Title	EmoBank : designing a device to show emotional balance in romantic relationship
Sub Title	
Author	Nguyen, Bao Tuan(Inakage, Masahiko) 稲蔭, 正彦
Publisher	慶應義塾大学大学院メディアデザイン研究科
Publication year	2021
Jtitle	
JaLC DOI	
Abstract	
Notes	修士学位論文. 2021年度メディアデザイン学 第875号
Genre	Thesis or Dissertation
URL	https://koara.lib.keio.ac.jp/xoonips/modules/xoonips/detail.php?koara_id=KO40001001-00002021-0875

Master's Thesis
Academic Year 2021

EmoBank: Designing a Device to Show
Emotional Balance in Romantic Relationship

Keio University
Graduate School of Media Design

Bao Tuan Nguyen

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

Bao Tuan Nguyen

Master's Thesis Advisory Committee:
      Professor Masa Inakage   (Main Research Supervisor)
      Professor Kai Kunze   (Sub Research Supervisor)

Master's Thesis Review Committee:
      Professor Masa Inakage   (Chair)
      Professor Kai Kunze   (Co-Reviewer)
      Professor Matthew Waldman   (Co-Reviewer)

EmoBank: Designing a Device to Show Emotional Balance in Romantic Relationship

Category: Design

Summary

The COVID-19 pandemic and lockdowns have caused more fights, breakups, and divorces for many couples all over the world. The present study explores how EmoBank, a device that can show emotional balance, has an impact on couples' relationships. A qualitative research was conducted with five couples living together. After one week of usage, semi-structured interviews were conducted to find out their perceptions of the prototype. Results show that the design of the first prototype was not well-received by participants but the second one, a plant form, received positive feedback. The mechanism of counting emotional balance had positive effects on couples, with participants saying this is an easier way to share feelings. The device also acted as a trigger for couples to discuss both positive and negative aspects, which improved their relationships, especially for those originally in a relatively worse condition. Concerns of physical design and acceptance level were different between demographic groups. Although observed effects are limited due to the experiment duration, this study showed EmoBank's potential as a new way for couples to share feelings and improve their relationships.

Keywords:

Keio University Graduate School of Media Design

Bao Tuan Nguyen

Contents

List of Figures

List of Tables

Acknowledgements

Chapter 1
Introduction

A healthy relationship is that all couples should maintain, regardless of age or years in love. It requires effort and plenty of work from both partners, and the work does not end after going on a date or after moving in together. Many couples who were happy living independently find that when they move in together they simply are not compatible in that way and many issues can come to light.

1.1. Backgrounds

Couples' fights increase during the pandemic

All relationships involve a degree of conflict, and it is common to argue more during stressful times. However, the COVID-19 pandemic has caused more fights and, more seriously, spikes in breakups and divorces. There are many statistics showing this trend. There was 122% increase in divorce inquiries between September and December 2020 at Stewarts Law, 50% increase in searches for online advice on ending a relationship at Citizen Advices, and 34% rise in sales of basic divorce agreements at Legal Templates (Gould 2021). These companies are in the United States, United Kingdom but this trend has been happening all around the world, and especially among young newlyweds. According to a survey conducted by Legal Templates on the impact of the COVID-19 pandemic on relationships, 58% of users pursuing a divorce during the COVID-19 pandemic were married within the last five years, and newly married couples with five months or less experienced the most destruction which had double the rate of 2019(Moric 2020).

There are several reasons for this trend. According to a survey Verywell Mind conducted with their readers at the beginning of 2021, there were two main things couples experienced most: boredom and too much together time(Sweet 2021).

When the couple is already stuck in a struggle, it is the catalyst that leads to disruption. On the other hand, new problems may arise. For instance, when male partner also works from home, a disproportionate share of housework and childcare is still falling on women (Savage 2020). Many women feel unfair because they also have to work and even split household bills equally. Second, the increase in mental health problems also plays a role in breakups. During the COVID-19 outbreak, people might have concerns about safety, suffer from personal losses including illness and loss of loved ones, economic insecurity, and social distancing can add up to unprecedented stress. People need more encouragement than ever before from their partners.

Importance of Couple Communication in Stressful Times

All relationships have ups and downs, but a healthy communication style can keep fights from escalating, prevent resentment and create closeness and meaningful connection in a relationship. According to an online poll conducted by Meiji Yasuda Life Insurance Company in October 2020, about 20% of the respondents from 20 to 50 years old reported that during the COVID-19 pandemic, their relationships had "improved" or "improved somewhat," because of increased communication. Sharing feelings, or more specifically telling the partner what we think and expect from them, is one of those communications (Yamashita 2020).

