Title	BAO-ME : design of a huggable device to improve mental well-being through haptic interactions
Sub Title	
Author	Levantino, Valeria(Sugiura, Kazunori) 杉浦, 一徳
Publisher	慶應義塾大学大学院メディアデザイン研究科
Publication year	2018
Jtitle	
JaLC DOI	
Abstract	
Notes	修士学位論文. 2018年度メディアデザイン学 第659号
Genre	Thesis or Dissertation
URL	https://koara.lib.keio.ac.jp/xoonips/modules/xoonips/detail.php?koara_id=KO40001001-00002018-0659

Master's Thesis
Academic Year 2018

BAO-ME: Design of a Huggable Device to
Improve Mental Well-Being through Haptic
Interactions

Keio University Graduate School of Media Design

Valeria Levantino

A Master's Thesis
submitted to Keio University Graduate School of Media Design,
in partial fulfillment of the requirements for the degree of
MASTER of Media Design

Valeria Levantino

Thesis Committee:
>   Professor Kazunori Sugiura   (Supervisor)
>   Professor Matthew Waldman   (Co-supervisor)
>   Professor Ichiya Nakamura   (Co-supervisor)

Abstract of Master's Thesis of Academic Year 2018

BAO-ME: Design of a Huggable Device to Improve Mental Well-Being through Haptic Interactions

Category: Design

Summary

Affective touch is an essential instrument in interpersonal communication, human development and emotional support. The experience of positive bodily contact plays a vital role in humans' psychological health. The sensation of being touched through physical embrace makes humans feel safe, more relaxed and less lonely. However, in the modern world, due to the nature of fast-paced daily life, there is an increasing absence of genuine haptic response between individuals. Moreover, the importance of touch has received little research attention and is difficult to objectively study. This research presents BAO-ME, a zoomorphic robot that is designed to help decrease stress levels and enhance feelings of support and companionship by recreating the sensation of being hugged through haptic interaction. This paper examines the ways in which humans who encounter BAO-ME, experience and interact with the device and how their conclusions compare to their preconceived expectations. Presented, is a user study in which volunteer participants were required to interact with BAO-ME and complete a total of six questionnaires in order to collect both quantitative and qualitative data. The results from the latter findings will provide insight in to all aspects of the user experience, thus assisting in redefining the future design of haptic robot pets and the benefits they contribute in human emotional well-being.

Keywords:

Affective Touch, Hug, Robot Pets, Haptic Interactions, Huggable Devices

Keio University Graduate School of Media Design

Valeria Levantino

Acknowledgements

First and foremost, I would like to express my gratitude to Professor Kazunori Sugiura for approval and full support of my master thesis. His guidance was truly important for my research and thesis writing. I also want to thank Professor Matthew Waldman for being an amazing co-supervisor and for guiding me through each steps of my research. Beside my supervisors, I also want to express all my appreciation to the Assistant Professor Roshan Peiris who helped with the understanding of the more technical part of my project. I am also grateful to have my fellow friend, Kaiyuan Lin, who supported me psychologically and helped me throughout the whole process. Another big thanks to Keitaro Tsuchiya who helped me in the technical realization of my final prototype. Thanks also to all my friends, my KMD fellows and people who were always there to cheer me up. Lastly, I am most grateful to have my mum and grandma that are my constant emotional anchor in my life and they are always there for me, no matter what. The completion of this research could not have been possible without the participation and assistance of so many people whose names may not all be enumerated. Their contributions are sincerely appreciated and gratefully acknowledged.

Table of Contents

TABLE OF CONTENTS

List of Figures

List of Tables

Chapter 1

Introduction

1.1. Background

Modern society is becoming increasingly competitive and it is thriving on performance and perfection, which leads to an insidious increase in stress and social isolation. Stress and isolation are two factors that are causing a lot of mental issues that are often underestimated. Several studies have found that one of the age groups that is more affected by such symptoms of stress and loneliness are young adults, who "stressed out" more than six hours a day. [12] In recent years, in countries such as Japan, a lot of young adults often move to the capital cities looking for more jobs opportunities. A lot of them also makes the decision to live in studio apartments alone by themselves. In a survey conducted as part of the Mental Health Awareness Weak, The Mental Health Foundation conducted a survey for more than 4,500 people and they found out that Millennials, those ages between 18 and 38, feel more under pressure in comparison to older adults. Young adults are finding it hard to cope manage their stress because they feel they do not have enough time for themselves especially in the early stages of their career. Every day life is always busy due the big amount of working hours and young adults do not have enough time to fully relax and socialize with their peers. Since a lot of them also live on their own, issues such as lack of social contact increases and it leads young adults to feel more stressed, lonely and isolated. Just as the lack of rest, food and water, the lack of social contact and affection leads to several problems. Previous studies have proven that people who are affected

by high levels of skin hunger are more likely to be less happy, sad and depressed, lonely and in general, in worse health. They tend to experience more anxiety and this also leads to a poor performance and effectiveness at work or university. Lack of physical contact has both psychological, physiological, and psychosomatic effects leading to symptoms such as fear, anxiety, sleep disturbance, fatigue and lack of motivation. When coping with stress and feeling of loneliness, being in contact with friends, lovers or pets seem to be a useful solution. However, it is not always possible to be in contact with the beloved ones, especially throughout a busy working day. Dealing with daily stress and feeling of isolation, requires a more effective and immediate approach that can help young adults facing such problems at any time of their daily life. Talking to other colleagues or chatting on the phone is often a solution in order to control such negative feelings.

1.1.1 Stress

Stress can be defined as, the inadequacy to handle a perceived threat to an individual's mental, physical and emotional well-being which results in a series of physiological responses [27]. This threat can be either positive such as the process of finding a job or a graduation, or negative, also called distress, with examples including work inefficiency or failing a university exam. Young adults can experience both positive and negative threats throughout their daily lives. Since university and work take a large portion of time in young adults' life, they consequently generate moments of intense stress. The way to handle working or university environment differs on individuals, and the level of stress that each of them experience is also different considering personality, sex, cultural backgrounds, ability to cope with issues, and other factors. It is hard to find a universal solution that solve people's daily stress. There is a series of previous research that analyze how individuals deal with work and university related stress and most often mentions social and physical contact with their peers. This type of interaction can be quite effective in generating a change of mind and improve people's mental well-being. Interacting with peers is good way to relax after those times of persistent stress, however, it might be difficult to constantly be surrounded by other people, especially during those moments where an individual might be alone facing certain stressful issues.

1.1.2 Loneliness

As a social species, humans always need a trusted social surround where they can feel safe and secure in order for them to live a healthy life. As soon as individuals perceive a certain level of social isolation or loneliness, their susceptibility and sensitivity increase and strengthen feelings of sadness and depression. Isolation and the feeling of loneliness often influence physiological and psychological functioning and they even increase mortality. [18] Loneliness is a common experience that 80 percent of young adults have reported to be affected by it. Loneliness is generally considered as a synonymous of social isolation. An interesting point is that, even if loneliness is identified as social isolation, people can still feel relatively lonely even if they are surrounded by family and friends. Loneliness is often defined as an afflictive feeling or a social pain that leads individuals thinking their social relations are deficient in some important way. Loneliness is typically measured by asking individuals to respond to a questionnaire such as the UCLA Loneliness Scale [26]: "I feel isolated," "I lack of companionship" and "I feel shut out and excluded by others." The results from this questionnaire generally indicate a range of scores that go from "very much socially connected" to "completely lonely". Each human being is predisposed to the feeling of lonely that consequentially leads to social disconnection and the hunger for social connection.

1.2. Motivation

Being a young adult can be a challenging moment throughout someone's life. It is the time of new discoveries, the moment that people need to assume their own responsibilities, finishing university, starting their career and leaving their families. This challenging moment can often influence the psychological health of young adults giving them feeling such being overwhelmed, lonely and stressed. Daily life can get busier and busier and there is not enough time to focus on social relationships. This leads to lack pf physical contact that can make people feel depressed and quite miserable. In this modern society, there is a big trend of a lot of young adults expatriating from their own countries looking to find new international experience. Living abroad, in a new culture where those young adults are not able to speak the language, can be very tiring and stressful. The

author of this research has personally experiences such challenges and difficulties. Living alone in an apartment in a new country without speaking the language, can be very upsetting. It is also very hard at the beginning to enter a social circle and make new friends. Owning a pet that can help releasing loneliness and stress is not always possible due to the fact that the majority of these young adults live in small rented apartments that do not allow any pets. But what can help alleviating such problems? As the Beatles have mentioned in one of their most popular songs, "all you need is love" in order to feel happier, less stressed and lonely. Hugging can be a perfect example as a form of love, that can help arising joy and happiness. The purpose of this research is to find a way to solve such problems related to stress and loneliness through hugging something anywhere and at anytime of the day.

1.3. Research Purpose

Maintaining a persistent state of mental well-being is a challenge for many young adults due to problems such as the feeling of being stressed and lonely. The purpose of this research is to design BAO-ME, a robot backpack shaped as a cute sloth that addresses the problems related to loneliness and exclusion by helping maintain a healthy mental state through haptic interactions that recreate the feeling of being hugged. By embedding the basic foundation of huggable devices and haptic interactions, BAO-ME allows users to experience a moment of affection and emotional warmth that can bring joy or happiness exercises almost anytime, anywhere. BAO-ME also provides an interesting and engaging way that motivates the users to hug it; it will call for their attention by vibrating over the straps so that it can manifest its love as soon as the users hug it back. BAO-ME is a robot pet shaped as backpack and will serve the purpose of carrying a companion anywhere and anytime on a daily basis. One of the main goals of BAO-ME is to provide effective emotional sensations to the users. However, it also represents an everyday object that can make daily life more playful. BAO-ME is designed both as a cute animal companion that users can hug and play with and practical backpack able to carry their personal belongings around. In order to create an effective huggable device, observational research was conducted on how people

hug and how young adults deal with feelings of loneliness and stress.

Serving as a quick solution to daily stress and feeling of isolation, BAO-ME therefore has to be designed to be easily accessible and act as a cute pet/companion that can help in daily stressful situations. It will be designed as a backpack that users can easily carry around and interact with during a short break or access it during their commute, to relax and feel less lonely. BAO-ME transforms lonely and stressful days into more playful and comforting interactions. By using BAO-ME, not only the users can hug a cute pet companion, but also they can also receive tangible health benefits by reducing their stress and loneliness levels.

1.4. Objective and Hypothesis

The objective of this project is to design a robot pet bag as a huggable device that can help reducing stress and loneliness levels throughout people's daily life. The sloth animals has been chosen because it resembles the idea of a relaxed type of life. A bag has been chosen because of its practical daily use. And lastly a huggable device has been chosen because it is proven that haptic interactions can bring comforting feelings and emotions to potential users. The hypotheses proposed here is that using a huggable device such a robot pet backpack can decrease stress and loneliness levels.

1.5. Research Structure

- **CHAPTER ONE (INTRODUCTION)** introduces stress and loneliness and their context, the motivation of this project and its purpose.

- **CHAPTER TWO (RELATED WORKS)** presents the literature review and related works about the psychology of emotional touch and hugging, affective haptic technology, huggable devices and human-robot pet interaction.

- **CHAPTER THREE (DESIGN PROCESS)** explains the design concept, including the target persona, user scenarios and concept sketches.

- **CHAPTER FOUR (IMPLEMENTATION AND EVALUATION)** describes the prototyping process and and analyzes the data using evaluation method.

- **CHAPTER FIVE (CONCLUSION)** concludes the result of the evaluation and discusses its limitations and future works.

Chapter 2

Literature Review

As mentioned in the previous chapter, the aim of this research is to design a zoomorphic robotic bag that can help decreasing stress levels and managing the feeling of loneliness by combining affective touch through haptic interactions. The literature review is focusing on three different aspects that are related to the topic of this research. In the first part, the literature review will focus on the psychological meaning of touch and how hugging can release oxytocin levels and improve people's well-being. The second part will mainly talk about the area of haptics and mediated tactile touch seen as a good affective communication tool. The last part will explore the concept of human-robot interaction and how pet robots are considered as an alternative way for pet therapy in places like hospitals or care homes.

