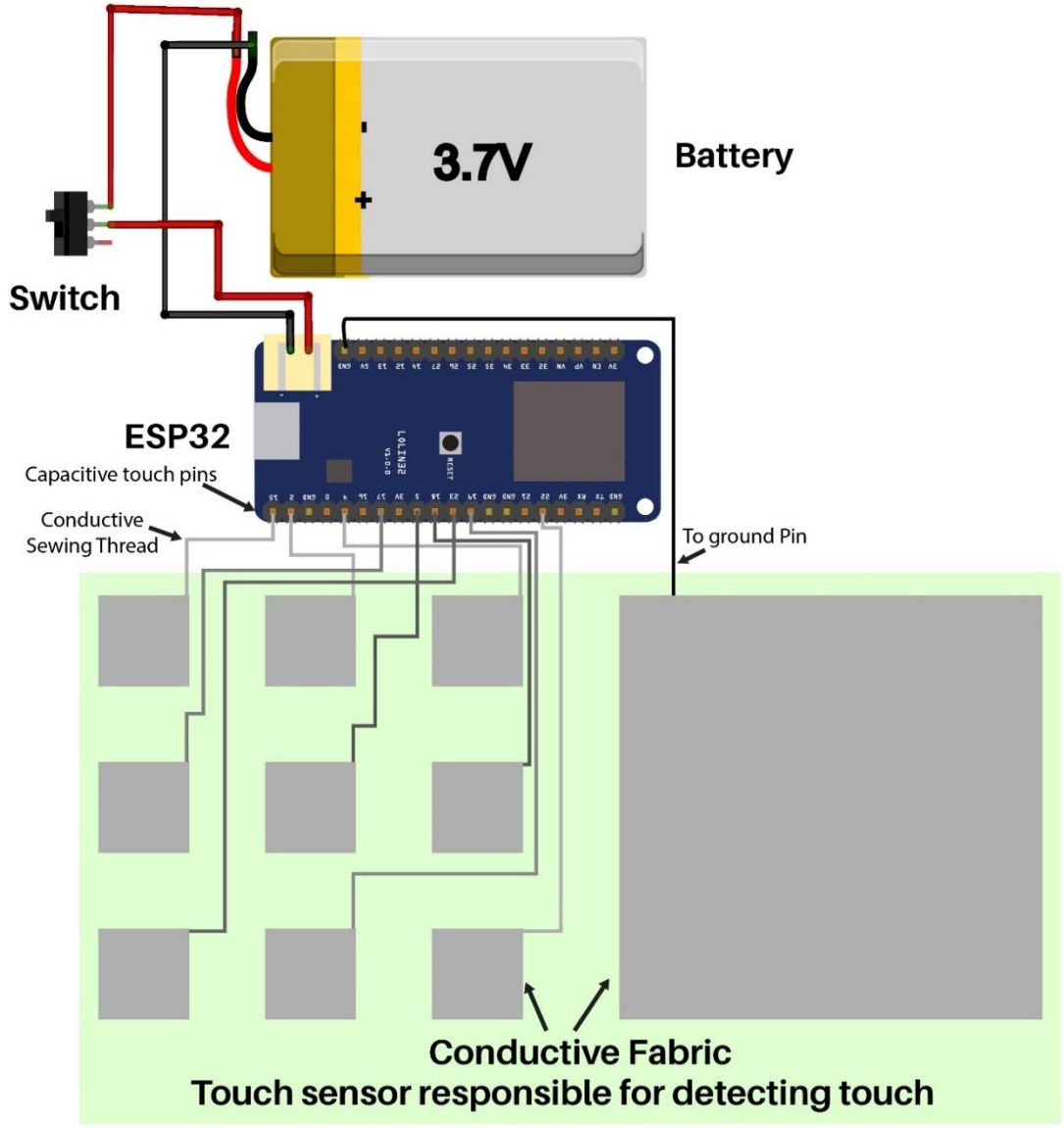
APPENDICES

A. Self-Exploration Prototyping Arduino diagrams



Remote social touch prototype, receiver Arduino diagram, illustrated by the author



Remote social touch prototype, sender Arduino diagram, illustrated by the author

B. Self-Exploration Prototyping Arduino Code

The sender

```
//Libs for espnow and wifi
#include <esp_now.h>
#include <WiFi.h>

//Channel used in the connection
#define CHANNEL 1

int sensorPoints = 9;
int incomingValues[9] = {0,0,0,0,0,0,0,0,0};
uint8_t macSlaves[][6] = {0x3C, 0x71, 0xBF, 0x03, 0x32, 0x54}; // send to a spesific esp32 or
device by MAC adress

void setup() {
  Serial.begin(115200);
  WiFi.disconnect(true);
  delay(10);

  WiFi.mode(WIFI_STA);
  Serial.print("Mac Address in Station: ");
  Serial.println(WiFi.macAddress());
  InitESPNow();
  int slavesCount = sizeof(macSlaves)/6/sizeof(uint8_t);
  for(int i=0; i<slavesCount; i++){
    esp_now_peer_info_t slave;
    slave.channel = CHANNEL;
    slave.encrypt = 0;
    memcpy(slave.peer_addr, macSlaves[i], sizeof(macSlaves[i]));
    esp_now_add_peer(&slave);
  }

//Registers the callback that will give us feedback about the sent data
  //The function that will be executed is called OnDataSent
  esp_now_register_send_cb(OnDataSent);

//  Calls the send function
  Serial.println ("start send");
  send();
}

void InitESPNow() {
  //If the initialization was successful
  if (esp_now_init() == ESP_OK) {
    Serial.println("ESPNow Init Success");
  }
  //If there was an error
  else {
    Serial.println("ESPNow Init Failed");
    ESP.restart();
  }
}
```

```
void send(){
  int TVR = 9; // how many sensor input
  int CR = 5; // how many raws to fill
  uint8_t values [TVR] = {0,0,0,0,0,0,0,0,0};

  long fillArray [CR][TVR]={
      {0,0,0,0,0,0,0,0,0},
      {0,0,0,0,0,0,0,0,0},
      {0,0,0,0,0,0,0,0,0},
      {0,0,0,0,0,0,0,0,0},
      {0,0,0,0,0,0,0,0,0}
    };

  for (int i=0; i<CR; i++){
      fillArray [i][0] = touchRead(T0);
      fillArray [i][1] = touchRead(T2);
      fillArray [i][2] = touchRead(T3);
      fillArray [i][3] = touchRead(T4);
      fillArray [i][4] = touchRead(T5);
      fillArray [i][5] = touchRead(T6);
      fillArray [i][6] = touchRead(T7);
      fillArray [i][7] = touchRead(T8);
      fillArray [i][8] = touchRead(T9);
  }

  for (int j=0; j<TVR; j++){
    for (int i=0; i<CR; i++){
      if (fillArray [0][j] < 10 && fillArray [1][j] < 10 && fillArray [2][j] < 10 && fillArray [3][j]
< 10 && fillArray [4][j] < 10
      ){
        values [j] = 1;
      }
      else {
      values [j] = 0;
      }
    }
  }

  uint8_t macAddr[] = {0x3C, 0x71, 0xBF, 0x03, 0x32, 0x54};
  esp_err_t result = esp_now_send(macAddr, (uint8_t*) &values, sizeof(values));

  Serial.print("Send Status: ");
  //If it was successful
  if (result == ESP_OK) {
    Serial.println("Success");
  }
  //if it failed
  else {
    Serial.println("Error");
  }

}
```

```
//Callback function that gives us feedback about the sent data
void OnDataSent(const uint8_t *mac_addr, esp_now_send_status_t status) {
  char macStr[18];
  //Copies the receiver Mac Address to a string
  snprintf(macStr, sizeof(macStr), "%02x:%02x:%02x:%02x:%02x:%02x",
           mac_addr[0], mac_addr[1], mac_addr[2], mac_addr[3], mac_addr[4], mac_addr[5]);
  //Prints it on Serial Monitor
  Serial.print("Sent to: ");
  Serial.println(macStr);
  //Prints if it was successful or not
  Serial.print("Status: ");
  Serial.println(status == ESP_NOW_SEND_SUCCESS ? "Success" : "Fail");
  //Sends again
  delay (10);
  send();
}

//We don't do anything on the loop.
//Every time we receive feedback about the last sent data,
//we'll be calling the send function again,
//therefore the data is always being sent

void loop() {
}
```

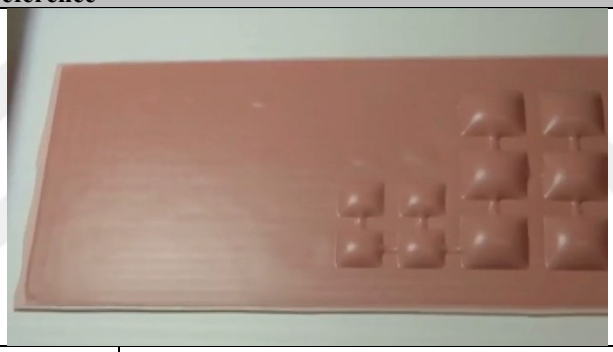
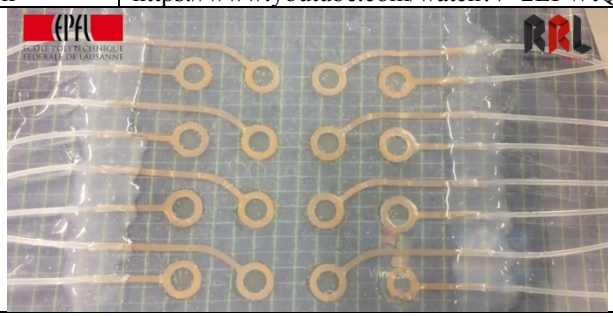
The reciver