However, it is common when couples refuse to open up and sharing the depth of feelings. It needs to take emotional risk and courage, and it also makes us feel exposed and vulnerable. Dr. Brown, a licensed marriage and family therapist, said: "It could be that they don't feel safe, in general, opening up. They have been hurt, betrayed, or shamed when they have opened up in the past. Perhaps they feel that you're more demanding that they open up, and are resisting you because they don't want to be controlled. Quite often, the core issue for people who have difficulty opening up is that they generally don't trust that the world is a safe place for them ." (Shatto 2020). In those situations, technology may be the way to push users out of their comfort zone, encourage them to open their minds, try new things and connect with their partners.

1.2. Objectives and Contributions

The purpose of this project is to create a device which would foster communication between couple living together and improve their relationship, especially during stressful times like a pandemic. Therefore, the objectives are:

- Determine what would be an appropriate design and functions for the device

- Investigate if the design would be likely to improve the user's relationship

Although current solutions both traditional like couple communication programs, couple therapy, and innovative like chatbots or mobile applications showed the effect in increasing relationship satisfaction (Shadish and Baldwin 2003), they still have many limitations. Many people who suffer from relationship distress do not go to therapy because they do not have enough money and time or believe that they can solve problems independently (Kaufman 2019). Whereas, mobile apps are convenient but easy to be ignored and may have bad effects on relationships (Misra et al. 2016, Rotondi et al. 2017).

This study contributes valuable insights to the field of couple relationship intervention. Young couples who are living together are the target users of this study. Although living together before marriage is common, it is not easy. Many relationship issues may happen if the couple do not prepare well. It will be more challenging for a relationship to recover if arguments and resentments are not solved early in the relationship. There is a chance for a product to make a couple happy while they are at home.

1.3. Thesis Organization

The organization of this thesis is as follows.

In Chapter One, the background, objectives and contributions of the study will be introduced.

In Chapter Two, the existing literature and related works will be reviewed.

In Chapter Three, the initial idea that leads to this current design will be revealed. And the concept and design of EmoBank will be described.

3

In Chapter Four, user testing to validate the prototype and results will be discussed.

In Chapter Five, limitations and future works will be presented.

Chapter 2
Literature Review

2.1. Relationship Stability

2.1.1 Emotional Bank Account

The emotional bank account is a concept describing the importance of positive interactions in daily interactions. An emotional bank account is made up of the positive, shared experiences that relationship partners have had together (Gottman 1999, Gottman et al. 2002). The experiences here all have in common in making relationship partners feel unique and valued. A few examples of positive experiences: having intimate conversations together, responding to a partner's needs, smiling together, and making plans together. Another study suggests that positive emotional experiences may take many forms within a relationship. It may include compliments, expressions of love, engaging in fun activities together, planning things to do together, and laughing together. This resource is considered to encourage positive relationship development and relationship success.

Besides, to avoid confusion, there are two types of experiences not constitute emotional capital. The first one has shared experiences but not positive, such as conflicts and an experienced stressor. However, positive, shared experiences can emerge from adverse life events. For instance, having an intimate or humorous conversation about a stressor or expressing love and affection as a way of providing comfort during a stressful time would constitute emotional capital. The second type is positive experiences that do not involve the partner. Emotional capital is a relational construct. The positive emotional experiences must be conveyed to the partner, such as through compliments and encouragement, or experienced with the partner, such as engaging in fun activities and laughing together. Finally, emotional capital is different from being "emotionally invested"

in a relationship. Emotional investment can include negative emotional investments that may manifest as jealousy and anger. Emotional investment may arise from various structural features of relationships unrelated to positive emotional experiences, such as mutual influence, investments of tangible resources, and lack of alternative (Berscheid et al. 1989, Rusbult and Buunk 1993).

2.1.2 Reactivity to Adverse Relationship Events

A main hypothesize of this theory is that the more deposits are made into a relationship's emotional bank account, the less affected by potentially destructive relationship events or behaviors. The reason is that making deposits into an emotional bank account will create an emotional buffer, and the withdrawals to their account are unlikely to break them (Gottman 1999).