2.1. The Psychology of Emotional Touch

According to some of the researches from Harry Harlow, a well-known American psychologist (1959), touch is one of the most important elements that living beings develop in the earliest stages of life as embryos. [17] In the article from Dressler, the "Psychology of touch"(1984) [8] it is noted that skin is the most important organ of our whole body. When the eyes cannot see in the dark and the ears cannot hear any sound, the only sense that allows humans to still be able to re-create feelings and sensations through the whole sensory system, it is touch. Touch is the most powerful non-verbal communication that allows humans

to express their own emotions and distinct feelings. It is interesting how people can distinguish emotions just by the feeling of being touched. [19] Harlow's studies on the nature of love, have confirmed that touch plays an important role on the development of interpersonal communication. It is proven that human need physical contact as much as they need to have food to survive. [16] Emotional touch is simply defined as the action of placing your hands or getting close to someone in order to show them empathy and affection. [34] Previous studies have proven the importance of touch between parents and children throughout their early stages of childhood. This leads the child to maintain a good emotional well-being that can lead to capacity of living a healthier life in their adulthood. [2] In the article "The effect of Interpersonal Touch during Childhood pd Adult Attachment and Depression: A neglected areas of family and developmental Psychology" [2], the experiment conducted proves that the way children perceive a touch from their parents, it is always seen as a way to communicate their love, affect and protection. For the child this is an important factor because he develops a higher sense of security and trust. Another study has also demonstrated how infants who receive more interpersonal touch and physical contact with their parents, are more likely to perform better in life. They are also less exposed to the development of depression and anxiety compared to the infants who received inconsistent physical contact and support from their parents. [1] Clinically, the sense of touch is also important in nursing care homes. Touching an ill patient is an essential element for his emotional stability and overall wellbeing among older adults. [5]

2.1.1 Hugging as a Stress Relief

As part of the sense of touch, hugging is a type of endearment that consists on two individuals putting their arms across each other's bodies in order to get closer. Numerous studies have demonstrated that positive physical contact such as hugging decreases blood pressure and cortisol levels caused by stressful factors and increases oxytocin levels, also known as "love hormone" or "cuddle hormone" (since it is released when individuals bond together). [14] Ditzen et. Al also examined how hugging a partner reduces cortisol levels and the feeling of being stressed on women. [32] It has also been demonstrated that not only hugging not only influences health status but it also induces altruistic and pro-social behaviors.

In the book "Pro-social development: a multidimensional approach" (2015) [3] an experiment was conducted in a school to induce pro-social behavior on elementary school children. Teachers were asked to use physical reinforcement such a hug as soon as a child behaved. As a result of this experiment, the children's pro-social and altruistic behavior significantly increased. Apart from human to human hug interaction, in another study from the article "touching a teddy bear mitigates negative effects of social exclusion to increase prosocial behavior" (2011) [33] it is proven that hugging an in-animated object such as a teddy bear, eases the feeling of exclusion and decreases stress levels, suggesting that even in this case oxytocin levels are released just by simply getting closer to a stuffed animal. Because stuffed animals represent the idea of a real pet, it is interesting how in another article "Attachment of people to companion animals. The Veterinary Clinics of North America. Small Animal Practice" (1985) [38] it is stated that humans' tendency to get attached to animals it is because they convey a sense of well-being and security. Based on these findings, it is interesting to explore the area of hugging an in-animated object such a stuffed animal and examined how humans react towards it.

2.2. Affective Haptic Technology

According to the article "A guided tour in haptic audio visual environments and applications" (2007) [9] haptics, is a term that comes from the greek verb "haptesthai" that means to touch. It is the technology of adding the sensation of touch and feeling to computers. When virtual objects are touched, they seem real and tangible. Haptic senses links to the the brains sensing position and movement of the body by means of sensory nerves within the muscles and joints. Despite the fact that touch is considered one of the most important senses of the human's body, research still has not paid a lot of attention towards this sense and how to use it communicate affection. [20] To communicate affection, a research area that is defined as affective haptics is focusing on the acquisition of human emotions through via tactile sensors and haptic interfaces. On the paper "Affective Haptics: Current Research and Future Directions" (2007) it is stated that affective haptics focuses on how users emotionally react to haptic stimuli and feedbacks. [9] It is

also proven that psychological health will benefit from the use of affective haptics since it is able to recreate the sense of touch and physiological reactions such as heart-beat, breathing, body-warmth etc. [37] In relation to the beneficial outcomes in the area of mental health, affective haptics and emotional communication has started to focus on the use of social robots such as robot pets for health therapy and personal assistance. [41] In accordance of previous studies, it is possible to notice that affective haptics is an interesting field that needs to get more attention since it is proven that is has beneficial effects on humans' life. This research will take into consideration the field of emotional communication and affective haptics in order to further explore the possibilities of reducing daily stress, feeling of loneliness as well as isolation.

2.2.1 Affective Haptics through Tactile Touch

Tactile interfaces that are used for expressing emotional communication are often represented as objects, wearable devices or robots. [9] A few research has been done towards robots that can communicate emotions and can express their feelings with humans.

Figure 2.1: The Haptic Creature

For example the **Haptic Creature** (Figure 2.1) is a touch-centric robot that mimics an animal sitting on a person's lab. The device reacts towards the modality of touch in order to express itself through stiffing its ears, breathing and purring. The combination of these different haptic stimulations are proven to bring positive emotions to the people using the Haptic Creature. Throughout the experiment

10

users felt the haptic creature could be their pet companion with which they have a close and emotional relationship with. The device was also able to reduce anxiety levels on the users who experience the creature's active breathing. [42]

Figure 2.2: The Hapticat

The Hapticat (Figure 2.2) is a device developed for observing the effects of haptic feedbacks on humans. The Hapticat is a relatively zoomorphic robot that borrows behaviors from different pets. The main focus is to recreate the tactile type of interactions that a cat generally gives such as its warmth, body-weight, vibrations from purring and other small movements. The Hapticat will express itself when the user starts to interact with it. It is able to reproducing five distinct responses such as "asleep, playing dead, content, happy and upset". These responses are accomplished by selecting those mechanism such as breathing, warming-up etc. [40]

Figure 2.3: Qoobo, the robot cat pet

Qoobo (Figure 2.3) is a therapeutic robot from Yukai Engineering, that resembles the idea of a cat. It is a cushion with a tail that mimics the motions of

a tail by waving and swinging it as soon as the user starts to stroke the pillow. Its playful way of communicating its emotions, provides a sense of comfort to the users. Yukai Engineer is trying to design a minimalistic looking robot cat that can provide that sense of joy that only animals can give. [25]

Figure 2.4: Nene

In the paper "Nene: an interactive pet device" (2027) [21] from a fellow student from Keio Media Design, **Nene** (Figure 2.4) is an interactive therapeutic device that is able to transmit real time simulations of a pet through different tactile simulations such as temperature, sound and vibration. This is a research is investigating the beneficial effects of robot pet therapy on humans in order to decrease stress levels and reduce the feeling of loneliness.

According to the previous studies, it is noticeable to see how these current products which have been testified with a different range of users, are able to give a sense of comfort and relaxation. By using different tactile interactions, such devices are providing a whole range of emotional experiences that can be beneficial in cases of mental stress and sense of isolation.

2.2.2 Huggable Devices

Huggable devices stands for those type of haptic inventions that are providing the feeling of being hugged. Many researchers have been focusing on how to incorporate the feeling of being hugged within technology by recreating different

emotional experience that only a hug can transmit (such as the warmth of a hug, the pressure of the arms over someone's body, the breathing, the heart-beat etc). In the paper "A Hug from a Robot Encourages Prosocial Behavior" (2017) [30] presents the effects on people when they are being hugged by a robot. A teddy-bear looking robot has been designed and it is able to give reciprocal hugs to people. At first the robot asks the participants to give it a hug and then it asks if they want to make some donations.Through their experiment, it is showed that the interaction with the robot teddy-bear encourages pro-social behavior since participants were more likely to make a donation after being hugged. This huggable haptic interaction proves to have positive effects on people mental health and behavior.

Figure 2.5: Sense-Roid

Some Japanese researchers have designed a wired torso-shaped device that is able to hug users. This device called the **Sense-Roid** (Figure 2.5) [28] looks like a mannequin that is packed with pressure sensors. It is further connected to a jacket worn by the user that replicates the hug through the help of air compressors. The Sense-Roid recreates the illusion of a mutual hug through artificial muscles and vibrating devices that are meant to give a comfortable and pleasurable feeling to the user.

Figure 2.6: Bubsy vest

Bubsy vest (Figure 2.6) is another huggable product from a Pratt research student, who has been focusing on anxiety and mental health and how to prevent such negative feeling through a simple hug. He designed a vest with a teddy bear coated in polyurethane vinyl to recreate an inflatable bladder. As the user inflates the teddy bear, the vest starts to inflate around the waste. Depending on how much air will be inflated, the user will more likely to experience different kind of pressures that resemble the idea of a firm type of hug. When the vest is fully inflated, the wearer can also hug the bear.

In conclusion it is proven how receiving a hug from a robot or a device can still be able to recreate a comforting hugging experience that is more likely to calm the user down.

2.2.3 Huggable Devices for Communication

In many cases, huggable devices are used as a form of communication between two or more people. Such devices are designed to enhance physical intimacy in the remote interaction between people. It is also demonstrated that hugging a huggable communication medium reduces the cortisol levels in blood and it also produces an effect at the endocrine level. From these findings, it is proven how physical contact with such devices can be effectively used for mental stress relief and feeling of isolation. [32] In the paper "HugMe: An Interpersonal Haptic Communication System" (2008) [6], a design for synchronous haptic teleconferencing system with touch interaction is presented. This system called HugMe is able to make remote interactions more intimate whenever two people cannot

physically meet. The system uses a force feedback device that the user can touch to remotely connect to the other user who, in turn, can feel the touch through a wearable jacket. This jacket contains different vibrotactile actuators, a temperature sensor and a heartbeat sensor in order to display a few of the most important emotions such as love, joy, surprise, anger and sadness.
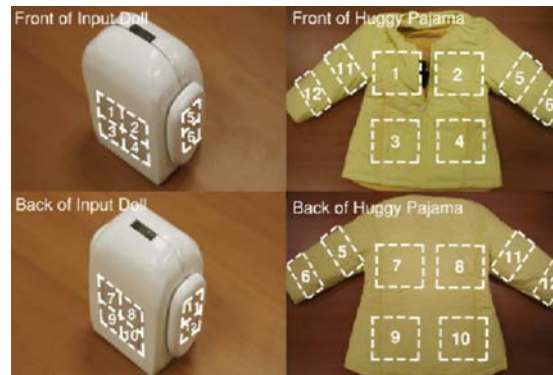

Figure 2.7: Huggy pajama

In the paper "Huggy Pajama: A Mobile Parent and Child Hugging Communication System" (2008) [35] some researchers from the National University of Singapore focus on the study of the **Huggy pajama** (Figure 2.7), a wearable system designed for promoting physical interaction between parents and children when they are not physically together. This system consists of an interface device and a wearable jacket that reproduce a the sense of being hugged.The hugging device is a small, mobile doll with an embedded pressure sensors that are able to sense different pressures of the human touch. This device sends hug signals in turn to a haptic jacket that simulates the feeling of being hugged to the wearer. This last one is designed with air pockets that when actuated, they are able to reproduce a hug. It also has a heating element to produce the sense of warmth that generally hugs transmit, and a color changing pattern. It is proven that remote haptic interaction may be a good alternative when the parent must be away from home due to busy work schedules. Although this system is not intended to replace a real physical hug, is still proven to be a great benefit for remote communication between parents and children. Based on this previous research, a final product named Tjacket [36] has been designed and used in occupational therapy centers

for children. This jacket simulates the feeling of a hug with applied air pressure in order to calm and soothe the nerves of stressed infants. It is also able to recreate different types of deep touch pressures by choosing different pressure programs on a mobile application.

Figure 2.8: Parihug

Parihug (figure 2.8) is another example of a huggable plush creature that allows to electronically connect to two lovers, parents or friends by hugging each other from a distance. The two users can be on different sides of the world but they are still able to feel each other's presence by hugging the bear. When the stuffed animal get squeezed, it will send a soothing haptic vibration to manifest a haptic tele-presence.

Based o these finding it is interesting to notice how huggable devices for remote communication can still be an efficient way to express people's emotions via tactile sensors.

2.3. Human-Robot Pet Interaction

Human-Robot Interaction (HRI) is a field of research that focuses on understanding and evaluating the use of robots with humans. Interaction, by definition, requires a form of communication between robotic devices and humans. Several studies have demonstrated how a robotic companion that is able to display emotions through haptic interactions (such as vibrations, movement, temperature etc), can have positive and therapeutic effects on humans, especially those who can be effected by any form of mental health problems. [31] Being touched by a robot also

increases people's motivation and effort during monotonous tasks to the point that are more likely to find a small form of excitement. [29]

2.3.1 Robotic Pets

Robotic pets are a sub-genre of socially interactive robots which are designed to communicate emotions and interact with humans. Socially interactive robots are becoming increasingly more important as robots are considered to have beneficial repercussion on humans' life. Numerous studies have also showed how long-term interaction with animal-like robots have positive psychological effect on elderly people. [39]

Figure 2.9: Paro robotic seal

An example can be **Paro** (Figure 2.9) [22], an advanced interactive robot in a form of a white seal. It is used as a device in alternative of assisted animal therapy at places such as hospitals and care homes. The robot is developed in the way that it recognizes and learn how to behave in accordance to the user's decisions. For instance, if Paro does a certain action and it receives a stroke, it will remember that as a good action and repeat it. Vice-versa if it get hit, it means that action was bad and it will not repeat it again. Thanks to this ability, Paro resembles more the idea of a living animal. Paro has been recognized to reduce elderly people's stress, improving their relaxation, motivation and socialization with caregivers at the rehabilitation centers or care homes.