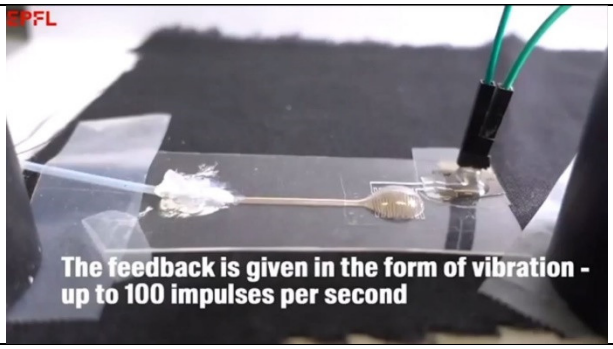
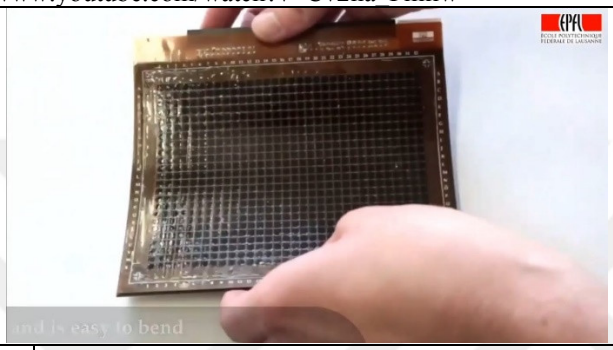
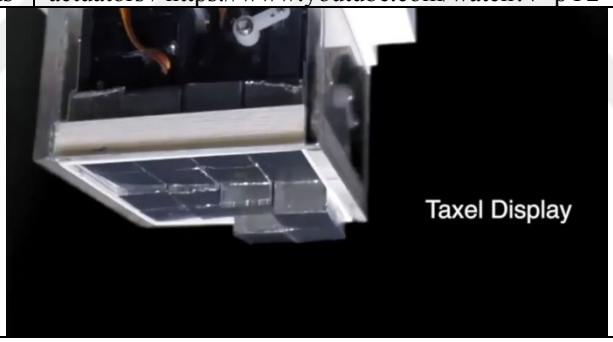
```
//Libs for espnow e wifi
#include <esp_now.h>
#include <WiFi.h>
#include <Servo.h>
/////////////////////////// PWM Servo
#include <Adafruit_PWMServoDriver.h>
Adafruit_PWMServoDriver pwm = Adafruit_PWMServoDriver();
#define SERVOMIN  125 // this is the 'minimum' pulse length count (out of 4096)
#define SERVOMAX  600 // this is the 'maximum' pulse length count (out of 4096)
uint8_t servonum = 0;
int pulse [9];
////////////////////////////////
int servosNum = 9;
int dataNum = 9;
int inc = 7; // incrment increases for servo pos
int servoMin = 0; // min degree pos
int servoMax = 180; // max degree pos
int servoPos [9] = {}; // servo position for each one it should = to data number coming and = to
number of servo
int delayGet = 5; // delay to get the new data

void setup() {
  ///////////////PWM Servo
  Wire.begin(33,32); //sda scl
  ///////////////
  Serial.begin(115200);
  WiFi.mode(WIFI_STA);
  Serial.print("Mac Address in Station: ");
  Serial.println(WiFi.macAddress());
```

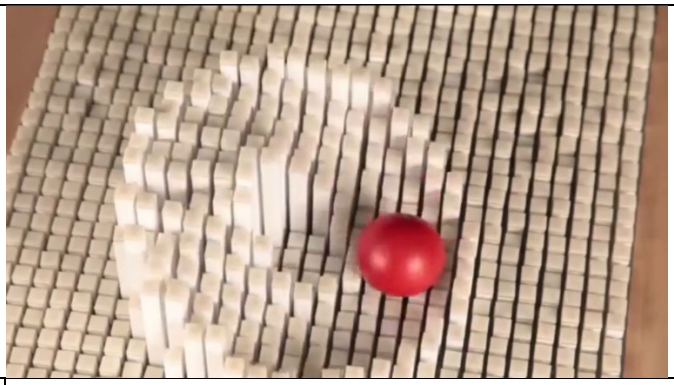
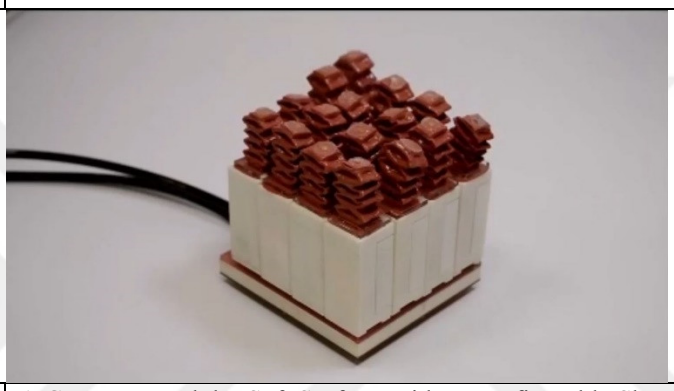
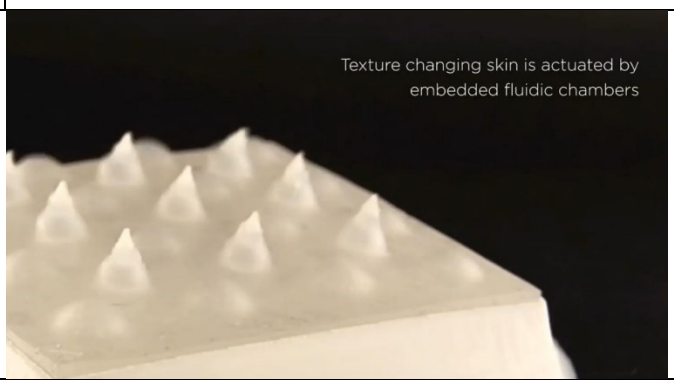
```
  InitESPNow();
  esp_now_register_recv_cb(OnDataRecv);
////////////////PWM Servo
    pwm.begin();
    pwm.setPWMFreq(60);  // Analog servos run at ~60 Hz updates
    yield();
////////////////
  for(int i=0; i<dataNum; i++){
    pwm.setPWM(i, 0, SERVOMIN);
  }
}

void InitESPNow() {
  //If the initialization was successful
  if (esp_now_init() == ESP_OK) {
    Serial.println("ESPNow Init Success");
  }
  //If there was an error
  else {
    Serial.println("ESPNow Init Failed");
    ESP.restart();
  }
}

//Callback function that tells us when data from Master is received
void OnDataRecv(const uint8_t *mac_addr, const uint8_t *data, int data_len) {
  char macStr[18];
  //Copies the sender Mac Address to a string
  snprintf(macStr, sizeof(macStr), "%02x:%02x:%02x:%02x:%02x:%02x",
           mac_addr[0], mac_addr[1], mac_addr[2], mac_addr[3], mac_addr[4], mac_addr[5]);
  //Prints it on Serial Monitor
  //Serial.print("Received from: ");
  //Serial.println(macStr);
  //Serial.println("");

    for(int i=0; i<dataNum; i++){
      if (data[i] == 1) servoPos [i] += inc;
      if (data[i] == 0) servoPos [i] = servoMin;
      if (servoPos [i] > servoMax) servoPos [i] = servoMax;
     }

  for(int i=0; i<dataNum; i++){
    pulse [i] = map(servoPos [i],0, 180, SERVOMIN,SERVOMAX);
    pwm.setPWM(i, 0, pulse [i]);
  }

 delay (delayGet);
}
//We don't do anything on the loop.
//Everytime something comes from Master
//the OnDataRecv function is executed automatically
//because we added it as callback using esp_now_register_recv_cb
void loop() {
}
```

C. Interview Video References

Tactical feedback	A Feedback that stimulates the skin
Low- and high-resolution tactile feedback grids	Actuators that are organized in grid format (e.g. 3x3/ 4x9) to deliver tactical feedback
Texture feedback	A Feedback resample a texture of something when one is being felt
Force feedback	A Feedback that exerts a force onto one's body
Contactless haptic feedback	A Feedback that stimulates the touch sense without being touched by the individual
Joint manipulation feedback	A feedback that forces one's joints to manipulate
Temperature feedback	A feedback that enables one to feel a temperature change
Simulated feedback	A feedback that simulates a real physical interaction such as shaking hands
Symbolic feedback	A feedback that does not simulate a physical interaction but stimulate the touch sense in abstract format (e.g. one vibration)

Video clip and its reference	
	
Tactical feedback an example of symbolic feedback	Zero Volume Air Chamber -- Pattern Molding Steps https://www.youtube.com/watch?v=2EFWtQ3oCP8
	