Consequently, this theory predicts that negative behaviors or any relationship threats would be more affected to the relationships of those who have not invested in positive emotional experiences. Low emotional capital couples will be less likely to engage in pro-relationship behaviors and less motivated to work through hard times and engage in problem-solving (Rusbult et al. 1991, Wieselquist et al. 1999). This standpoint adds other theoretical perspectives that identify factors promoting relationship stability.

Evaluations of both between- and within-person variability in emotional capital commonly supported the emotional bank account viewpoint. Results showed that those who reported acquiring more emotional capital showed lowered reactivity to a partner's daily negative behaviors at the between-person level (Walsh et al. 2017). Specifically, following days of relationship threat, these individuals felt more optimistic about their partner and the relationship. They were less likely to do hurtful behaviors toward the partner. At the within-person level, results also exposed that daily accumulations of emotional capital showed similar effects. If individuals acquired more emotional capital on one day, they were less reactive to their partner's negative behaviors the following day. Therefore, higher levels of both chronic and recent emotional capital seemed to promote more stable levels of relationship health when facing negative relationship experiences. In conclusion, all results suggest that the accumulation of shared positive moments can be an essential element to long-term relationship success.

2.1.3 Measure Daily Emotional Capital and Partner Negativity

A study examined the longitudinal effects of emotional capital from 167 couples across the first three years of marriage by measuring participants' daily emotional capital and daily negative behaviors. They used a checklist of 14 daily relationship behaviors and asked participants to select all of the behaviors they experienced that day (Walsh 2016).

Emotional capital was assessed using six of the checklist's positive behaviors, such as "Spouse said something that made you feel loved." Scores were calculated each day for each participant, with scores ranging from 0 (no emotional capital) to 6 (high emotional capital) for that particular day.

Daily negative partner behaviors were measured using four negative behaviors from the checklist, such as "Spouse let you down or broke a promise." Composite scores were calculated each day for each participant, with scores ranging from 0 (no negative behaviors) to 4 (many negative partner behaviors) for that particular day. Participants also responded to these same four negative items rephrased to represent their own negative behavior enacted towards their partner, such as "You let your spouse down or broke a promise." A composite score of own negative behavior was also calculated each day for each participant.

2.1.4 Pet Ownership and Romantic Relationship Outcomes

Nearly 70 percent of American households own a pet (iii 2199) and 90 percent of pet owners think of their dogs and cats as members of the family (Corso 2011). Humans are happy to provide a lot of care for pets, just as much as a child. Research has shown that owning a pet can have a number of physical and psychological health benefits, ranged from higher survival rates from heart attack (Friedmann et al. 1980), reduced risk of cardiovascular disease (Arhant-Sudhir et al. 2011) ; and better physical and psychological wellbeing (Headey and Grabka 2011). Few examinations of pet ownership in a relational context has been conducted. Couples who own a pet are more likely to report better relationship quality than couples who do not. Furthermore, it was reported that the length of time an individual had owned a pet was associated with higher concerns, which was linked to

greater willingness to engage in relationship maintenance behaviors, commitment to the relationship, and couple identity (Cloutier and Peetz 2016).

2.2. Couple Communication

2.2.1 Importance of Communication in Intimate Relationships

"Communication is the transfer of information from one place to another. In relationships, communication allows to you explain to someone else what you are experiencing and what your needs are. The act of communicating not only helps to meet your needs, but it also helps you to connect with the other person" (Diggory 2019). Active listening and effective speaking are two critical skills of couple communication. Communicate clearly is useful to avoid misunderstandings that may cause hurt or confusion and active listening keeps us engaged with our partners in a positive way. Moreover, positive communication is commonly linked with high intimacy.

The idea of self-disclosure is that a relationship is built on trust. It is demonstrated by gradually revealing personal information, such as thoughts, feelings and experiences that they share with their partners. Social Penetration Theory proposed by Altman and Taylor declared that people gain a greater understanding of each other and show trust by gradually revealing their emotions and experiences (Altman and Taylor 1973) . Similarly, people usually feel intimate with their partners when they both can discuss their vulnerabilities and respond to each other's self-disclosure (Laurenceau et al. 1998, Laurenceau and Bolger 2005, Mitchell et al. 2008). A study investigated daily mood changes related to disclosing joyous and stressful events of their day affecting regulation to their partners. Participants said they had a more significant positive effect when they told their partner about their day's most joyous occasion and when their partner shared their most positive event. Conversely, partners may find it challenging to develop and maintain intimacy when such communication processes are not present (Hicks and Diamond 2008).