Figure 2.10: Sony Aibo

Sony Aibo (Figure 2.10) is another perfect example of social robot.Sony Aibo is a dog with extremely robotic features that a series of sensors and cameras to understand both its environment and the interactions with its user. In the article "Robotic Pets in Human Lives: Implications for the Human━Animal Bond and for Human Relationships with Personified Technologies" (2009) [23] Aibo is considered as a potential substitute of a real dog and it plays an important role as a perfect artificially intelligent and social companion. Studies have also confirmed that that children and adults often treated Aibo as if it were a living dog. Adults owning Aibo developed a form of attachment towards it to the point that the even treat him as a real dog.

In relation to these studies, it is revealed both that robot pets can be an effective substitute for a living companion animal or Assisted-animal therapy.

2.3.2 The Uncanny Valley

The concept of the uncanny valley, an hypothesis postulated by by Japanese robotics professor Masahiro Mori, (figure 2.11) is related to human-like robots which appear almost, but not exactly, like real living beings. This leads to a strangely familiar feeling of revulsion in the observers. Specifically, when robots appear almost exactly human, people experience a series of mixed up feelings that causes a sense revulsion and creepiness. However Fong et al. [11] postulated that zoomorphic looking robots may suffer less from the "uncanny valley" because the relationship between humans and animals are less complicated.
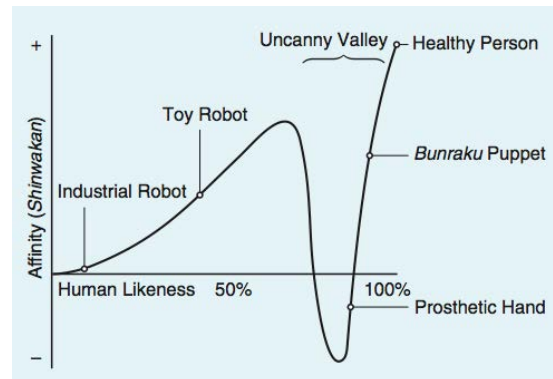
Figure 2.11: The Uncanny valley

Based on these studies, in order to avoid the pitfalls of the uncanny valley, this research will explore further different types of haptic interactions that never approximates realism.

2.4. Contribution of this Research

This research addresses the issue of stress and loneliness problems among young adults, and aims to create a huggable communication device in order to reduce negative feelings. BAO-ME approaches the concept of haptic interactions, huggable devices and social pet robots to offer a new solution to reduce stress levels and feeling of loneliness and isolation. BAO-ME will not only give users the chance to hug a companion anywhere and anytime they want throughout their daily life, but it will also help the users improving their quality of life and their psychological well-being. Hence, the success of this research can contribute further research on the field of haptic interactions devices and pet robots for people who may suffer from any type of mental issues. The design concept and process will be further explained in the next chapter.

Chapter 3

Design Process

The aim of this research is to help users reduce their levels of daily stress and lack of physical contact in a more playful and accessible way. Users will be able to easily carry a robotic backpack anywhere they want to and interact with it at any time of the day. By recreating the sensation of a small hug through haptic feedback, the users will manage to soothe their nerves and flourish their well-being. Throughout the design process is important to keep in mind that the final goal of this research is to focus on what users need in order to feel less stressed and lonely. In this chapter, the design concept, user research, process and implementation will be introduced. The first section will discussed about the concept and the initial idea. The second part will focus on the user understanding and the overall design process. Lastly, the final section will mainly focuses on the design limitations and its implementations.

3.1. Design Elements

BAO-ME is a robotic backpack in the shape of a sloth aimed for young busy adults who can encounter stressful situations during their daily lives. By slightly hugging them and making them feel there is always a constant presence with them, BAO-ME helps reducing stress and the feeling of loneliness. It is a representation of a cute pet that is always there, ready to cheer the user up in a more playful and fun way. It is the perfect companion that it is always possible to bring around since its purpose is also being a backpack. Based on the analysis of previous

research, the recreation of the sensation of touch, the vibration, the heart-beat and the warmth through a robot pet, are a good solution for fighting against the feeling of loneliness and stress. The design of the backpack consists of these main important features:

1. A vibration mechanism across the straps that represents a call from the sloth trying to catch the attention of the users and making them believe it is asking for a hug and some affection.

2. The vibration mechanism is always unexpected. The user does not decide when the backpack vibrates and calls for a hug. The reason why this is happening is because BAO-ME is supposed to have its own personality and freedom to manifest its emotions and interaction whenever it wants to. The autonomy of BAO-ME also leads the user to believe the backpack has its own personality and it is like a real living creature.

3. When the users hugs the sloth backpack back, the sloth will show his love and affection by the sound of his heart-beat through a music speaker embedded in its chest.

4. When hugged, the "body" of the sloth will slowly increase its temperature and warm up recreating the feeling it is alive.

5. Crossed shoulder straps that can make the backpack wearing more comfortable. This also resembles the idea of two long arms trying to hug the user.

6. The backpack can be worn in the front side or in the back depending on the user's preference.

7. The "head" of the sloth backpack can be used to lay user's head on it as if it is a small cushion.

3.1.1 Backpack: Daily Object

Bags in general are easy to carry around and they are considered as an extra attachment to people's body. Like kangaroos have a marsupium (pouch) to carry

their babies, humans use bags to carry their personal belongings. In the early development of human civilization, bags were used in order to carry seeds and fruit. [4] In the modern days, bags serve different purposes and usage such as:

- Practical usage: People carry bags to go to work, school, travelling, grocery shopping etc.

- Status symbol: Many men and women use bags to show their social status, style and individual identity. [15]

Bags also come in different shapes and different materials. There is a wide selection of bags depending on the user's purpose. Backpacks in the case of this research, are mainly used to carry more objects or heavier loads. Backpacks are generally considered safer to carry around since they are secured with two straps that go over people's shoulders. (Figure 3.1)

Figure 3.1: Japanese girl wearing a backpack

3.1.2 Sloth: Symbol of Relaxation

Sloths are arboreal mammals that mainly live in the tropical areas of South America. Sloths are known for their laziness and slow movements. They spend the majority of their time hanging on tree branches. [13] Since they are well known

as slow and lazy animals, sloths resemble the idea of a relaxed type of life. Since part of the purpose of this research is to reduce stress levels, sloth can be a perfect example from the animal world that can transmit a calmer feeling. Sloths became very popular because of the internet and media. This is also one the reasons why a lot of people started to like them as their favourite kind of animal. In the recent years a lot of animated films have as one of their protagonists, a sloth. They are often represented as cute, friendly and funny creatures. Their funny shape of the body and their long arms, also make sloths as perfect animals to hug. (Figure 3.2)

Figure 3.2: A brown-throated sloth hugging a child

3.1.3 Hug: Expression of Affection

The reason why BAO-ME has chosen the recreation of the concept of hugging is because of its notorious healing powers against stress. As mentioned in the previous chapter, numerous studies have demonstrated that hugging decreases blood pressure and cortisol levels caused by stressful factors and increases oxytocin levels. [14] Hugging BAO-ME will help easing the feeling of exclusion and decreases stress levels, suggesting that even in this case oxytocin levels are released just by simply getting closer to a stuffed animal.

3.2. Fieldwork Research

The research has started with the aim of recreating a daily object that through haptic interaction is able to personify a cute and cheerful companion for busy young adults. To understand how young adults try to cope and deal with the feeling of daily stress and loneliness, a fieldwork and two observations were conducted.

Figure 3.3: Sakura

Fieldwork 1 This first fieldwork was conducted on April 18th on Sakura Niimi. Sakura is a 25 years old Japanese girl who was born in Nara and moved to Tokyo two years ago to start her new job. She graduated at the age of 23 and now she has started working as a full-time job recruiter. During a one-to-one interview, it was asked her to talk about her previous day at work. Now that she is in Tokyo, Sakura lives alone by herself. When she was living back in Nara, she used to live with her family and a dog. Since she moved out from her home, she said that one of the things she misses the most is her pet. Having a dog was a

way for her to stay more positive. She also used to enjoy going for a stroll around
the parks with her dog. Throughout the interview, she mentioned that recently
she has been stressing a lot because of her full time job. Her boss often ask her
to stay until late and she always feel very tired. Since she finishes working late,
she does not get to go out with her friends. Throughout her day at work, Sakura
often feels lonely and overwhelmed and the only way for her to release her tension
is by video-calling her sister during her lunch break, while she is eating. Her sister
often shows their dog on the video-call and that always helps Sakura feeling more
relieved. On her way back home, she often falls asleep on the train if she can find
an available seat. Lying her head on her bag and covering her face is a good way
for her to find her own relaxing and comforting zone. At night when she is back
in her apartment, she video-calls her whole family while hugging a dog stuffed
animals and watching TV.This helps her feeling she is not alone. A flow model
and a mental model were created to analyze all her interactions throughout the
day. Family, pet and video-calling were the most frequent words used by Sakura
to describe what can help her releasing all her daily stress and feeling of loneliness.
Her family and her pet are one of the most important figures on Sakura's life and
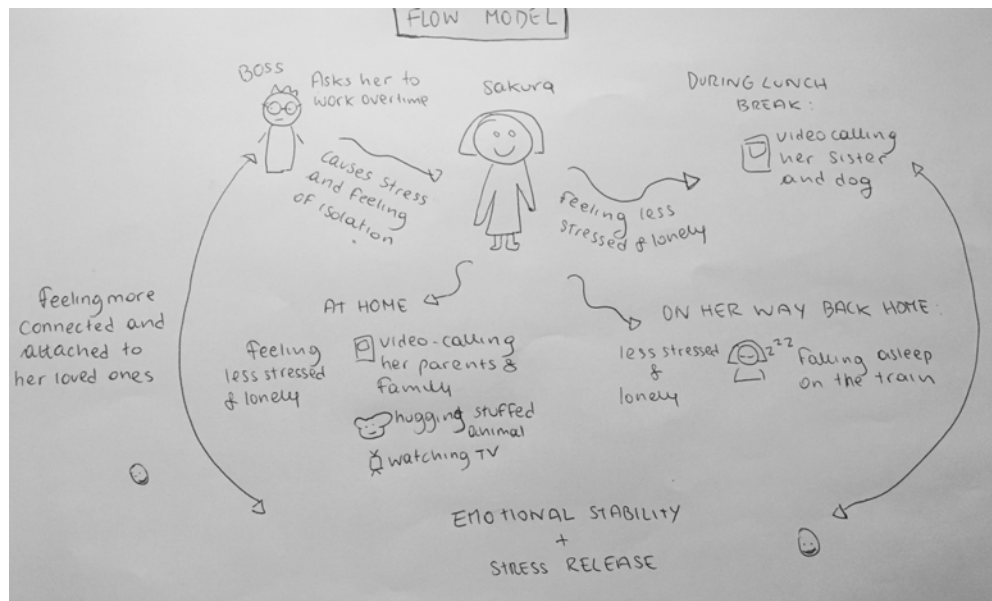it is important for her to always feel their love and their presence.