Tactical feedback	Interactive Soft Pnuematic Actuator Skin for Tactile Feedback https://www.youtube.com/watch?v=KONyGObNE8I

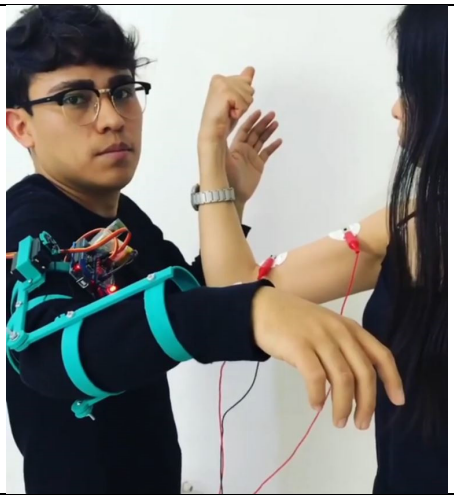
	
Tactical feedback	Artificial skin could help rehabilitation and enhance virtual reality https://www.youtube.com/watch?v=Cv2ha_Fmliw
	
Low-resolution tactile feedback grids	active skin with 768 independent elements using shape memory polymer actuators / https://www.youtube.com/watch?v=pY2-7OiYDeI
	
High-resolution tactile feedback grids	UIST 2017 - RetroShape Leveraging Rear-Surface Shape Displays for 2.5D Interaction on Smartwatches https://www.youtube.com/watch?v=8uRskDzkKl0
Low-resolution tactile feedback grids	Applications of Switchable Permanent Magnetic Actuators in Shape Change and Tactile Display https://www.youtube.com/watch?v=obwrVn7EdPE

	
High-resolution tactile feedback grids	Amazing Technology Invented By MIT - Tangible Media https://www.youtube.com/watch?v=lvtfD_rJ2hE
	
Low-resolution tactile feedback grids	A Compact Modular Soft Surface With Reconfigurable Shape and Stiffness https://www.youtube.com/watch?v=HiILkgaunUY
	
Texture feedback	Goosebumps - Texture-Changing Soft Robotic Skin https://www.youtube.com/watch?v=-RkCu7-ljmQ

Force feedback	Squeezing sensations on the wrist using shape memory springs https://www.youtube.com/watch?v=DT96CNQ9d2o
Force feedback	Meet the Paik Lab https://www.youtube.com/watch?v=RUWUWW8qZcg
Force feedback	Origami-Inspired Artificial Muscles https://www.youtube.com/watch?v=Ir69MXyOvFs

Force feedback	a tri gripper fabricated in one printing process https://www.instagram.com/p/B1dt_dqhsTm/?utm_source=ig_web_copy_link

Contactless haptic feedback using ultrasound	Ultrahaptics Demo at CES 2015: Feeling Without Touching https://www.youtube.com/watch?v=zJK7IF91jmQ



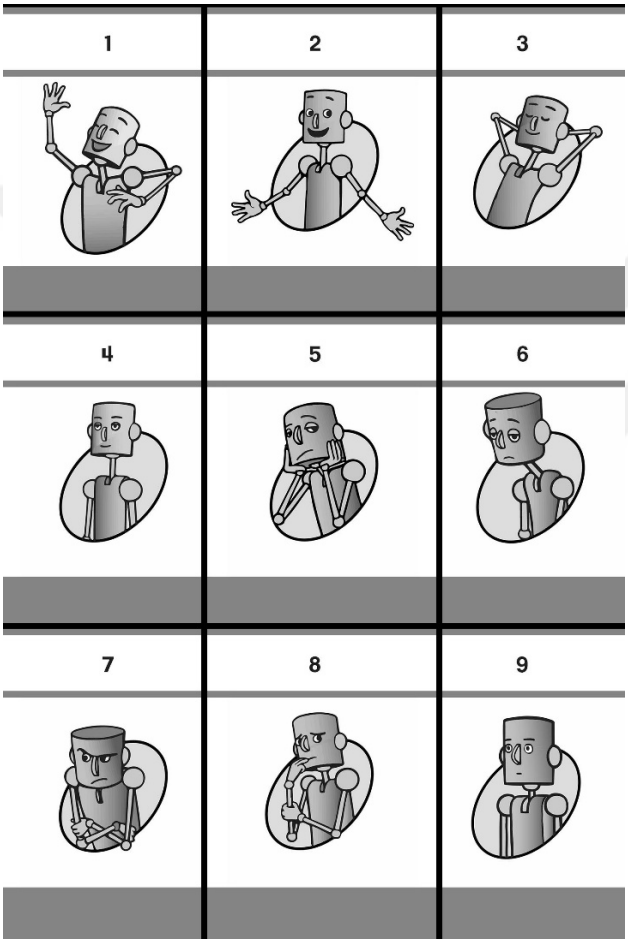
Joint manipulation feedback	Exoesqueleto Bluetooth EMG https://www.instagram.com/p/B3OFSevpXC_/?utm_source=ig_web_copy_link

Simulated feedback	The Handshaking Anthropomorphic Reactive Robotic Interface (HARRI) https://www.youtube.com/watch?v=852N5cg4tF0	

D. Remote Social Touch (RST) Elicitation Cards

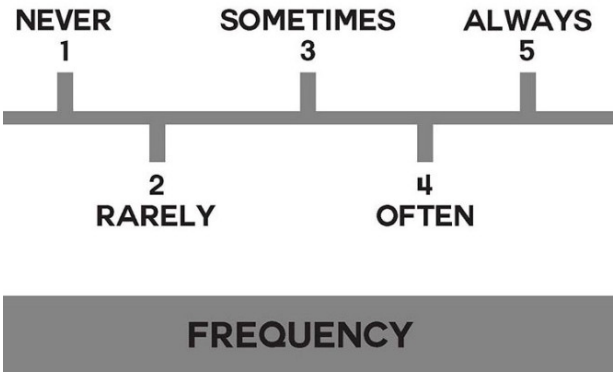
Pick-A-Mood (PAM) cards

Nine cards representing various emotions/feelings (i.e. exited, cheerful, relaxed, calm, board, sad, irritated, tense, neutral) through a robot-looking character.



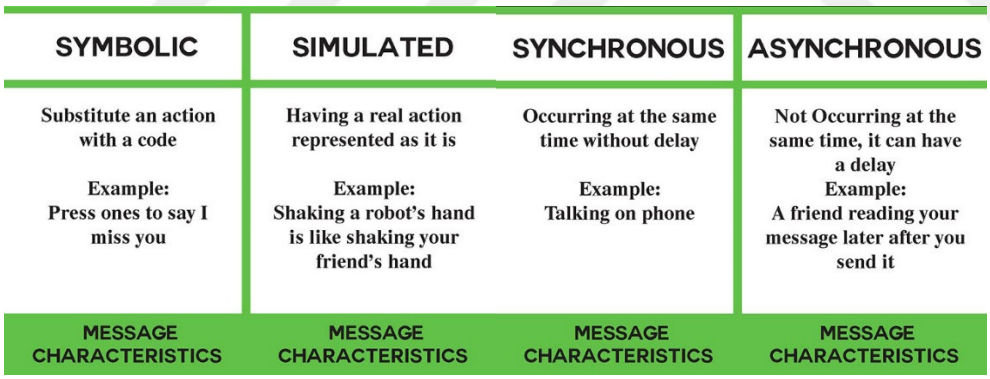
Frequency card

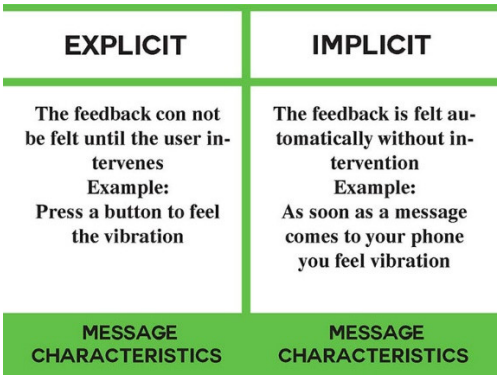
This card is intended to accompany the question 'How often…? It is believed to make it easier for the participants to have a reference scale of frequency in front of them. The scale included: Never (1) - Rarely (2) - Sometimes (3) - Often (4) - Always (5)