Figure 3.4: Sakura's Flow Model

SAKURA'S MENTAL MODEL

LISTENS TO HER BOSS

SEES NO FRIEND

SEES HER SISTER AND DOG

EATS FOOD

SLEEPS ON THE TRAIN

SEES HER FAMILY

TOUCH STUFFED ANIMAL

WATCH TV

FEELING STRESSED

FEELING ISOLATED

FEELING NOT LONELY

FEELING HAPPY

FEELING MORE RELAXED

FEELING LESS LONELY AND STRESSED

FEELING NOT LONELY

FEELING NOT LONELY

Figure 3.5: Sakura's Mental Model

Figure 3.6: Demi

Fieldwork 2 While travelling to Shanghai, the second fieldwork was conducted on Demi Wang, a 25 years old Chinese female who is originally from Qingdao. Demi Wang is an assistant manager for an Investment and Re-Financing firm in Shanghai. The fieldwork took place on the 23rd of April and it was possible to observe Demi throughout one of her daily working days. She mentioned several times that she often feels isolated from the rest of her collegues. Since she is one of the youngest within her team, they often treat her as an outsider. This also leads her to a lot of psychological stress because she does not feel fully part of the team. One interesting point about Demi is that she keeps a small stuffed seal on her desk that reminds her of her best-friend. During the fieldwork, she had to complete a lot of different tasks that her boss required to be done within the same day. She mentioned that looking at the small stuffed animal seal helps her going through a tough day. She feels more motivated to complete her tasks because she feels her best-friend is thinking about her and she is constantly with her. During her lunch break, Demi meets up with one friend who works in the same area as hers. Interacting with her friend during her lunch break helps her releasing all her stress. Demi also mentioned that a simple physical contact such as a hug or

a pat on her shoulder from a friend, helps her staying more positive. In the flow and mental model, Demi's actions are indicated. Interacting and hugging are the two most frequent verbs that Demi kept mentioning throughout the fieldwork. In order for Demi to relax during her daily life, it is important for her not to feel lonely.
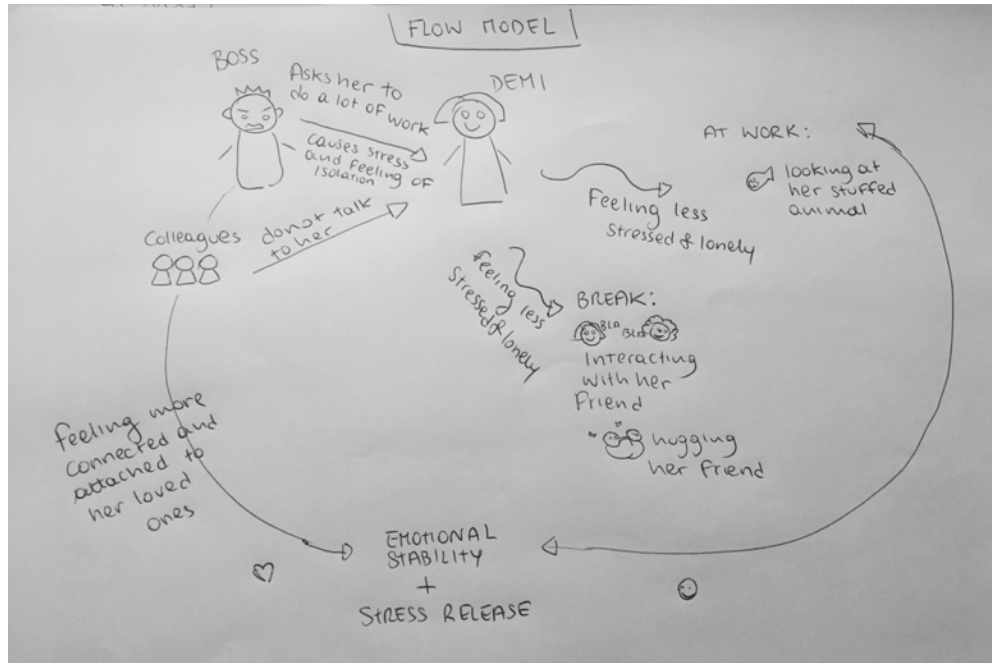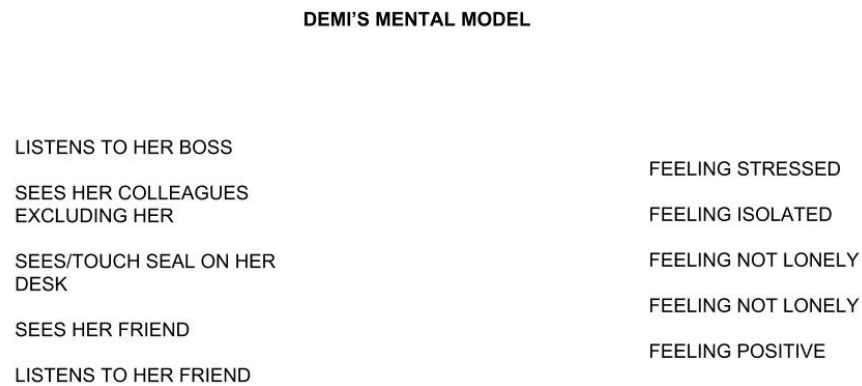
Figure 3.7: Demi's Flow Model

DEMI'S MENTAL MODEL

LISTENS TO HER BOSS

SEES HER COLLEAGUES
EXCLUDING HER

SEES/TOUCH SEAL ON HER
DESK

SEES HER FRIEND

LISTENS TO HER FRIEND

FEELING STRESSED

FEELING ISOLATED

FEELING NOT LONELY

FEELING NOT LONELY

FEELING POSITIVE

Figure 3.8: Demi's Mental Model

Conclusion Throughout the two fieldworks conducted in Tokyo and Shanghai, it is possible to analyze and determine a few main key points that the two potential users often mentioned about :

- In order for them to relax, they need to interact with their loved ones.

- Having a stuffed animal is a way to feel less lonely throughout their day.

- Hugging is an important factor for both of them; Sakura hugs her stuffed animal while Demi hugs her best-friend.

- Feeling connected and attached to someone they love are two important aspects that help them reaching a certain level of emotional stability.

After analyzing and observing those two potential users' flow and mental models, a final fieldwork was conducted to understand in more depth the concept of hugging.

Final Fieldwork The final fieldwork was based on a group interview with five people from four different countries. Their age group was between 24 and 28 years old. They were three women and two men. All of them were either graduate students or fresh graduates who recently started their jobs in Japan. The interview took place after their university and working hours. It was asked them to hug with each other and describe their feelings after receiving a hug. Before the observation, everyone stated that they were all very tired and stressed after a whole day spent at university or at the office.

- Charles, a researcher student from Taiwan admitted that he always need a daily hug. He likes different types of hugs pressure. He likes the feeling of getting close to somebody.

- Lana, a graduate student from the United Kingdom, admitted that she really enjoyed hugging someone after a long day spent at university. She mentioned that she generally likes gentle hugs where she can feel the presence of someone being next to her.

- John, a graduate student from the United Kingdom, said that since he moved to Japan he lacks of physical contact. He also lives alone and he does not get to interact much with people throughout his weekdays. He mentioned that he wish he could get to hug more during the day.

- Daniel, an intern from Sweden, said that after a stressful day at his workplace, all he wants is just to go back home and hug and cuddle with his partner.

- Shaina, an English teacher from the USA said that she really enjoys hugging. She also mentioned that whenever she feels lonely and stressed, she hugs a teddy bear that his grandfather bought her when she was young. She said that this teddy bear means so much to her and it is a representation of the love between her and her grandfather.

In conclusion, this final fieldwork confirmed that the action of hugging something or someone, is a good way for releasing stress and encourage people to keep being more positive and relaxed.

BAO-me will be designed in accordance to the understanding of this final observation.

3.3. Target Persona

Based on the previous observations, the ideal target persona was created to better define the user group and develop the design and the purpose of BAO-ME. Among the potential users, Jodie Wong was selected to represent the target persona. Figure **??**

Figure 3.9: Target Persona: Jodie Wong

Jodie Wong is a 24 years old female originally from Hong Kong who recently moved to Japan to teach English language to young children. She graduated in the UK and she studied English Literature and Japanese language minor. Her aspiration is to become a professional writer for children's books. She moved to Tokyo on 2017 and she is planning to live here in Japan for a longer period of time. She thinks that working here in Japan with children is good for her future career goal. When Jodie used to live back in Hong Kong, she used to own a dog. She

said her dog was her perfect companion always ready to calm her down. She also found very relaxing to take her dog out in the evening for a stroll around her area. But since she moved to Japan, Jodie does not have any pet anymore and she lives alone in a small apartment in Saitama. She also has to commute every day for about 45 minutes to go to work. She admitted that she really does not enjoy the long commute to work and she also mentioned that working with children can be very stressful. After a long day at work, she always needs to commute for another 45 minutes to go back home. Jodie generally arrives at home around 7.30pm. She is finding difficult for her to fully relax and enjoy her friends' company. Jodie does not have enough available time during weekdays and commuting takes a lot of her time. In order for her to relax, especially during weekdays, she needs a solution that can help her emotional stability.

3.4. User Scenarios

Three users scenarios were created to describe the occasions where the users will use BAO-ME and how they will interact with it.

1. **During work or lecture break**

Figure 3.10: Tired during work or lecture

In this first scenario the users can be at work or school. If they are tired and stressed they can use BAO-ME in order to calm down and find some comfort. The user can start hugging BAO-ME will sitting and the feeling of warmth and heart-beat will help the user relaxing. The head of BAO-ME can also be used as a pillow where the users can lay down their head.

2. **While Walking Outside**

Figure 3.11: Tired during work or lecture

This is the scenario where BAO-ME is simply used as a normal bag to bring around. In this occasion, BAO-ME's function will mainly be the one of carrying it around and its haptic interactions and functions will most likely to be ignored. If BAO-ME starts vibrating because it is calling for attention, the user can decide to ignore it or interact with it and start hugging it.

3. **While Commuting in the Train**

Figure 3.12: While walking around

In this scenario, the users will use BAO-ME while commuting. This moment of the day can be very tiring and stressful especially if the commuting time is quite long. BAO-ME can be worn on the users' lap and it will detect that the users are sitting down. This is when BAO-ME will activate its hugging function. By detecting that the user is still, the straps will start vibrating in order to call for the users' attention. The users can decide if hugging BAO-ME or not. If BAO-ME will be hugged, it will detect that by the pressure sensor on its back and it will show his affection by warming up and activating its heart-beat.

3.5. Ideation

To come up with the final concept, three steps have been taken int consideration.

1. First Sketches

2. Rough Prototyping

3. User Understanding

4. Final Sketches

Based upon this initial design process, the final concept was realized by brainstorming and drawing different initial sketches, creating a rough first prototype and conducting a user understanding to analyze their opinions and reactions towards the overall idea.

3.5.1 First Sketches

The first sketches represent the overall idea of BAO-ME.

- This first sketch (Figure 3.13) shows how BAO-ME would potentially look like. The arms of the sloth are supposed to represent the straps of the backpack. When the users wear the bag, the straps/arms of the sloth are supposed to cross over their chest, to recreate the feeling of the longs arms hugging them.

Figure 3.13: Overall look of BAO-ME

- On the second sketch it is shown how the potential user will wear BAO-ME when it is placed on the back. The straps/arms will hug the user from behind resembling the idea of a hug from behind. The arms will form a cross on the chest.

Figure 3.14: Front look of BAO-ME

- The third sketch shows how BAO-ME looks like when the wearers place the bag in front of them like holding a child. When placed on the front it is when the whole haptic hugging process will take action. This is the standard way to wear BAO-ME.

Figure 3.15: Back look of BAO-ME

3.5.2 Rough Prototyping

Figure 3.16: First rough prototype of BAO-ME

By making a rough prototype, the concept made in the previous initial sketches was tested. A simple soft pillow with two straps attached to it was used to simply verify if the users were understanding the overall concept. By mechanically pulling the straps, it was possible to recreate the feeling of a moving mechanism in order to make the users feeling like the straps were trying to move and hug them. A small heating pad was also placed inside the pillow in order to test if the users like the concept of the bag heating up. After briefly testing the concept, more ideas were taken into consideration.

3.5.3 User Understanding

The rough prototype was tested with six female participants from six different countries (Mexico, Morocco, Indonesia, China, Thailand and the USA). The overall concept was fully understood and all of them expressed a positive reaction towards the idea. They were asked to sit on a chair and hug the pillow. After that the straps were manually pulled from behind. Subsequently, they were asked to hug the pillow close to their chest in order to feel the warmth from the heating

pad that was placed inside. The results were promising, all the users liked the idea of a backpack trying to hug them and comfort them, however they were not sure about the straps movement and they felt they wanted more interaction and connection with the sloth.

3.5.4 Final Sketches

Based on the initial sketches and the user understanding of the first prototype, the final sketch was realized.