Message characteristics cards

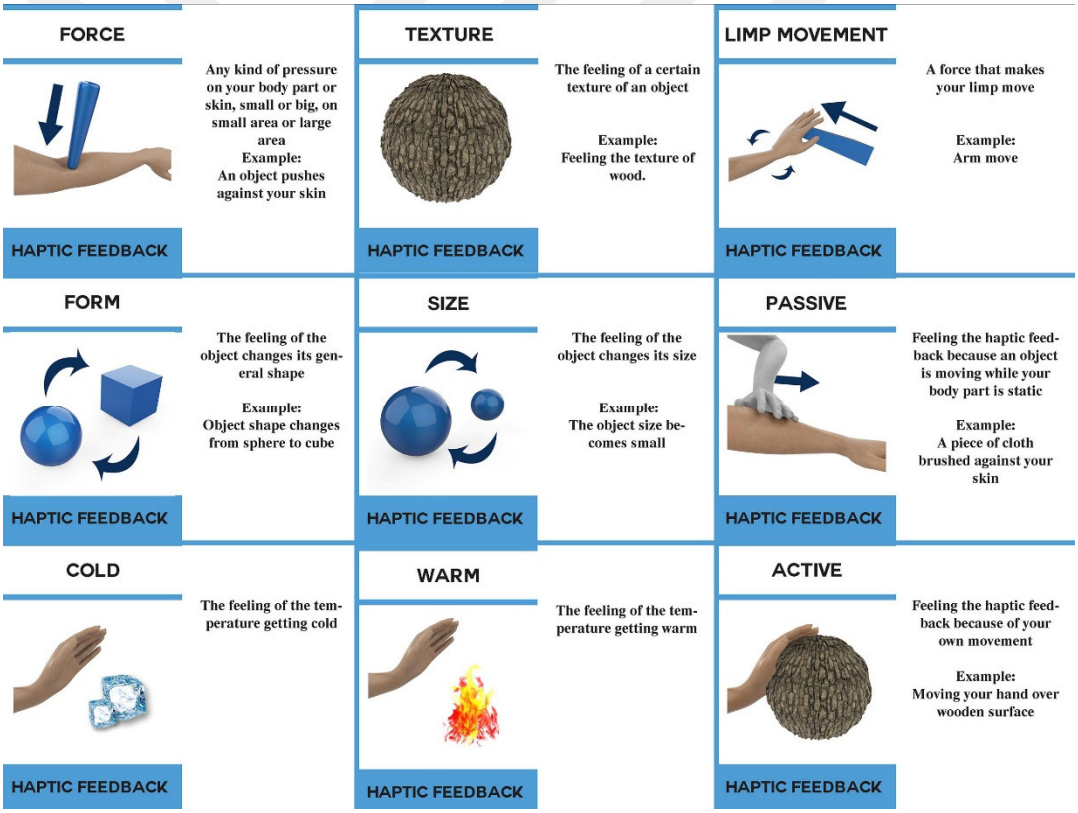
This category of cards consisted of explanations of *simulated* (performing the PI to send it) vs *symbolic* (substitute the PI with a code), *synchronous* (feeling the PI at the same time) vs *asynchronous* (the PI message can be recorded and felt later anytime), *implicit* (feeling the PI message without the user intervention) vs *explicit* (the user intervene to feel the PI message).





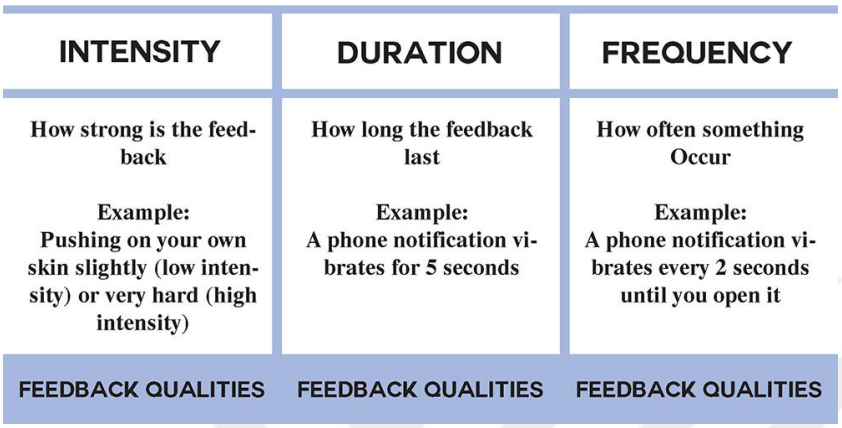
Haptic feedback characteristics cards

This category of cards included representations of force (the feeling of a force against oneself), texture (feeling of either a texture change or a texture move along the skin), limp movement (feeling ones limp move in a certain way), form and size change (deforming of an object to deliver the haptic feedback), passive (feeling the haptic feedback being applied on oneself) v active (one need to do something to feel the haptic feedback), and temperature changes (whether one want to feel cold or warmth to represent the PI). Vibrotactile feedback is excluded from the set to study how other kinds of haptic feedback can be utilized as the vibration was widely used in RST literature.



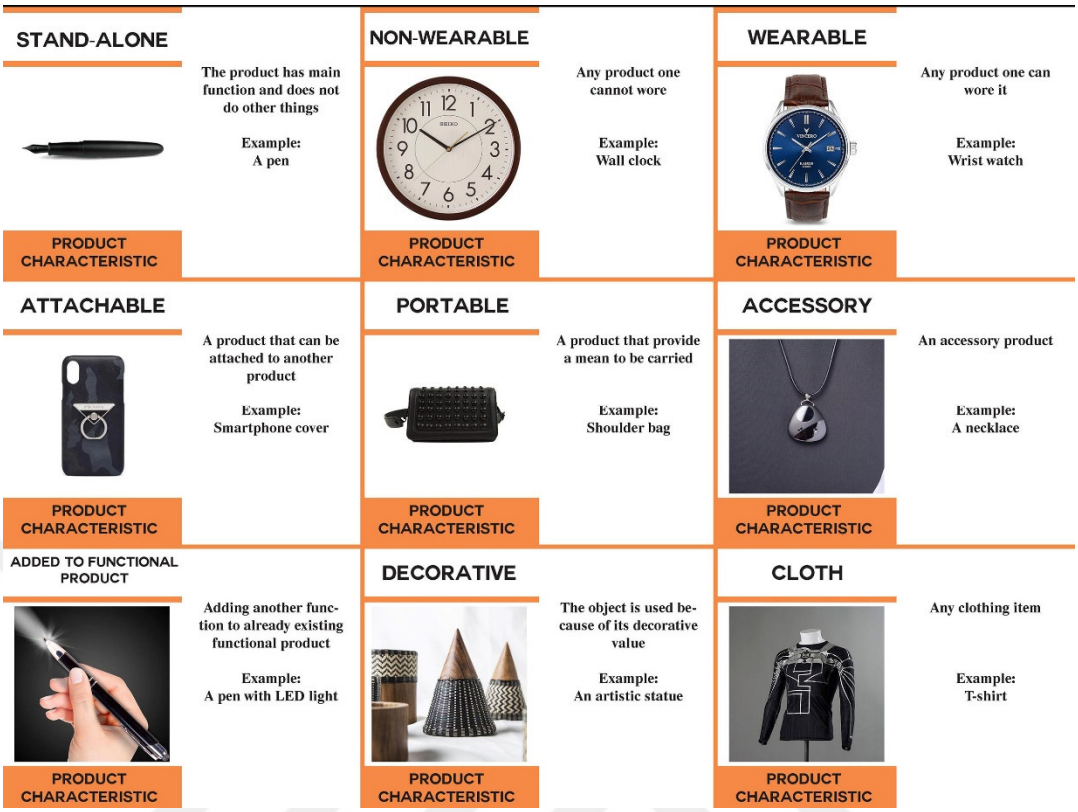
Haptic feedback qualities cards

This category of cards included explanations of intensity (PI haptic feedback strength), duration (how long is the PI haptic feedback last), and frequency (within the same message how many PI haptic feedback).



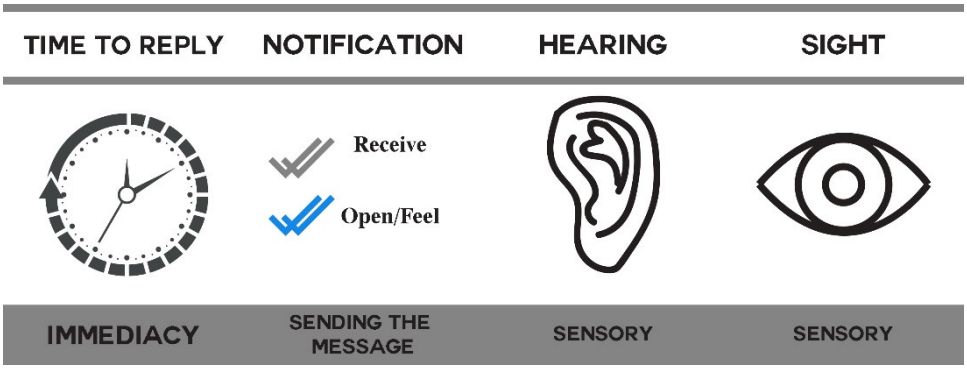
Product characteristics cards

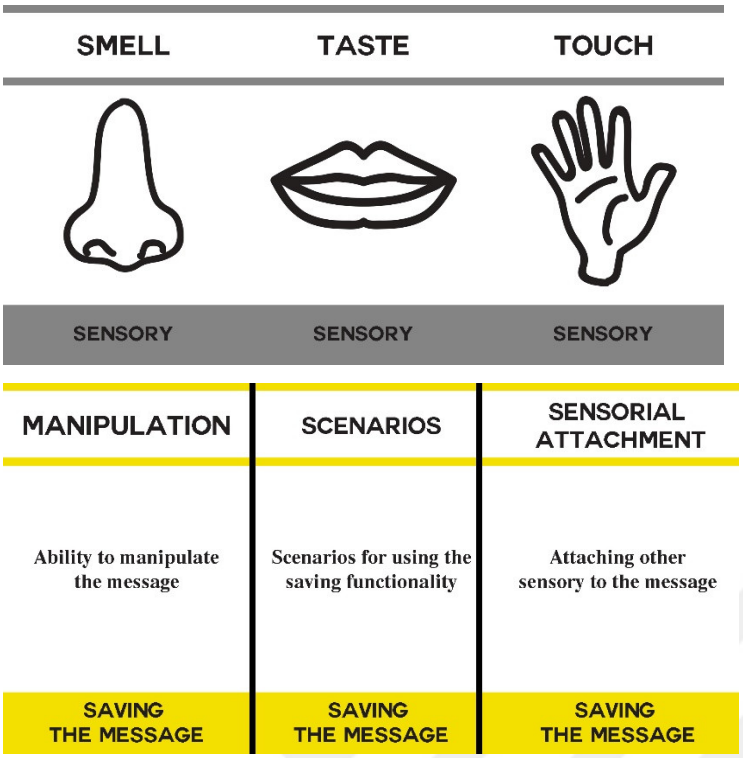
This category of cards aimed at facilitating the discussion on certain product features that would be desirable to the participants. The features included: stand-alone (a product only for RST), non-wearable v wearable; attachable, portable, accessory-like, ad-on (RST product added on to a functional product used daily), decorative (a product can be for RST and also decorative or fashionable), and a clothing item.



Miscellaneous cards

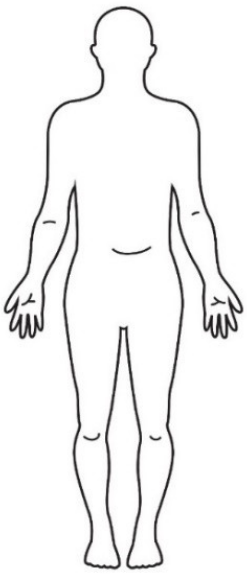
Various cards that meant to be used with few questions to act as a focal point for the participants while answering the questions



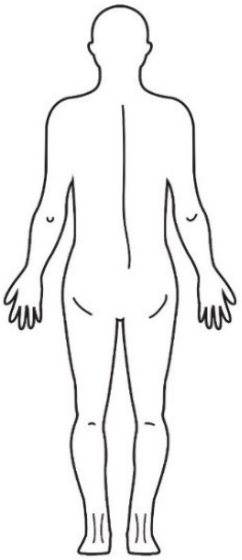


Human figure card

This card illustrated a human-body from the front and the back. The participants can indicate "where on their body they would like to feel the PI", and "if a wearable product was available where it should have been located on the body". The human figure used in this research is adopted from Jones and Yarbrough (1985) research where they used a similar approach to check the non-vulnerable and vulnerable part of the body for touch.

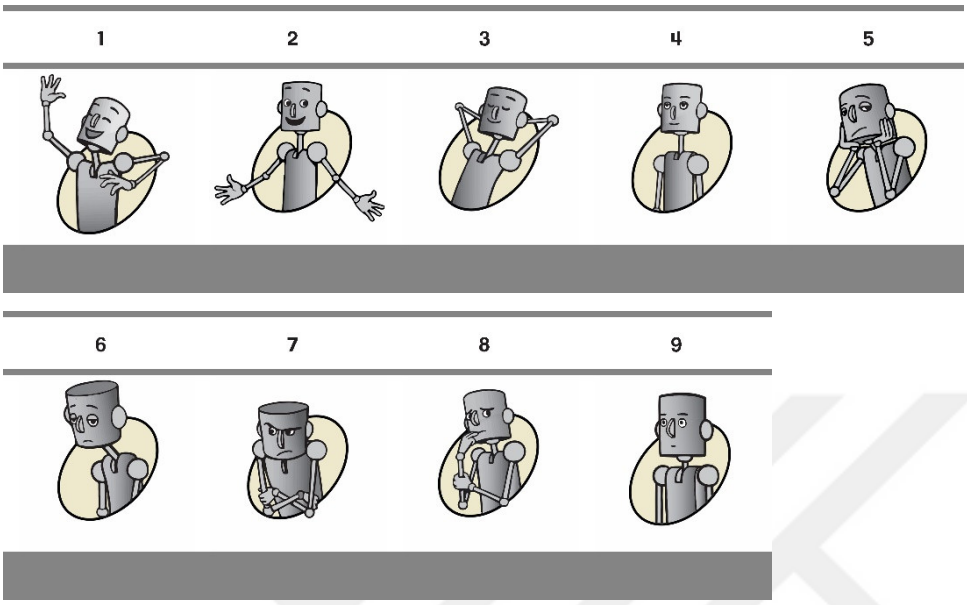


Front



Back

E. Pick-A-Mood (PAM)



The below table compares the interview finding about the meaning of the PAM character with the meaning of PAM characters from the original reference PMA Desmet et al. (2012).

Pam	Reference*	This research findings**
1 (excited)	Joyful (17%) happy (17%) excited (15%) exuberant (14%)	Much happy (48% / 27) Excited (11% / 27) Fun (11% / 27) Joyful (7.4% / 27) Secure (3.7% / 27) I am doing a good job (3.7% / 27) I don't want to let you go (3.7% / 27)
2 (cheerful)	Happy (30%) joyful (29%) cheerful (13%) relieved (8%)	Happy (52.6% / 19) Joyful (15.8% / 19) Relaxed (10.5% / 19) Being okay (5.3% / 19) Safe (5.3% / 19) Excited (5.3% / 19) Very loved (5.3% / 19)
3 (relaxed)	Relaxed (81%) satisfied (8%) content (6%) enjoying (2%)	Relax (40% / 30) Comfortable (20% / 30) Neutral (10% / 30) Happiness (6.7% / 30) Not feeling very comfortable (3.3% / 30) Being thanked (3.3% / 30) Joyful (3.3% / 30) Satisfaction (3.3% / 30)

		Safe (3.3% / 30) Feel free (3.3% / 30) Supported (3.3% / 30)
4 (calm)	Neutral (59%) dreamy (11%) satisfied (5%) calm (4%)	Neutral (42.9% / 28) It's okay (17.9% / 28) Hide your emotion (7.1% / 28) Feel just fine (3.6% / 28) Feeling tired (3.6% / 28) Lonely (3.6% / 28) Do it and move on with our life (3.6% / 28)
5 (bored)	Bored (64%) disinterested (5%) pensive (5%) tired (5%)	Sad (37% / 27) Bored (11% / 27) Disappointment (7.4% / 27) Thinking about it (7.4% / 27) Nervous (7.4% / 27) Felt want to talk to someone (3.7% / 27) Stressful day (3.7% / 27) Bad (3.7% / 27) I wish it is there (3.7% / 27) Miserable (3.7% / 27) Feeling longing (3.7% / 27) Contemplation (3.7% / 27)
6 (sad)	Sad (50%) depressed (10%) gloomy (9%) disappointed (8%)	Very sad (42.3% / 26) Miss them (11.5% / 26) Frustrated (3.8% / 26) Tired (3.8% / 26) Disappointment (3.8% / 26) Depression (3.8% / 26) Lonely (3.8% / 26) Troubled (3.8% / 26) Helplessness (3.8% / 26)
7 (irritated)	Angry (55%) irritated (12%) suspicious (6%) grumpy (4%)	Frustrated (50% / 4) Angry (50% / 4)
8 (tense)	Angry (55%) irritated (12%) suspicious (6%) grumpy (4%)	Anxious (42.8% / 7) Nerves (28.5% / 7) Unsure (14.3% / 7) Scared (14.3% / 7)
9 (neutral)	Neutral (42%) astonished (15%) surprised (8%) serious (5%)	Neutral (37.5% / 8) I can't relax (25% / 8) A bit sad (12.5% / 8) Frustrated (12.5% / 8) Try not to mess it up (12.5% / 8)
Not represented	-	Frustrated (33.3% / 3) Adventurous (33.3% / 3) Very sad (33.3% / 3)

* PMA Desmet et al. (2012)

** (X% out of X) percentage out of the number of the participants mentioning the word.

F. Ethical Approval

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
APPLIED ETHICS RESEARCH CENTER

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
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Sayı: 28620816 /438

21 KASIM 2019

Konu: Değerlendirme Sonucu

Gönderen: ODTÜ İnsan Araştırmaları Etik Kurulu (İAEK)

İlgi: İnsan Araştırmaları Etik Kurulu Başvurusu

Sayın Prof.Dr. Bahar Şener-PEDGLEY

Danışmanlığını yaptığınız **Ali Abdulrazzaq Al-Samarei "Remote Social Touch"** başlıklı araştırması İnsan Araştırmaları Etik Kurulu tarafından uygun görülmüş ve **418 ODTU 2019** protokol numarası ile onaylanmıştır.

Saygılarımızla bilgilerinize sunarız.

Prof. Dr. Tülin GENÇÖZ
Başkan

Prof. Dr. Tolga CAN
Üye

Doç.Dr. Pınar KAYGAN
Üye

Dr. Öğr. Üyesi Ali Emre TURGUT
Üye

Dr. Öğr. Üyesi Şerife SEVİNÇ
Üye

Dr. Öğr. Üyesi Müge GÜNDÜZ
Üye

Dr. Öğr. Üyesi Süreyya Özcan KABASAKAL
Üye

G. Participants Invite

I am looking for as many people as possible who are currently living away from their loved ones (loved ones can be any relationship: parents, children, significant other, saplings, friends). Each person will answer a 5-minutes online questionnaire for 7 days then on another day an interview session will be conducted to discuss about technologies related to the topic. To apply either contact me directly or through the google form, link: Google form:

For further information: Ali Alsamarei (Email / WhatsApp)

H. Acquiring Participants Form

Remote Social Touch

'Remote Social Touch' (RST) study is carried out as part of the PhD research of Ali Al-Samarei, supervised by Prof. Dr. Bahar Şener-Pedgley at the Department of Industrial Design, Middle East Technical University.