- As shown in Figure 3.17, this is how BAO-ME will look like on the front side. The head of the sloth will function as a comfortable pillow where the potential users can lay their head down. Across each straps, four actuators are placed to recreate a feeling of vibration like BAO-ME is calling for your attention. On the upper body of the sloth a speaker will be placed to recreate the sound of the heartbeat. On the lower part a heating mechanism is placed in order for BAO-ME to warm up as soon as it gets hugged back by the user.
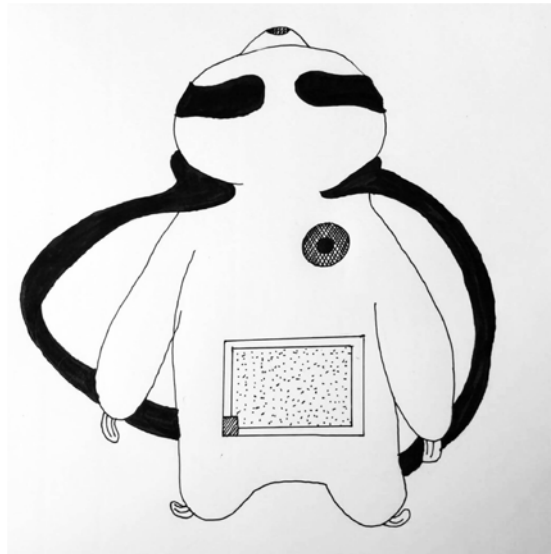
Figure 3.17: Final sketch front part

- The back side of BAO-ME is where the backpack will be attached to in order to put all the items inside. Moreover a pressure sensor will also be placed so

that the heating and heart-bit mechanism will be activated as soon as the user touch the backpack.

Figure 3.18: Final sketch back part

3.6. Design Summary

In this chapter, the concept of BAO-ME was first defined, then fieldwork and ethnography research were analyzed to understand the potential target users. Sketches, ideation a rough prototype were then conducted, at last the detailed sketches and two working prototypes will be developed between back and forth reviews from potential users. To summarize, BAO-ME is a robot pet bag that aims to improve mental well-being by recreating the feeling of being hugged through haptic interaction.

- Users can easily carry BAO-ME around, anywhere and anytime they want throughout their daily life.

- Through haptic interaction, BAO-ME can hug, comfort the user in a more playful way.

- Using BAO-ME will help the users feeling less stressed and less lonely.

The experiment and evaluation results of the prototype will be further discussed in the next chapter.

Chapter 4

Implementation and Evaluation

BAO-ME is a robot pet bag for young busy adults that it can be used anywhere, anytime, when in stressful and negative conditions. By recreating the sensation of being hugged through haptic interactions, it helps reducing stress and acts as a small little companion always ready to cheer someone up. BAO-ME aims to help users feeling less stressed, less lonely and comfort them, hence improve their mental well-being. BAO-ME approaches the goal of this research through (1) calling for attention because it needs affection ,(2) shows its love by manifesting its "aliveness" to the user, (3) helps users reducing stress and feeling of loneliness trough the recreation of a hug. Two working prototypes were developed to test the feasibility with the above focus points. The two working prototypes will be first analyzed and the two evaluation methods will be further defined. Results will list in detail the two evaluations. Discussion will then be analyzed as validation and proof of concept.

4.1. Methodology

The results of this project will be discussed by analyzing the emotional reactions from the users in two experimental setups with the first version and the last version of BAO-ME. Quantitative data is used in order to compare the emotional impact that users have before and after trying out BAO-ME. By analyzing the emotional effectiveness along with qualitative data from the surveys taken by the users, the project can finally be discussed. As an initial step, an initial survey

was prepared for the user to take before beginning the experiment. The initial survey consists of general questions for meta-data such as age, nationality, gender and the level of interest towards stuffed animals and robotic stuffed animals. By collecting this data, the target persona and level of interest towards a potential robotic animals will be firther understood. Aside from the pre-survey that gathers participants' general identity, two more surveys will be conducted in order to collect quantitative data; the UCLA LONELINESS SCALE survey and the DASS21 (Depression, Anxiety, Stress Scale) survey. The UCLA LONELINESS SCALE survey [26] is a commonly used survey to measure users' subjective feelings of loneliness as well as feelings of social isolation. Participants rate each item as either O ("I often feel this way"),S ("I sometimes feel this way"), R ("I rarely feel this way"), N ("I never feel this way"). The researchers came up with this method of evaluation in order to develop an adequate assessment instrument for social psychological research on loneliness. DASS21 (Depression, Anxiety, Stress Scale), on the other hand, is a survey developed by researchers at the University of New South Wales (Australia). This method had been developed over three-year cycle that included around 40 laboratory simulations. This survey measures is a set of three scales designed to measure the negative emotional states of depression, anxiety and stress. The DASS is mainly created to measure negative emotional states as depression, anxiety and stress. DASS-21 is a shorter version that contains scales of seven items, divided into sub-scales with similar content. The depression scale assesses devaluation of life, lack of interest and involvement. The anxiety scale assesses autonomic arousal, panic and subjective experience of anxiety. The stress scale is focusing on measuring the levels of nervous arousal, irritability and relaxing difficulties. Both surveys are measured twice, at the beginning of the session before interacting with BAO-ME and after the interaction. Before taking the DASS-21, in order to recreate a stressful moment, the users are asked to play the dual n-back game, a continuous performance task that is used as an assessment to measure a part of working memory capacity. The participant is exposed to a sequence of stimuli, and the task consists of indicating when the current stimulus matches the one from n steps earlier in the sequence. The load factor n can be adjusted to make the task more or less difficult.The n back test is categorized as memory game of "Concentration" that also leads the subject to
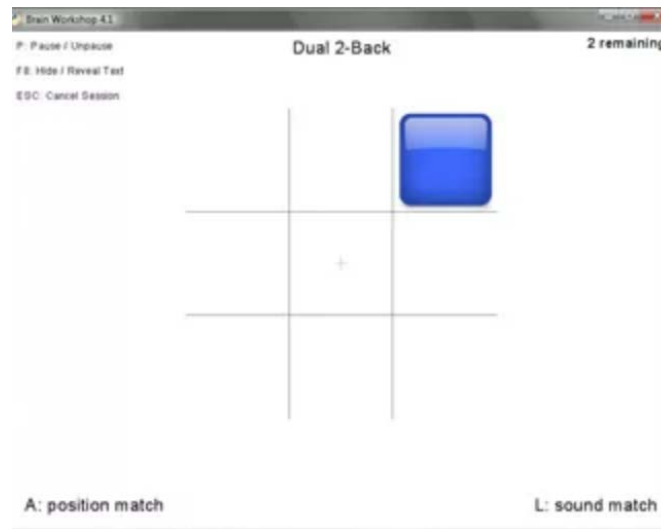
use a lot of nervous energy that leads to stress.

Figure 4.1: Dual N back

The combination of these surveys and the game will be used in this specif order: Pre-survey in order to collect meta-data, UCLA loneliness scale survey as a starting point to gather data about how the users feel emotionally at the moment and if they feel lonely or isolated. Afterwards, in order to test the DASS21, the users will have to play the dual N back game so that they can experience a stressful situation. When the game session is completed, the users will take the DASS21 to collect more data about their anxiety and stress levels. Thus, the user is allowed to interact freely with the BAO-ME for around five minutes while being filmed. Once it finishes, the user will be given a break for about 30 seconds before completing another set of survey. The next survey will be the UCLA loneliness scale survey again followed with the DASS21. This serves the purpose of measuring the change of their emotional experience and to see if after interacting with BAO-ME there was an change on their negative emotions. Lastly a post survey will be conducted and it will work as a cross sectional descriptive survey to understand the opinions from the users about the product and their personal experience while testing BAO-ME. Participants will be asked what kind of feelings they experienced while trying the product. The post survey is divided into two sections:

- Design/Usability

- User Experience

In the Design/Usability part participants will be asked questions like "Do you like the concept/design of a backpack that resembles the idea of a sloth?", "On a scale from 1 to 5, how good did the heating mechanism feel?", or "Do you like the placement or setup of the straps vibration sensors?". These series of questions are mainly focusing on the design of the bag and its interactions. In the User Experience part, questions about their personal experience and satisfaction with the interaction with the product. They will have to answer to questions such as "I feel comfortable to use the device", "I think BAO-ME is a good companion", or "I think BAO-ME will help me fight stress" and rate them from one to five, with one being "strongly disagree" and five "strongly agree". Throughout the whole experiment, the users will be asked to wear the Xiaomi Mi Band in order to measure their heart rate through the Mi Heart Rate application. This is because is proven that increasing or decreasing of the heart rate is often linked to stress levels. Through this, it will be possible to collect more quantitative data. The users will not know when their heart rate is measured because this may influence the process and the results of the test. Through the evaluation process, this research aims to validate: (1) BAO-ME recreated the feeling of a cute animal companion that can provide you a hug and affection through haptic interactions, (2) BAO-ME helps in stress and loneliness reduction and improves mental well-being. On the figure below, the flow of the experiment will also be explained into details.
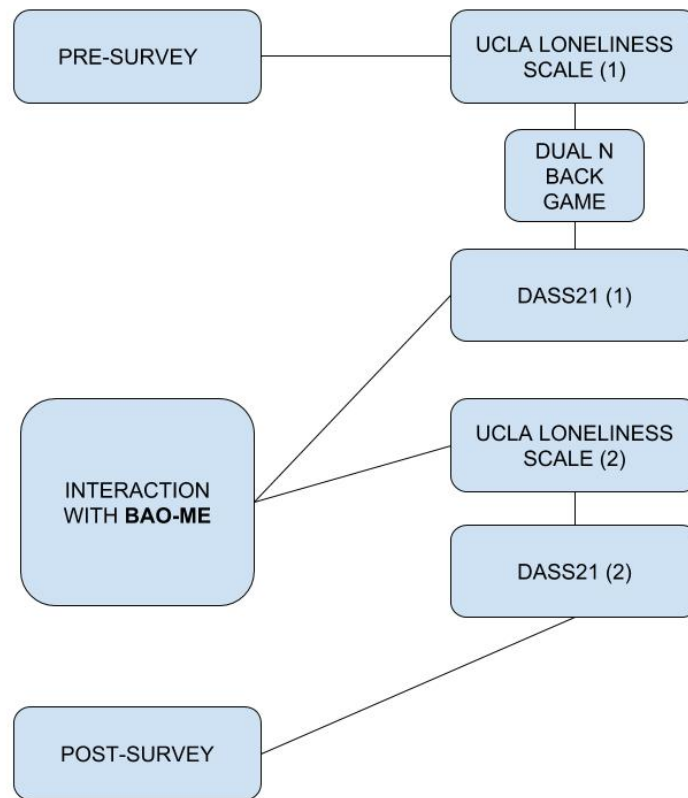
Figure 4.2: Flow of the experiment

4.2. Implementation

In the implementation process, two prototypes were designed in order to gather more information and opinion towards the concept and design of BAO-ME. The first prototype was a representation of an animal sewed by hands and its main aim was to focusing on the interactions rather than the overall design look. Following the first prototype, the second and final prototype was made based on the evaluation from the first experiment and user test. The details of each prototypes and its evaluation process are explained in this chapter.

4.2.1 First Prototype

Based on the user understanding and analysis of the rough prototype, the first prototype was developed. In this prototype the attention was focused on the interactions themselves rather than the design. The aim was to keep the overlook of the bag very simple and not particularly cute so that the users were focusing their attentions more on the interactions. This first prototype was sewed by hand. The fabric that has been used to sew was ripstop, making the bag more resistant to tearing and ripping. Furthermore the inside of the bag was filled with polyester fiberfill in order to make it soft and comfortable like a pillow or stuffed animal. The color that has been chosen was gray because it resembles the color of the fur of the sloth which is a mixture of gray, brown and black.

Figure 4.3: User wearing the second prototype of BAO-ME

As we can see from Figure 4.1, the user is wearing BAO-ME on the back. The idea is that the straps cross over the user's chest in order to recreate the feeling of two long arms trying to hug someone tightly. The straps were made adjustable

so that they could fit into different kind of body shapes. In order to recreate the feeling of the hug, the straps need to be as closer as possible to someone's chest or back in order to feel the haptic interactions.

For the interactions part, in this first prototype the attention was mainly focused on the straps, because it is where the first haptic interaction takes place. In order for BAO-ME to manifest its aliveness and love towards the user, it will need to move its straps like it is trying to hug or call for the user's attention. Initially different types of motors were used in order to recreate the feeling of the straps were moving. At the initial stage, a stepper motor was connected to a wire which was sewed to the extremity of the strap. The idea was to recreate the feeling that the straps were trying to pull and tighten over the shoulders. After testing the stepper motor, the bag and the straps just felt too heavy and the interaction did not turn out to be as good as it should have been.

Figure 4.4: Servo motor

Based on those previous finding, a servo motor SG90 (Figure 4.2) was chosen to be the most appropriate one to use in order to recreate the feeling of movement over the straps. Tiny and lightweight with high output power, this motor can rotate approximately 180 degrees (90 in each direction), and works just like the standard kinds but smaller and lighter. Because of its lightweight, it was easy to be attached to the body of the sloth and then the servo's horn was connected to the strap through a wire.