Social touch can be regarded as any kind of physical communication/connection between individuals such as handshaking and hugging each other, etc. RST refers to (digitally) simulating social touch over a distance, where individuals are not present in the same physical space. The aim of this study is to explore whether RST can be an alternative way of expressing our need of (physical) 'touch' in situations where a physical-touch is not possible.

I am looking for people who have been living away and currently living away from their loved ones (including any kind of relationship that you define them in the circle of loved ones such as parents, friends, spouse, boyfriend/girlfriend, etc.). You should have been living away from them at least for a few months to participate in this study. If you are interested in taking part, you will be invited to an one-to-one study session* (see further explanation below) to discuss about RST.

This study will run in the span of a few months for that I will either contact you immediately or within the next few weeks from answering this form. Your participation will be greatly appreciated.

[*] The study session:

The session will be conducted on a day/time suitable for you. Before the study session, you will be asked to keep a week-long diary (further details will be provided).

The one-to-one session will take around 1.5 to 2 hours, breaks included. You will be asked some questions in relation to: communication with loved ones, social touch, and remote social touch. Additionally, you will be introduced to new technologies, then the researcher will discuss with you how these technologies can be utilized to communicate with the loved ones. The meeting will be video/audio recorded to help the researcher refer to information. All the personal information will be kept confidential by the researcher and used anonymously.

Please leave your preferred communication details (e.g. WhatsApp, E-mail or other social media) below. I will contact you to send out diary information and arranging a time to meet. Your participation will be greatly appreciated.

X I would like to participate in this study

Name Surname

For further details or questions contact: Ali Alsamarei (Email / WhatsApp)

** This study is approved by “applied ethics research center” at METU

I. Online Diary Keeping Questionnaire Form

1 Name Surname:

Think about the loved ones you are currently living away from:

2 Have you contacted your loved ones today? Yes No

3 If YES: What medium(s) did you use to communicate?

4 If YES: How many hours/minutes did you spend communicating?

5 If YES: Can you briefly explain the reason why did you contact them?

For example: Just to ask how they are doing today; I had a problem and I needed their help..

6 If NO: still did you want to contact them but you couldn't? if yes why you couldn't?

7 Did you feel today you wanted to have some kind of physical contact with your loved ones? (For example: a hug or shaking hands…) Yes No

8 If Yes: how did you feel by the absence of the physical contact? [Using Pick-A-Mood]

J. Consent Form

This research is being done within the scope of a PhD research of Ali Al-Samarei, supervised by Prof. Dr. Bahar Şener-Pedgley at the Department of Industrial Design, Middle East Technical University. The aim of the study is to explore remote social touch. This form is made to inform you about the research context. Participation in the research is voluntary. This session will be audio and video recorded. All the information will be evaluated by the aforementioned researcher and used anonymously, the obtained data will be used for scientific purposes. This session will take approximately 2.5 hours to 3 hours. During participation, for any reason, if you feel uncomfortable, you are free to quit at any time. Your contribution is very appreciated.

About the session and what you are expected to do:

In this meeting we are going to discuss about remote social touch through open ended questions with the help of card kits and some materials. You are expected to share your thought, reaction and feeling freely and utilize anything in front of you to express your ideas. The information that you will provide is going to be used to understand more about this subject. Your participation is highly appreciated.

We would like to thank you in advance for your participation and contribution in this study. For further information about the study, you can contact Ali Al-Samarei (Ali Al-Samarei Email)

I am participating in this study totally on my own will and am aware that I can quit participating at any time I want/I understand that photograph and video recording may be taken to collect data, and I consent to their use for this purpose/ I give my consent for the use of the information I provide for scientific purposes.

Name Surname Date Signature

K. Interview Questions

1st set: introduction and consent

2nd set of questions will be recorded:

Reminding about daily assignment, explained by the researcher

2.1 First Let's talk about the diary assignment. Any thought to add? Explain your answer related to missing PI?

Warming up with:

For the next group of questions think about a loved one you lived away from for certain amount of time (loved ones can include any kind of relationship that you define them in the circle of loved one such as: parents, friends, spouse, etc.):

2.2 What is the relationship with the loved one you are thinking of?

2.3 The maximum years / months lived away from loved ones?

2.4 In the time away from the loved one in which medium did you usually use to stay in contact? A phone call, a text messaging, video conversations, other ----- / Anything else you communicate about? [why] [what reason]

2.5 What kind of physical interactions do you miss while being away from the loved one? (for example, shaking hand, hug,…) [Write on Post-it]

2.6 How do these physical interactions make you feel? [Explain through PAM Cards]

2.7 How did you feel when you are away from them because of the absence of these physical interactions? [Pick-A-Mood]

2.8 When you meet them in same physical space how often do you: 1-5[Never/Rarely /Sometimes /Often /Always]

2.8.1 initiate these physical interactions with them

2.8.2 (your loved ones) initiate these physical interactions with you

3rd set of questions will be recorded:

Explaining Remote Social Touch with video clips [Example Technologies] and the prototype.

[Introduction to What IF exercise] / What if technology permit:

3.1 Thinking about the physical interactions you provided before: **[Remind of above physical interactions]**

How do you want technology represent these physical interactions? If you …. It

3.1.1 **Receive**: **[How do you want to feel it]** Simulated - Symbolic / Synchronous – Asynchronous / Explicit – Implicit / Haptic feedback Characteristics / Haptic feedback qualities /

3.1.1.1 where do you want to feel it "human Figure"?

3.1.2 **Reply**: **[How do you want to reply to a haptic message]**

3.1.2.1 How long after receiving the message will you answer it? (e.g., immediately,…)

3.1.2.2 By which way you prefer to answer it? (one of the senses)

3.1.2.3 what message to reply this PI? if another PI

3.1.3 **Send**: **[How do you want to send it]** Simulated - Symbolic / Synchronous – Asynchronous / Explicit – Implicit / **Gestures Style**/ Haptic feedback qualities / [sending not as a reply]

3.1.3.1 if you want to be **notified** when the loved one receive your message, how?

3.1.3.2 Do you want to send or receive a warning message before establishing the communication? Explain.

3.1.3.3 Is it acceptable to use a haptic device to communicate in public? Explain.

3.1.4 **Save**: **[How do you want to save this PI from someone]** [you can save it for ever and feel it for example after 30 years]

3.1.4.1 how this can change your life?

3.1.4.2 How are you going to use it? (scenario)

3.1.4.3 same as above received or **manipulate** it?

3.1.4.4 Is there any **other physical interaction** you would like to save?

3.1.4.5 What **other relationships** you would like to save their physical interactions?

3.1.4.6 Anything else you would like to add to this concept?

3.2 Do you want one **product** do **all** (send/ receive/ reply/ save) or **one for each**?

3.2.1 what are the product characteristics? [using the cards]

3.2.2 If it is wearable point on the **human figure**:

3.2.2 how do you want to interact with the product for each physical interaction? [By acting touch gestures for each physical interaction]

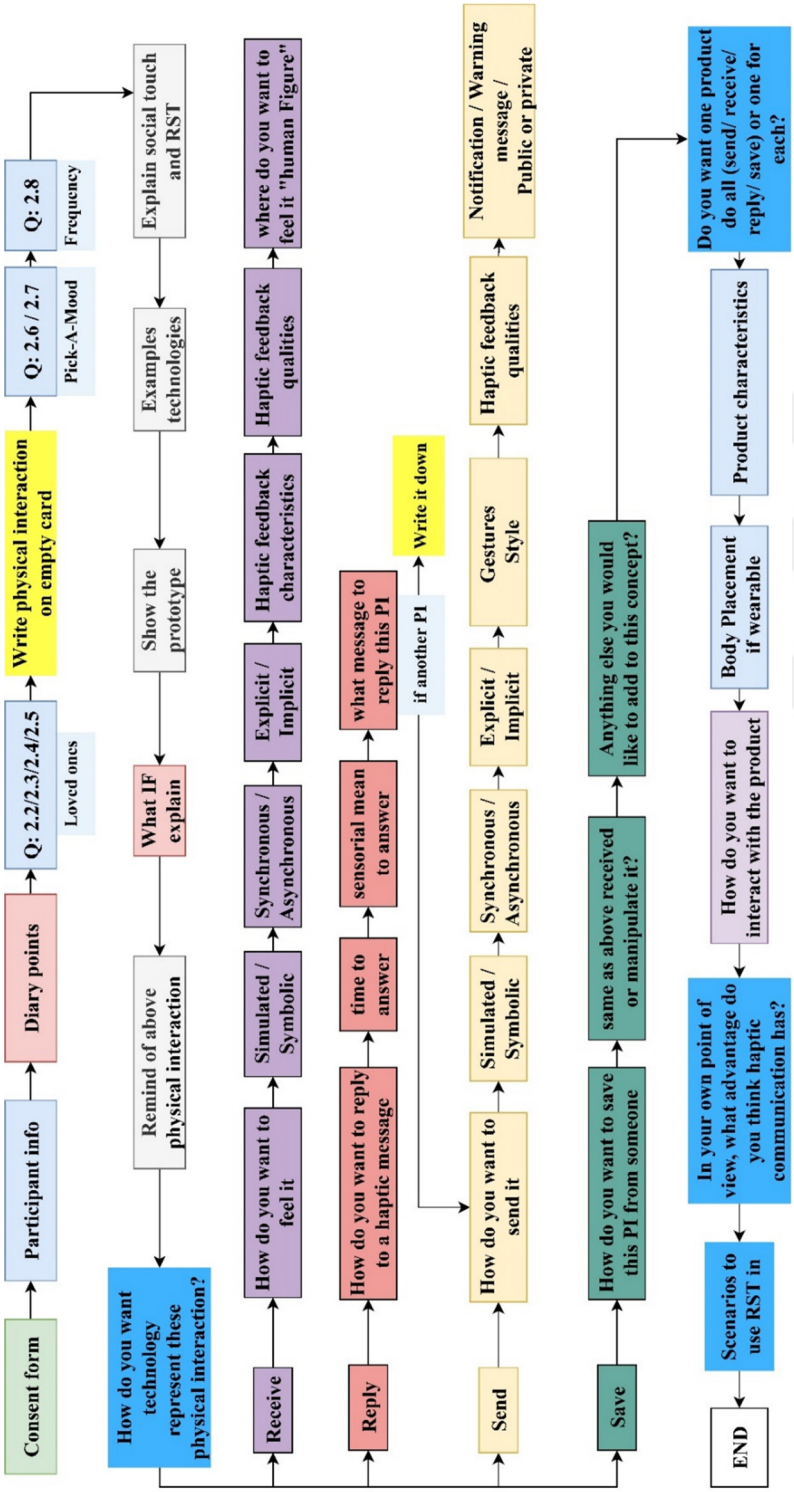
3.3 What kind of **scenario** would you use **RST**?

3.5 In your own point of view, what **Advantage** and **Disadvantages** do you think **RST** has?

3.6 In the end, any **thought** you would like to add about **RST**?

End

L. Interview Process



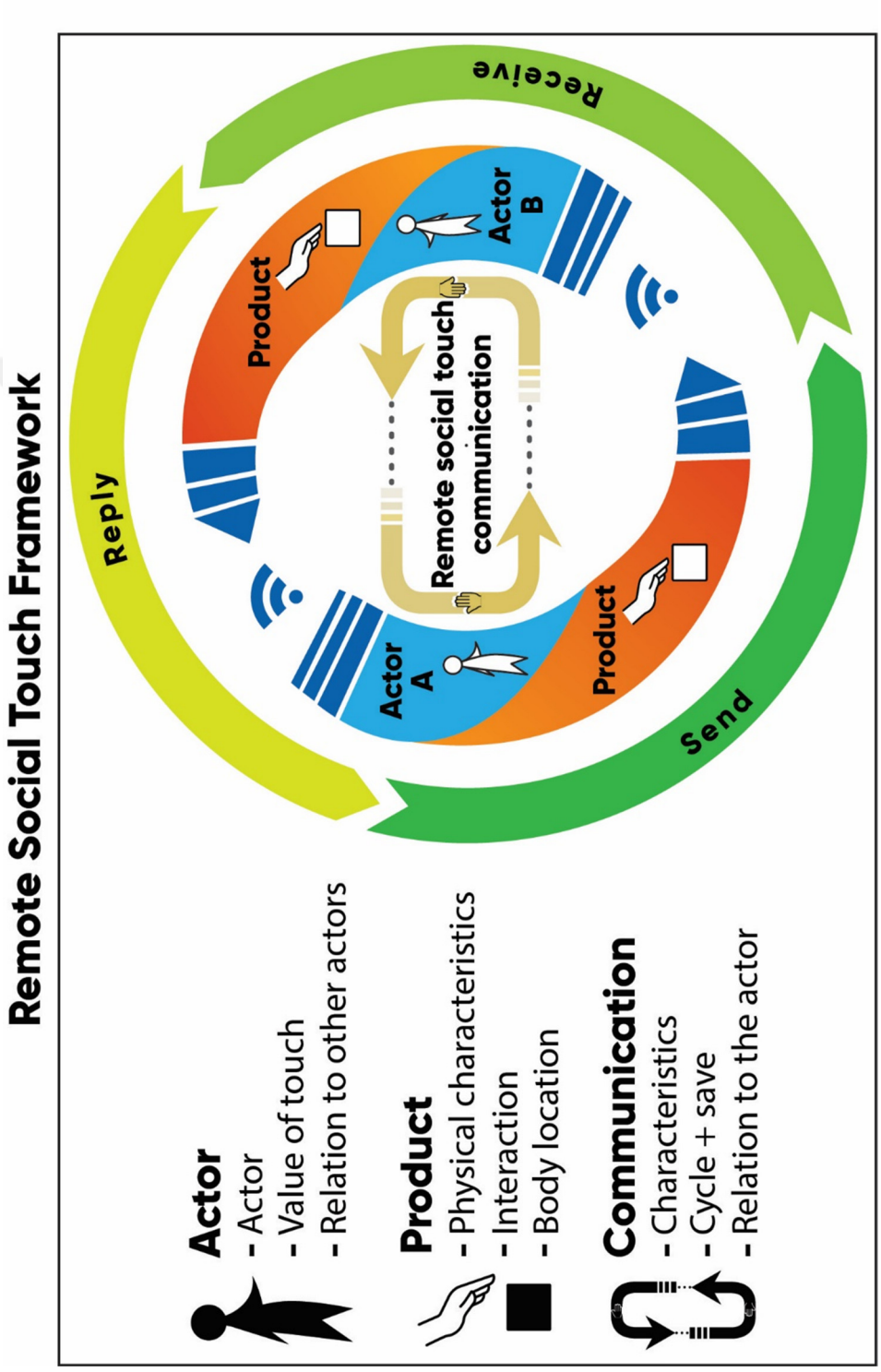
M. PAM and frequency for all physical interaction and relationships

#	M/F	Relationship	Physical interaction	PAM-Doing	PAM-Missing	Frequency-Initiate	Frequency-Receive
2	F	Best friend	1 kissing / 2 tickling / 3 cuddle / 4 hug	cuddle is 1 and 3 / kissing is 1 and 2 / tickling is 1 /	all 5 and 6	all 5	all 3
12	F	best friend	1 hug / 2 hand around shoulder / 3 unintentional touch / 4 head on the shoulder	1 for 1 / 2 is 3 / 4 and 3 for 3 / 2 for 4	For all 4 but if I need is 6	1 is 3 / 4 is 2 / 2 is 3 / 3 is 4	1 is 3 / 4 is 2 / 2 is 3 / 3 is 4
26	F	Boyfriend	1 hug / 2 holding hand	1 1 / 2 is 1 and 3	5	5/4	5/4
28	F	Boyfriend	1 hug / 2 sex / 3 holding hand / 4 kissing on cheek	1 is 1 / 2 3 / 3 3 / 4 2 and 3	1 is 6 5 7 / for 2 is 4 5 7 / for 3 is 8 6 / for 4 is 5 6 7 8 /	1 4 / 2 4 / 3 2 / 4 1	1 4 / 2 4 / 3 4 / 4 5 /
5	F	father	1 head on shoulder [send]/2 holding hands	1 is 3/ 2 is 1	1 is 5 / 2 is 6	1 3 / 2 5	1 1 / 2 2
23	F	father	1 setting side by side / 2 Hug / 3 shaking hand	2	6	4/3/4	5/2/5
10	F	Husband	1 Brushing eyebrows with my / 2 hug / 3 kiss / 4 sex / 5 touching side by side while sitting or sleeping / 6 Light hit / 7 fixing his cloths	1 is 3 / 2 the hug is 2 / 3 is 1 and 2 / 4 is 1 / 5 is 3 / 6 is 5 / 7 is 3	1 is 4 / 2 the hug is 6 / 3 is 6 / 4 is 5 / 5 is 6 / 6 is 4 / 7 is 4	1 is 4 / 2 is 5 / 3 is 5 / 4 is 3 / 5 is 5 / 6 is 4 / 7 is 3	1 is 1 / 2 is 5 / 3 is 5 / 4 is 4 / 5 is 5 / 6 is 4/ 7 is 1
13	M	little brother	1 hug / 2 practical jokes / 3 head buts	hug is 3 / 2 is 2 / 3 is 1	six for all if I miss	/ Hugs rarely The others sometimes	For all of them between sometimes and offten
11	F	little sister	1 hugging / 2 kissing her cheek / 3 arm around shoulder	/ 1 for 1 / 2 for 2 / 3 for 3	for all 5 and 6	1 and 3 sometimes always for 2	1 and 3 sometimes Never for 2
3	M	Mother	1 hug / 2 kiss	1 is 9 / 2 is 4	1 is 9 / 2 is 4	1	3
4	M	Mother	1 hug / 2 sleeping on lap / 3 tickling / 4 kiss [send]	3 is 1 / 2 is 3 / 1 is 123	1 is 5 6 / 2 is 5 6 / 3 is 9 /	4 / 5/4/	5 / 3 / 5