Figure 4.5: Servo motors attached to BAO-ME

As shown in Figure 4.5, the two servo motors are sewed into the two edges of the bag. These two are connected to an Arduino Genuino board and when the mechanism starts, the two straps start moving and rotating at 180 degrees in each direction, recreating the feeling of a poke or something swinging its arms.
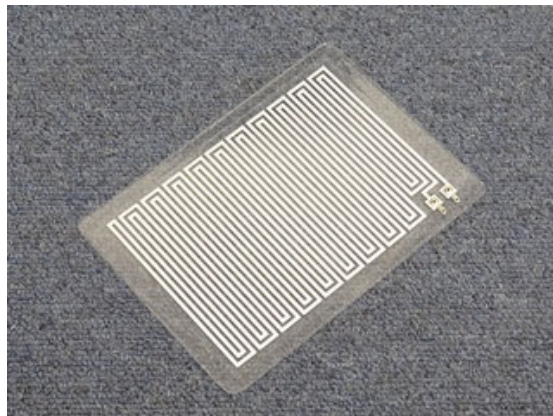
Figure 4.6: Flexible Heater

For recreating the feeling of warmth, an aluminum foil flexible heater A6 size (Figure 4.6) was used. Since it immediately generates heat from the moment the power is turned off, it is ideal for heating requests in a short time. Also because of its flexibility and thinness, it is easy to insert into the "body" of BAO-ME. The flexible heater can warm up to 60 degree Celsius, which is sufficient for this experiment as sloths' average body temperatures is 33 degrees Celsius. For sensing the temperature, a TMP006 temperature sensor is used in order to control the temperature' range produced by the heater.

In order to sum up the main interactions of this second prototype, a table below will sum up the main functions connected to the sensation that BAO-ME wants to recreate:

Sense	Actuator
Warmth	Flexible Heater
Movement	Servo Motors

Table 4.1: Sense/Actuator table.

Figure 4.7: The Overall look of the second prototype

As shown on Figure 4.5, this is how the first prototype looks like.

4.2.2 Final Prototype

The final prototype was developed after conducting the first experiment and user test of the first prototype. In this prototype the attention was focused both on the design and the technology part of BAO-ME. Concerning the design, a stuffed animal representing a sloth was used. Its dimensions are W66 x D37 x H22cm and the material consisted of 95 percent polyester, 5 percent polyurethane. The inside of the sloth is stuffed with 100 percent polyester.

Figure 4.8: The Overall look of the second prototype

Its softness and the fur resemble the idea of a cute animal ready to be hugged. Its sleepy facial expression also helps feeling healed and more relaxed after a long day at work. Its face can also be used as a pillow so that potential users can lay their head down. In general this type of cute design was chosen because it feels like it is a real pet that users can bring around with them throughout their day.

Regarding the technology part, a lot of new improvements were also done. After conducting the first experiment with the second prototype, a lot of ideas for new interactions came up. Users suggested different haptic interactions that might have been more effective in order to recreate the feeling of a hug. First of all, concerning the strap function, servo motors were substituted with four linear

resonant actuators for each straps (Figure 4.9). Those actuators were distributed over the strap so that the users can feel the vibration all over their shoulders, chest and back. The actuators activate when it detects that the users are standing still through an accelerometer sensor. When the sensor recognizes that the user is either standing still or sitting, the actuators will start to vibrate. This represents a call from BAO-ME because it wants to be hugged.
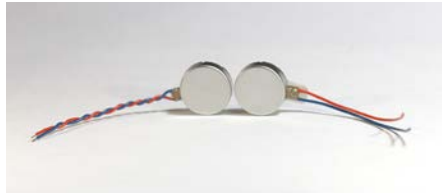
Figure 4.9: Linear Resonant Actuators

After BAO-ME call for users' attention through haptics, it is time for the users rather to hug BAO-ME or not. If the users do not want to hug it, they can decide to ignore the vibration. But if they need a hug, they can start to hug BAO-ME. A pressure sensor FSR 402 that is embedded inside BAO-ME's back will sense the hug's pressure from the users and it will activates the second round of interactions to manifest BAO-ME's love and its aliveness. The second round of interactions consist on the sound of a heart-beating and a flexible heater that will start to warm up. For the heart-beating part a speaker was used to reproduce the sound of heart-beat a soon as pressure sensor detects the hug.
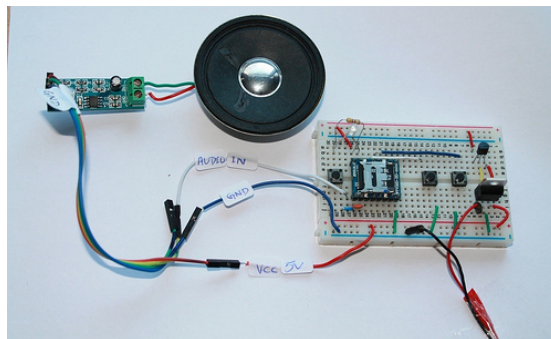
Figure 4.10: Speakers to reproduce the sound of a heart beating

Meanwhile BAO-ME heart starts beating it will also slowly warm up up

through the flexible heater attached to his stomach. As soon as the users will
release the hug, the interactions will stop. On the table below the haptic interac-
tions of this final prototype are listed.

Sense	Actuator
Vibration	Actuators
Heart-beat	Speaker
Warmth	Flexible Heater

Table 4.2: Sense/Actuator table.

If the users want to experience more feelings from the hug, they can also
chose to activate a mechanism positioned on the small arms of the sloth. This
mechanism consists on two measurement tools used for tailoring embedded inside
the small arms. When the users decide to press a button, the small arm will swing
and move, giving that extra sensation of its aliveness.

As shown on the picture below, this is how the final prototype of BAO-ME
will look like:

Figure 4.11: Final version of BAO-ME

4.3. Evaluation

The age of subjects taking part in the product experiment ranged from 23 to 30 years old. All individuals were either working for companies, working independently or engaging in post-graduate studies. All come from a wide variaty of backgrounds and different nationalities. The users were selected based on their specific age bracket and life style, so that the group is representative of a wide spectrum of potential users. In accordance with the evaluation method, each user was required to participate in the 30 minute process, which consisted of the completion of six surveys, a game and the interaction with BAO-ME. Two sets of experiments were conducted: the first one, using the second prototype of BAO-ME and the final one, with the completed version of the product. Both experiments were carried out in the same location, a room in the Collaboration Complex at Keio Media Design in Hiyoshi, Kanagawa.

4.3.1 First Interviewees Information

An initial user study was conducted in order to gather more detailed information and understanding with regards to what users expect from BAO-ME. The objective was to prove or disprove the theory that this product concept is able to successfully alleviate feelings of stress and loneliness, in addition to collecting user feedback which could suggest how the product can be improved and further developed. The test was conducted over the final week of May 2018, with twelve participants, 5 females and 7 males. The majority of them are of foreign nationality, living alone in Tokyo studio apartments. Three of the individuals selected are Japanese. All subjects own a stuffed animal and all reported to feel a form of attachment to it. All but one participant claimed to like stuffed animals in general. The table below lists the overall demographics and essential information associated with each person who took part in this first user study.

	Nationality	Gender	Occupation	Living	Likes Stuffed Animals
User J	China	Male	Student	Alone	Yes
User G	China	Female	Student	Alone	Yes
User G	China	Female	Student	Alone	Yes
User H	Taiwan	Male	Researcher	Alone	Yes
User K	Japanese	Female	Office worker	Alone	Yes
User T	Japanese	Male	Designer	Alone	Yes
User P	Japanese	Male	Researcher	Alone	Yes
User N	Indonesia	Male	Student	Shared House	No
User S	Thailand	Female	Student	Alone	Yes
User A	Morocco	Female	Student	With House Mate	Yes
User C	Morocco	Male	Student	Alone	Yes
User D	USA	Male	Student	Alone	Yes

Table 4.3: Demographics and General preferences table of the first user study

4.3.2 Evaluation of First User Study

Based on the method of evaluation, the first experiment took place over the last week of May 2018. 12 people participated in this experiment and each of them have various cultural and academic backgrounds. As explained on the Method of Evaluation, two kinds of survey were used as a way to measure stress and loneliness levels of the subjects while interacting with BAO-ME; UCLA loneliness scale Survey and DASS Survey. Each user was asked to fill both surveys twice throughout the experiment, before and after using BAO-ME, in order to record their emotional condition at the time. Before filling the first DASS21 Survey however, the users were asked to play the Dual N back game so that a stressful situation could be created as a base environment. The two UCLA loneliness scale surveys were then compared, to measure any increase or decrease in loneliness depending on the users' responses; same procedure was then done with the two DASS21 survey to measure the stress levels changes before and after the interaction with BAO-ME. After the data from all users were counted, the total change of the data could then be summarized.

The two UCLA loneliness scales gave some positive results. The first one shows that without the prototype, the participants' level of loneliness increased by 0.75

points. But there was a noticeable decrease in loneliness when the participants interacted with the BAO-ME.

Figure 4.12: User G interacting with the first prototype of BAO-ME

The second part of the experiment was evaluated with the DASS21 Survey. This survey was conducted in order to evaluate how much a user's stress levels can decrease in using BAO-ME, and compare it to the effects observed following use when subjects were placed in a stressful situation. Users completed two tests consisting of 42 questions. The first test was completed after the Dual N Back game, with all 12 users admitting that the game was a stressful task. After the interaction with BAO-ME, users were asked to fill the second part of the DASS21. In the second part, 5 participants reported to have experienced a notable change between answers from the first survey and the second one. There was a considerable decrease of their stress levels. The rest of the participants did not showed much difference between the first and the second survey. For the last final section of the test, all participants were asked to complete a post survey in order to provide feedback regarding their feelings towards the product and their personal experience while testing BAO-ME. The overall participants stated that they liked the concept of BAO-ME with the average of 4.083 (on a scale from 1 to 5, with 1 being strongly disagree and 5 being strongly agree).

4.3.3 Second Interviewees Information

The second user study was conducted in order to gather a wider volume of feedback regarding the final design and interactions with BAO-ME. The objectives were to prove if this final concept works better as a remedy for the feeling of stress and isolation. The test was conducted throughout the second week of June 2018 with five participants, 3 females and 2 males, with occupations ranging from university students, office workers and independent researchers. Their ages ranged from 23 to 30 years old. The participants selected were as the same ones from the previous user experiment. The reason of making this choice was due to the fact that interviewing the same users helped understanding if the second implementation was actually affective.

	Nationality	Gender	Occupation	Living	Likes Stuffed Animals
User J	China	Male	Student	Alone	Yes
User G	China	Female	Student	Alone	Yes
User H	Taiwan	Male	Researcher	Alone	Yes
User S	Thailand	Femae	Student	Alone	Yes
User K	Japanese	Female	Office worker	Alone	Yes

Table 4.4: Demographics and General preferences table of the second user study

4.3.4 Evaluation of Second User Study

The second evaluation was following as the same methodology as the first user experiment and it was conducted over the second week of June 2018. This time five people participated in this experiment and each of them took part on the previous studying. As in the precedent experiment, the participants were asked to fill all the six surveys over again in order to compare the results with the last experiment. UCLA loneliness scale Survey and DASS21 Survey will be compared this time with the previous ones too. Each user will be be asked again to fill both surveys twice throughout the experiment, before and after using BAO-ME, in order to record their emotional condition at the time and at the time of the first experiment.

The two UCLA loneliness scales did not change as much in comparison to the previous experiment. There was a more noticeable decrease of loneliness when the

participants interacted with the new prototype. Some extra observation was done and in comparison to the first experiment, users were smiling more and they felt much more comfortable using the new version of BAO-me.

The second part of the experiment was evaluated with the DASS21 Survey again. This survey was conducted in order to comprehend how much level of stress BAO-ME can help decreasing, and compare it to when the users can be in a stressful situation. This second time all 5 participants revealed that the new version of the prototype was much more effective as a stress reliever. All of them showed a considerable decrease of their stress levels. For the last part of the test, all the participants graded the overall concept of BAO-ME with the average points of 5 (on a scale from 1 to 5, with 1 being strongly disagree and 5 being strongly agree). This summarized that there is an increase of task load by 0,20 points whenever the user uses BAO-ME. This means that people feel more mentally attached to the device and they are more likely to use it as a real working product.

Figure 4.13: User H interacting with the second prototype of BAO-ME

4.4. Findings

By analyzing the recorded results of each users, it was noticed that when they interacted with BAO-ME they were more likely to express feelings of happiness and comfort. When utilizing BAO-ME, the users firstly felt a bit unfamiliar with its haptic interactions, but after understanding how it worked, they started to show a certain level of familiarity with the product. It was very interesting to watch users' reaction when first interacting with BAO-ME. The majority of the users was very engaged and enthusiastic excited while using BAO-ME and they all manifested very positive reactions. However, two participants felt slightly disturbed by the device and felt very uncomfortable using such bag. One of them stated that he does not like anything technological embodied within a bag. He said he will never feel comfortable to carry it around. The other participants commented saying that she will feel very odd carrying BAO-ME around. She affirmed that she would be particularly worried about people's judgment. Whether positive or negative, the main focus was to observe a change in a participant' s emotional state regarding their stress and feeling of loneliness levels. Regarding the strap movement during the first prototype, the majority of participants felt very uncomfortable and the movement of the strap was either described as a "poke" or a "drill" on the back. Participants admitted that that movement did not resemble the idea of a hug and the majority of them would have preferred a vibration instead. An interesting comment from a user was that the movement over the straps felt like the animal was not behaving properly. The reason why in the final prototype the strap movement was changed into the vibration was because of the comments and opinions received throughout the first experiment. With the vibration over the straps, the participants felt much more comfortable and the vibration was described as a "nice feeling that releases tension over the shoulders" and as a "cute and comfortable way to call for my attention". Regarding the design of the straps, the majority of the user felt that it was nice to have them crossed over the back or chest but it was a bit uncomfortable to fasten them. The majority of them requested a better design in order to facilitate the way the straps are fastened. Regarding the hear-beat, all the users felt very happy and pleased by such sensation and they felt very emotional while hearing that type of sound. One of the participant had a very strong emotional reaction to the

point that she started crying. She admitted that it felt like a real living creature ready to comfort her and manifest its love. She said that BAO-ME reminded her of her real pet at home and she would have treat the device as a real living being. Another interesting finding was the one regarding the heating interaction of BAO-ME. All the participants felt very pleased by such feeling and they all said it resembles the idea of holding a living creature, like a pet or a child. One participant suggested that he would like to have a cooling down mechanism too to use during summer. Other findings that came from the users' feedback was that many of them felt more "secured" like they have always a companion that can protect them and make them feel it is always with them. One of the participant admitted that she lacked of physical interactions for many days because she was busy with university work. She admitted that she felt very excluded and the interaction with such device helped her boosting her positiveness. Another interesting finding was that a lot of users would have liked if BAO-ME could have also started breathing. They thought that having all these different types of haptic interactions will make BAO-ME more "alive", like it is a real living animal. Overall everyone also liked the concept of the sloth animal as a symbol of relaxation. One participant suggested a dog because it is one of his favorite animals and he would feel more attached to it. Another user suggested to have a more minimalistic design so that she will not feel judged in public. Concerning the heart bit, it was interesting to observe a slight heart rate decrease of 5.6 beats while interacting with BAO-ME, however, all other conditions showed no significant change in the heart rate. The results from the two user studies have been suggesting that more work can be done to further explore affective touch with BAO-ME. It is strongly believed that more study should be done in order to select an appropriate choice for haptic actuations and improve the user experience.

Chapter 5

Conclusion

The presented research and assessment material was conducted with a focus on the design and effectiveness of BAO-ME, a zoomorphic robotic bag, developed to help users reduce levels of stress and loneliness, improving their overall mental well-being. BAO-ME not only provides a more playful way to manifest sensations of affection through hugging, but is also accessible almost anytime and anywhere. Instead of using a standard backpack, BAO-ME becomes the perfect inanimate pet companion, providing instantaneous physical embrace to the user through haptic interactions. The device's ability to recreate the feeling of a heart beating against your chest and warming function, acurately recreates the experience of a warm embrace, instilling in the user a sense of ease and comfort, reducing feelings of loneliness and isolation, as they move through daily life.

5.1. Design Approach

To complete the design concept of BAO-ME, various fieldwork activities were conducted in order to observe and analyze feedback from potential target users. The approach to targeting a specific persona was decided upon to assist the process of the initial concept development and sketches. The preliminary prototype was created in order to explore how the users felt about the product and what kind of interactions they expected to receive. The first prototype was designed, mainly focusing on the haptic response of the bag's straps, since this was considered to be one of the most unique and essential aspects of the design. Ultimately, the

final prototype was developed and implemented onto a more advanced design offering more realistic interactions for a final evaluation and feedback. During the evaluation stage of BAO-ME, surveys, interactions and interviews were conducted. The evaluation was performed on a total of 17 individuals testing the first and final prototype and the session was divided into six phases; pre-questionnaires, UCLA loneliness scale, Dual N back game, DASS21, interaction with BAO-ME, UCLA loneliness scale, DASS21, Post-survey. In addition, the participants were required to use a wearable device to measure the heart beat during the experiment in order to produce tangible and quantitative data. Through the evaluations, the concept of BAO-ME was proven to have a good success and positive results. The design intention of the robotic pet backpack was proven to be a perfect companion that can help reducing stress levels and feelings of loneliness and isolation.

5.2. Limitations

This research aims to create a robotic pet backpack that through haptic interactions is able to reduce stress, loneliness and improve the mental well-being of users by the feeling of being hugged. Users can interact with BAO-ME whenever they are feeling stressed or lonely, and by hugging it and experiencing the emotional embrace, a calmer and more positive state of mind can be achieved. However, considering the mental state of each individual, the effectiveness of the device may differ and the evaluation, regardless of its positive results from the previous users, has only been conducted on a small amount of participants. Using BAO-ME as an emotional robot for companionship that can help promoting mental well-being has shown promising results. However, it is important to consider BAO-ME not as a substitute of a real embrace or a replacement of real human physical contact, but as an additional device that can recreate the emotion of the hug when the users are feeling particularly stressed and lonely and have no one to interact with. Another limitation of the research, is that there were time constraints which affected the freedom to explore a wider range of different kinds of haptic interactions and designs. Additional time would be necessary in order to achieve a more defined working product and gather extra opinion for users. The evaluations were also conducted for a short period of time and, although

the concept is proven to have promising results on user's mental well-being, it is not proven yet if this can be effective for the long-term. Additionally, it will be interesting to investigate other emotional aspects, such as the level of "connectedness" individuals have for BAO-ME. The evaluations conducted in this research also are not equivalent to a medical research, because of the high price and the more professional facilities that a medical trial requires, therefore, the effectiveness of BAO-ME as a medical solution in reducing stress and loneliness levels needs to be further discussed.

5.3. Future Works

Based on the feedback and results gathered during the evaluation process, there are two main features of BAO-ME that can be further developed: (1) explore new haptic interactions, and (2) the design of the straps. By exploring new interactions, adjusting the way to fasten the straps, it can lead the user to have a better experience. The core of the device, however, should and must still be representing a cute companion that can manifest its emotions by recreating the sensation of a hug. With a variety of haptic interactions embedded into the device, the attractiveness of BAO-ME is expected to increase. Further evaluation for long-term benefits should also be conducted in order to examine the effects on users mental health. In the current stage, BAO-ME is only proven successful on a limited number of users, however, BAO-ME has the potential to become (1) a medical device for people with mental health disorders, (2) assisted pet-robot therapy for elderly people, (3) a device for helping children stay calm and less agitated, and (4) a more practical minimalistic device for everyday use. For medical usability on patients with mental health issues or a as a companion for elderly people, further evaluation needs to be be conducted to testify the effectiveness of BAO-ME. If proven successful, more types of haptic interactions can be embedded into the device to assist patients as a certified medical device or companion care. As a gadget for helping children staying calmer, BAO-ME can be a perfect companion especially in situations where parents are not able to be with their children due to work commitments. Lastly for a more practical use, BAO-ME can also have extra functions such as phone charging and music player.

Summary The data gathered from observations and interviews on users supports the concept of BAO-ME. Through such haptic device, it is easy to experience a sense of comfort by the feeling of being hugged. To conclude, the goal of this research aimed to design a haptic device to improve mental well-being by recreating the sense of hug and it is proven to be successful. Although there are still many other interactions to be explored and other design features to be improved for a better user experience, the core concept of BAO-ME has proven to have positive results.

References

[1] Ainsworth, M. D. S. Attachment as related to mother-infant interaction. In *Advances in the study of behavior*, vol. 9. Elsevier, 1979, 1–51.

[2] Andersen, P. A., and Leibowitz, K. The development and nature of the construct touch avoidance. *Environmental psychology and nonverbal behavior 3*, 2 (1978), 89–106.

[3] bags 2018, C. A short history of the use of bags. `https://books.google.co.jp/booksid=fM7RAgAAQBAJ&pg=PA291&lpg=PA291&dq=hugging+induces+prosocial+behavior&source=bl&ots=jOXaTAO5UT&sig=OgC_udOJg7QjYMjZBh1PZVxAJc&hl=en&sa=X&ved=0ahUKEwi2r5Slvr_bAhVDnJQKHaZCB90Q6AEIPzAC#v=onepage&q&f=false/`. Online; accessed 07-June-2018.

[4] bags 2018, C. A short history of the use of bags. `https://www.chapmanbags.com/journal/short-history-use-bags/`. Online; accessed 28-May-2018.

[5] Bush, E. The use of human touch to improve the well-being of older adults: A holistic nursing intervention. *Journal of holistic nursing 19*, 3 (2001), 256–270.

[6] Cha, J., Eid, M., Rahal, L., and El Saddik, A. Hugme: An interpersonal haptic communication system. In *Haptic Audio visual Environments and Games, 2008. HAVE 2008. IEEE International Workshop on*, IEEE (2008), 99–102.

[7] Chang, T. Bubsy vest. `https://www.taeyoungchang.com/work-1#/bubsy-vest/`. Online; accessed 11-June-2018.

[8] Dresslar, F. B. Studies in the psychology of touch. *The American Journal of Psychology 6*, 3 (1894), 313–368.

[9] Eid, M., Orozco, M., and El Saddik, A. A guided tour in haptic audio visual environments and applications. *International Journal of Advanced Media and Communication 1*, 3 (2007), 265–297.

[10] Eid, M. A., and Al Osman, H. Affective haptics: Current research and future directions. *IEEE Access 4* (2016), 26–40.

[11] Fong, T., Nourbakhsh, I., and Dautenhahn, K. A survey of socially interactive robots. *Robotics and autonomous systems 42*, 3-4 (2003), 143–166.

[12] Francis, G. Young adults spend more than six hours per day feeling 'stressed out', finds mental health study. `https://www.independent.co.uk/life-style/mental-health-young-adults-stress-depression-anxiety-ocd-study-a8233046.html/`. Online; accessed 12-June-2018.

[13] Geographic, N. Three-toed sloths. `https://www.nationalgeographic.com/animals/mammals/group/three-toed-sloths//`. Online; accessed 12-June-2018.

[14] Grewen, K. M., Girdler, S. S., Amico, J., and Light, K. C. Effects of partner support on resting oxytocin, cortisol, norepinephrine, and blood pressure before and after warm partner contact. *Psychosomatic medicine 67*, 4 (2005), 531–538.

[15] Grotts, A. S., and Widner Johnson, T. Millennial consumers' status consumption of handbags. *Journal of Fashion Marketing and Management: An International Journal 17*, 3 (2013), 280–293.

[16] Harlow, H. F. The nature of love. *American psychologist 13*, 12 (1958), 673.

[17] Harlow, H. F., and Zimmermann, R. R. Affectional responses in the infant monkey. *Science 130*, 3373 (1959), 421–432.

[18] Hawkley, L. C., and Cacioppo, J. T. Loneliness matters: a theoretical and empirical review of consequences and mechanisms. *Annals of behavioral medicine 40*, 2 (2010), 218–227.

[19] Hertenstein, M. J., Holmes, R., McCullough, M., and Keltner, D. The communication of emotion via touch. *Emotion 9*, 4 (2009), 566.

[20] Hertenstein, M. J., Verkamp, J. M., Kerestes, A. M., and Holmes, R. M. The communicative functions of touch in humans, nonhuman primates, and rats: a review and synthesis of the empirical research. *Genetic, social, and general psychology monographs 132*, 1 (2006), 5–94.

[21] Julsaksrisakul, P., Chernyshov, G., Nakatani, M., Tag, B., and Kunze, K. Nene: an interactive pet device. In *Proceedings of the 2017 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2017 ACM International Symposium on Wearable Computers*, ACM (2017), 89–92.

[22] Kidd, C. D., Taggart, W., and Turkle, S. A sociable robot to encourage social interaction among the elderly. In *Robotics and Automation, 2006. ICRA 2006. Proceedings 2006 IEEE International Conference on*, IEEE (2006), 3972–3976.

[23] Melson, G. F., Kahn Jr, P. H., Beck, A., and Friedman, B. Robotic pets in human lives: Implications for the human–animal bond and for human relationships with personified technologies. *Journal of Social Issues 65*, 3 (2009), 545–567.

[24] Parihug. Parihug. `http://www.parihug.com/`. Online; accessed 11-June-2018.