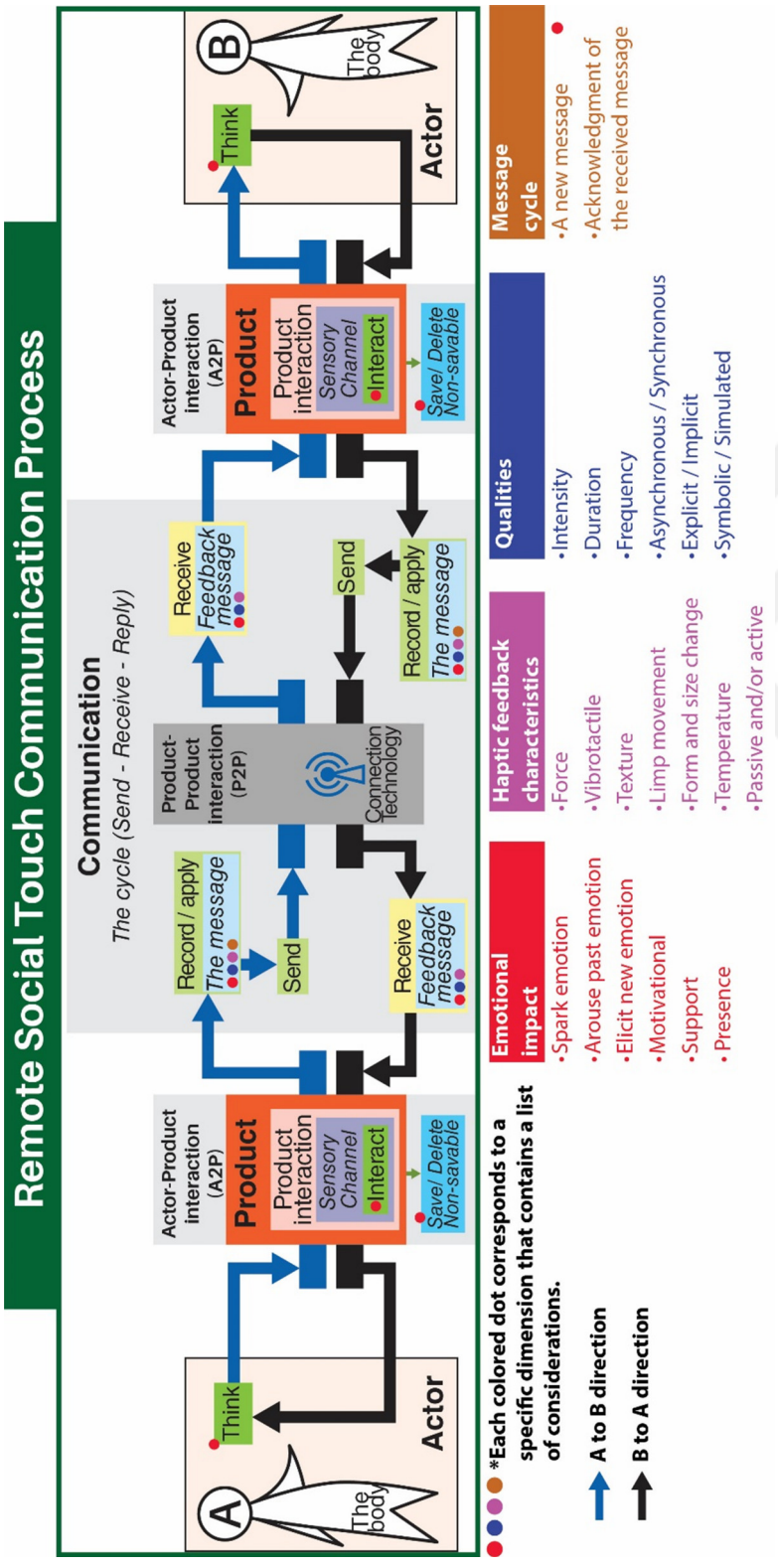
6	M	Mother	1 sleeping on arm / 2 forehand kisses / 3 hug / 4playing with mam hair	2 is 1 / 4 is 1 / 3 is 2 / 1 is 3	2 is 6 / 4 is 5 / 3 is 4 / 1 is 5	1 is 3 / 2 is 1 /3 is 3 /4 is 4	1 is 2/ 2 is 2 /3 is 3/ 4 is 1
7	M	Mother	1 hug / 2 kisses / 3 massage	1 for All of them	5 or 6 for 1 / 2 and 3 is 2 or 3	4 1 1	3
8	F	Mother	1 hug / 2 linking arms	/ 1 and 3 for 1 / 2 for 2	8 and 6 for 1 / 5 for 2	1 is 2 / 2 is 1	4
9	M	Mother	1 hug / 2 pat on my head or back	1 and 2 is 3 /	1 is 6 / 2 is 7	1	2 is 4
14	F	Mother	1 hug / 2 kiss / 3 linking arms	1 is 1 / 2 is 1 / 3 is 3	4 or 5 for all but hug mostly 5	1 often / 2 often / 3 sometimes	1 rarely / 2 is rarely / 3 is sometime
15	M	Mother	1 hug / 2 kiss /3 keep head in her lap	/ 1 hug is 2 / 2 is 2 / 3 is 3	4 I just like I got to use to it	5	4
16	F	Mother	1 hug / 2 patting on shoulder or back	hug is 2 / 2 is 3	4 for both	1 often / 2 rarely	1 often / 2 sometimes
17	M	Mother	1 patting on shoulder or back / 2 hug	1 is num 1 / hug is 3	1 is 5 / 2 is 9	3 / 4	4 /3
18	M	Mother	1 hugs / 2 patting shoulder / 3 play with hair / 4 tickling in the morning / 5 holding hands	1 hug is number 3 / 2 2 / 3 5 / 4 1 / 5 3	6 for all of them / 5 is 5	5 / 3 /1/1/4	5
19	F	Mother	1 hug / 2 kisses / 3 sleeping in her lap	3 is 3 / 2 is 2 / 1 is 2	4 for all but if I miss is 6	always for 1 3 / 2 is often	1 and 3 never / 2 sometimes
21	M	Mother	hug	3	4 or 5	4	4
22	F	Mother	1 hug / 2 kissing on the cheek and forehead / 3 holding hands	1 hug 1 / 2 3 / 3 3	9 sad	3	4/4/3
24	F	Mother	1 stroke my ear with cotton buds / 2 stroke the hair /3 Hug /4 kissing randomly	1 is 1 /2 is 3 / 3 is 3 / 4 is also 1 or 3 /	4 or 5 or 6	5 / 4 /2/2	1 / 3/5/5
25	M	Mother	1 hug	1	5	5	3
29	M	Mother	1 hug / 2 kiss	For all 1 2 3 4	789	4	3
30	M	Mother	1 hug / 2 kiss her hand / 3 patting or stroking on the head	1 is 2 / 2 is like 3 / 3 is like 3	1 is 5 / 2 is 4 normal/ 3 like 6/	1 is 4 /2 is 5 / 3 is 1	/ 1 is 5 / 2 is 1 / 3 is 4
31	M	Mother	hug	2	9	4	3
32	F	Mother	1 hug / 2 sleeping on lap / 3 head on the shoulder	1 the hug is like 1 / 2 is like 3 / 3 is like 3	all num 4	/ hug is often / 2 and 3 always	/ 1 sometimes / 2 and 3 never

33	M	Mother	1 hug / 2 sleeping on her lap / 3 eating from her hand / 4 playing some games / 5 kissing	1 is 2 and 3 / 2 is 3 / 3 is 1 / 4 is 1 / 5 is 1 and 3	1 is 6 / 2 is 6 7 8 / 3 is 7 / 4 is 7/ 5 is 7	5	1 often / 2 sometimes / 3 never / 4 often / 5 always
34	F	Mother	hug	2 or 4	4	2	4
35	F	Mother	1 hug / 2 kissing on cheek / 3 playing with hair / 4 sleeping on arm	1 hugging 2 / kissing 1 / 3 is 3 / 4 is 3 /	6 for all	4 /5/1/3	4/3/5/3
36	M	Mother	1 hug / 2 holding hand	both 3	5	4	4
27	F	Niece	1 hug /2 side by side touching / 3 physical play / 4 make or build things together / 5 tickling	1 is 2 / 3 is 1 / 4 is 3 / 2 is 3 / 5 is 1	1 and 2 is 6 / 3 4 5 is 5	5/4/2/4/5	5/2/3/5/5
20	F	older brother	1 hugging / 2 fighting	For all 1	For all 4	2 /3	4/1
1	M	Wife	1 holding hands / 2 hug / 3 kiss/ 4 cuddle / 5 side by side	3 is 1 / 2 is 2 / 1 4 5 is 3 /	3 is 6 / 4 is 5 / 2 is 5 / 1 is 9	1 is 4 / 2 is 3 / 3 is 4 /4 is 2 / 5 is 3	1 is 2/2 is 2 / 3 is 3 /4 is 4/ 5 is 3/

N. Early Proposed Remote Social Touch Framework



O. Remote social touch communication process



CURRICULUM VITAE

PERSONAL INFORMATION

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EDUCATION

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BA	Limkokwing University of Creative Technology, Animation department	2012

FOREIGN LANGUAGES

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