[25] Qoobo. Qoobo. `https://www.kickstarter.com/projects/1477302345/qoobo/`. Online; accessed 08-June-2018.

[26] Russell, D., Peplau, L. A., and Ferguson, M. L. Developing a measure of loneliness. *Journal of personality assessment 42*, 3 (1978), 290–294.

[27] Seaward, B. L. *Managing stress: Principles and strategies for health and wellbeing.* Jones & Bartlett Pub, 1999.

[28] seibun 2010-2011, K. Sense-roid. `http://novriki.com/sense-roid/en/about.html/`. Online; accessed 11-June-2018.

[29] Shiomi, M., Nakagawa, K., Shinozawa, K., Matsumura, R., Ishiguro, H., and Hagita, N. Does a robot's touch encourage human effort? *International Journal of Social Robotics 9*, 1 (2017), 5–15.

[30] Shiomi, M., Nakata, A., Kanbara, M., and Hagita, N. A hug from a robot encourages prosocial behavior. In *Robot and Human Interactive Communication (RO-MAN), 2017 26th IEEE International Symposium on*, IEEE (2017), 418–423.

[31] Stiehl, W. D., Lieberman, J., Breazeal, C., Basel, L., Lalla, L., and Wolf, M. Design of a therapeutic robotic companion for relational, affective touch. In *Robot and Human Interactive Communication, 2005. ROMAN 2005. IEEE International Workshop on*, IEEE (2005), 408–415.

[32] Sumioka, H., Nakae, A., Kanai, R., and Ishiguro, H. Huggable communication medium decreases cortisol levels. *Scientific reports 3* (2013), 3034.

[33] Tai, K., Zheng, X., and Narayanan, J. Touching a teddy bear mitigates negative effects of social exclusion to increase prosocial behavior. *Social Psychological and Personality Science 2*, 6 (2011), 618–626.

[34] Takeuchi, M. S., Miyaoka, H., Tomoda, A., Suzuki, M., Liu, Q., and Kitamura, T. The effect of interpersonal touch during childhood on adult attachment and depression: a neglected area of family and developmental psychology? *Journal of Child and Family Studies 19*, 1 (2010), 109–117.

[35] Teh, J. K. S., Cheok, A. D., Peiris, R. L., Choi, Y., Thuong, V., and Lai, S. Huggy pajama: a mobile parent and child hugging communication system. In *Proceedings of the 7th international conference on Interaction design and children*, ACM (2008), 250–257.

[36] Tjacket. Tjacket. `https://www.mytjacket.com/`. Online; accessed 11-June-2018.

[37] Vaucelle, C., Bonanni, L., and Ishii, H. Design of haptic interfaces for therapy. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM (2009), 467–470.

[38] Voith, V. L. Attachment of people to companion animals. *The Veterinary Clinics of North America. Small Animal Practice 15*, 2 (1985), 289–295.

[39] Wada, K., Shibata, T., Saito, T., Sakamoto, K., and Tanie, K. Psychological and social effects of one year robot assisted activity on elderly people at a health service facility for the aged. In *Robotics and Automation, 2005. ICRA 2005. Proceedings of the 2005 IEEE International Conference on*, IEEE (2005), 2785–2790.

[40] Yohanan, S., Chan, M., Hopkins, J., Sun, H., and MacLean, K. Hapticat: exploration of affective touch. In *Proceedings of the 7th international conference on Multimodal interfaces*, ACM (2005), 222–229.

[41] Yohanan, S., and MacLean, K. E. Design and assessment of the haptic creature's affect display. In *Proceedings of the 6th international conference on Human-robot interaction*, ACM (2011), 473–480.

[42] Yohanan, S., and MacLean, K. E. The role of affective touch in human-robot interaction: Human intent and expectations in touching the haptic creature. *International Journal of Social Robotics 4*, 2 (2012), 163–180.

Appendix

A. Arduino Codes

```cpp
#include <SoftwareSerial.h>
#include <DFPlayer_Mini_Mp3.h>

SoftwareSerial mySerial(10, 11); // RX, TX

void setup() {
  // initialize digital pin LED_BUILTIN as an output.
  pinMode(2, OUTPUT);
  pinMode(3, OUTPUT);
  pinMode(4, OUTPUT);
  pinMode(5, OUTPUT);
  pinMode(6, OUTPUT);
  pinMode(7, OUTPUT);
  pinMode(8, OUTPUT);

digitalWrite(8, HIGH);

//  Serial.begin (9600);
  mySerial.begin (9600);
  mp3_set_serial (mySerial);
  mp3_set_volume (30);
}

bool heat_and_sound(){
  digitalWrite(2, LOW);
  digitalWrite(3, LOW);
  digitalWrite(4, LOW);
  digitalWrite(5, LOW);
  digitalWrite(6, LOW);
  digitalWrite(7, LOW);
```

Figure 5.1: Arduino Code 1

```
    mp3_play(1);
    delay(30000);
    if(analogRead(A0)>6){
      heat_and_sound();
    }
    else{
      return 1;
    }
}

void loop() {
    for(int i=0;i<10;i++){
      digitalWrite(2, HIGH);
      digitalWrite(3, HIGH);
      if(analogRead(A0)>6){
        if(heat_and_sound()){goto next_wait;}
      }
      delay(500);
      digitalWrite(2, LOW);
      digitalWrite(3, LOW);
      if(analogRead(A0)>6){
        heat_and_sound();
      }
      digitalWrite(4, HIGH);
      digitalWrite(5, HIGH);
      if(analogRead(A0)>6){
        if(heat_and_sound()){goto next_wait;}
```

Figure 5.2: Arduino Code 2

```
  }
  delay(500);
  if(analogRead(A0)>6){
    if(heat_and_sound()){goto next_wait;}
  }
  digitalWrite(4, LOW);
  digitalWrite(5, LOW);
  if(analogRead(A0)>6){
    if(heat_and_sound()){goto next_wait;}
  }
  digitalWrite(6, HIGH);
  digitalWrite(7, HIGH);
  if(analogRead(A0)>6){
    if(heat_and_sound()){goto next_wait;}
  }
  delay(500);
  if(analogRead(A0)>6){
    if(heat_and_sound()){goto next_wait;}
  }
  digitalWrite(6, LOW);
  digitalWrite(7, LOW);
  if(analogRead(A0)>6){
    if(heat_and_sound()){goto next_wait;}
  }
}
next_wait:
delay(90000); //wait 1.5min
```

Figure 5.3: Arduino Code 2

B. Pre-survey

Figure 5.4: Pre-survey part 1

Occupation *

○ Student

○ Employed

○ Self-employed

○ Retired

○ Other:

Marital status *

○ Single

○ Married

○ Divorced/Separated

○ Widowed

Figure 5.5: Pre-survey part 2

Figure 5.6: Pre-survey part 3

Do you like stuffed animals? *

◯ Yes

◯ No

Do you have any stuffed animal you feel attached to? *

◯ Yes

◯ No

If yes, what kind of animal is it?

Your answer

If not, do you have any other particular objects you feel attached to?

Your answer

Figure 5.7: Pre-survey part 4

Do you sleep with a stuffed animal? *

○ Yes

○ No

○ Sometimes

Do you carry stuffed animals around with you? (while going out, travelling, etc) *

○ Yes

○ No

○ Sometimes

When you were younger, did you have any stuffed animal that you consider your friend/companion? *

○ Yes

○ No

Figure 5.8: Pre-survey part 5

If yes, what kind of animal was it? Do you still have it? Do you still see it as your friend?

Your answer

If not, did you have any other object? Do you still keep it with you?

Your answer

Have you ever owned any robotic stuffed animal? If yes, which one was it? *

Your answer

BACK   SUBMIT

Never submit passwords through Google Forms.

Figure 5.9: Pre-survey part 6

C. UCLA LOLINESS SCALE

UCLA LONELINESS SCALE (1)

*Required

Indicate how often each of the statements below is descriptive of you.

I am unhappy doing so many things alone *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

I have nobody to talk to *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

Figure 5.10: UCLA LONELINESS SCALE PART 1

I cannot tolerate being so alone *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

I lack companionship *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

I feel as if nobody really understands me *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

Figure 5.11: UCLA LONELINESS SCALE PART 2

I find myself waiting for people to call or write *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

There is no one I can turn to *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

I am no longer close to anyone *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

Figure 5.12: UCLA LONELINESS SCALE PART 3

My interests and ideas are not shared by those around me *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

I feel left out *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

I feel completely alone *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

Figure 5.13: UCLA LONELINESS SCALE PART 4

I am unable to reach out and communicate with those around me *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

My social relationships are superficial *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

I feel starved for company *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

Figure 5.14: UCLA LONELINESS SCALE PART 5

No one really knows me well *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

I feel isolated from others *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

I am unhappy being so withdrawn *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

Figure 5.15: UCLA LONELINESS SCALE PART 6

It is difficult for me to make friends *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

I feel shut out and excluded by others *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

People are around me but not with me *

○ I often feel this way

○ I sometimes feel this way

○ I rarely feel this way

○ I never feel this way

Figure 5.16: UCLA LONELINESS SCALE PART 7

D. DASS21

Please read each statement and pick a number 0, 1, 2 or 3 which indicates how much the statement applied to you. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:
0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

I find it hard to wind down/relax *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I am aware of dryness of my mouth *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I can't seem to experience any positive feeling at all *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

Figure 5.17: DASS21 PART 1

I experience breathing difficulty (eg, excessively rapid breathing, breathlessness in the absence of physical exertion) *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I find it difficult to work up the initiative to do things *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I tend to over-react to situations *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I experience trembling (eg, in the hands) *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

Figure 5.18: DASS21 PART 2

I feel that I am using a lot of nervous energy *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I am worried about situations in which I might panic and make a fool of myself *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I feel that I have nothing to look forward to *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I find myself getting agitated *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

Figure 5.19: DASS21 PART 3

I find that I am very irritable *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I feel sad and depressed *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I found it difficult to tolerate interruptions to what I was doing *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I feel I am close to panic *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

Figure 5.20: DASS21 PART 4

I am unable to become enthusiastic about anything *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I feel I am not worth much as a person *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I am in a state of nervous tension *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I am aware of the action of my heart in the absence of physical exertion (eg, sense of heart rate increase, heart missing a beat) *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

Figure 5.21: DASS21 PART 5

I feel scared without any good reason *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

I feel that life is meaningless *

	0	1	2	3	
Did not apply to me at all	○	○	○	○	Apply to me very much

BACK   SUBMIT

Figure 5.22: DASS21 PART 6

E. Post-Survey

Design/Usability

Do you like the concept/design of a backpack that resembles the idea of a sloth? *

○ Yes

○ No

Do you like the design of the straps? *

○ Yes

○ No

Do you like the design of the "body" of the backpack? *

○ Yes

○ No

Did you like the "vibration" feeling of the straps? *

○ Yes

○ No

Figure 5.23: Post-survey PART 1

On a scale from 1 to 5, how good did the strap vibration feel?

	1	2	3	4	5	
Not good	○	○	○	○	○	Very good

Do you like the placement or setup of the straps vibration sensors? *

○ Yes

○ No

Do you like the heart-beat mechanism?

○ Yes

○ No

On a scale from 1 to 5, how good did the heart beat feel?

	1	2	3	4	5	
Not good	○	○	○	○	○	Very good

Figure 5.24: Post-survey PART 2

Do you like the heating mechanism?

○ Yes

○ No

Do you like the placement of the heating mechanism?

○ Yes

○ No

On a scale from 1 to 5, how good did the heating mechanism feel?

	1	2	3	4	5	
Not good	○	○	○	○	○	Very good

Do you think there are better simulations that should be included in the bag?

Your answer

Figure 5.25: Post-survey PART 3

Anything you would change about the design?

Your answer

BACK   NEXT

Never submit passwords through Google Forms.

Figure 5.26: Post-survey PART 4

Figure 5.27: Post-survey PART 5

It was enjoyable to feel its heart beating?

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I think BAO-ME is a good companion *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I think BAO-ME resembles the idea of a hug *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

I experienced a positive emotional change after using BAO-ME *

	1	2	3	4	5	
Strongly disagree	○	○	○	○	○	Strongly agree

Figure 5.28: Post-survey PART 6

I think BAO-ME will help me fight loneliness as I feel there is
someone always with me *

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

I think BAO-ME will help me fight stress *

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

I think BAO-ME can represent a sort of cute companion *

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

I think BAO-ME makes me more happy *

	1	2	3	4	5	
Strongly disagree	◯	◯	◯	◯	◯	Strongly agree

Figure 5.29: Post-survey PART 7

Any comments? *

Your answer

BACK   SUBMIT

Never submit passwords through Google Forms.

Figure 5.30: Post-survey PART 8

95