2.2.2 Couple Communication Exercises

There are many ways to improve couple communication. Firstly, they can attend courses provided by professional instructors who use experience and expertise in helping couples in troubled relationships. In these courses, participants can learn how to build a healthy relationship, choose suitable communication styles, make decisions and resolve conflicts.

Secondly, there is an easier way by searching for exercises online and practicing at home. Celeste and Rich, owners of a blog about love and marriage- Marriage Laboratory, came up with a solution called the 10-minute connect for busy couples. Every night a month, they took 10 minutes to talk about the good stuff and the hard stuff that happened each day. Then they celebrated each other's happy moments and successes. Positive questions are like "What was the best part of your day?", "What was a success you had today?" or "What energized you today?" and negative questions are like, "What was something hard that happened today?", "What did you struggle with today?" or "What drained you today?" (Davis 2016). Knowing to have a safe place to get the day's crummy stuff off the chest without fearing how the partner will react is like therapy and helpful. They tested together, and they were surprised at how much closer and understood they felt to each other.

2.3. Social Robots

2.3.1 Embodiment

"Embodiment: A term used to refer to the fact that intelligence cannot merely exist in the form of an abstract algorithm but requires a physical instantiation, a body. In artificial systems, the term refers to the fact that a particular agent is realized as a physical robot or as a simulated agent." (Pfeifer and Scheier 2001). Different types of robots have different relationships with the world. For example, the Aibo robot has a greater range of interactive skills than a robot vacuum. The interactive capabilities of a system in its environment are considerably impacted by the nature and extent of embodiment (Dautenhahn 1997).

There are four notions of embodiment: structural coupling, physical embod-

iment, organismoid embodiment, and organismic embodiment. "The broadest notion is that embodied systems are 'structurally coupled' to their environment and this does not necessarily require a body. Physical embodiment is when embodied systems is connected to their environment through physical forces, sensors and motors. Organismoid embodiment are physical bodies which at least to some degree have the same or similar form and sensorimotor capacities as living bodies. The most restrictive notion of embodiment is that cognition is not only limited to bodies of organism-like form, but in fact to organisms such as living bodies" (Ziemke 2001).

Physical embodiment is a mandatory requirement for some types of robots which are built to do physical work, ranged from house works (e.g., cleaning, cooking) to industrial use (e.g., assembling and delivering). For social robots, however, physical embodiment may not be mandatory, because their major purpose is social interaction which is not directly related to physical activities.

2.3.2 The Benefit of Being Physically Present

Physical robots and virtual agents are both defined and distinguished by the nature of their embodiment (Dautenhahn 1998). The form and structure of a robot can be used to set expectations (Fong et al. 2003). Therefore, it is possible that a physically embodied agent can facilitate better social interaction by providing more affordance for social interaction than a disembodied agent.

A recently published meta-analysis by Li found that in 73% of cases physical robots were reported that having a positive impact such as being more persuasive, more arousing, perceived more positively, and result in better performance (Li 2015). Even though the robot itself is exactly the same, people reacted more positively to a co-present robot than a digital robot. Furthermore, Li concluded that the benefits of robots are due to how that embodiment enables an agent to be present in a user's space, not its physical embodiment.

2.3.3 Expression of Artificial Emotions in Social Robots

Humanoid robots can express artificial emotion by borrowing from recognizable anthropomorphic features like facial expressions, gestures, or speech (Chuah and

Yu 2021). However, many appearance-constrained robots do not possess these output modalities. Social agents that lack expressive features have to draw on modalities like color, sound, or vibration to communicate effectively (Terada et al. 2012).

Santamaria-Bonfil and Lopez used emoji to power virtual and physically embodied entities with the capacity to recognize and express emotional content (Santamaría-Bonfil and López 2019). Ishii and Watanabe used a robotic plant that can move its stem to react with the human voice. Results showed that the speaker feels more interested when talking to a robot, even though it does not need to respond with words (Ishii and Watanabe 2019). Song and Yamada discussed how to express emotions with a social robot through color, sound, and vibration. They found some expressions that can well convey relaxed, sad, and angry emotions. For example, relax can be expressed by white color; sad can be expressed by blue color, falling beep sound and/or low intense vibration; angry can be expressed by red color, rising beep sound and/or highly intense vibration (Song and Yamada 2017).
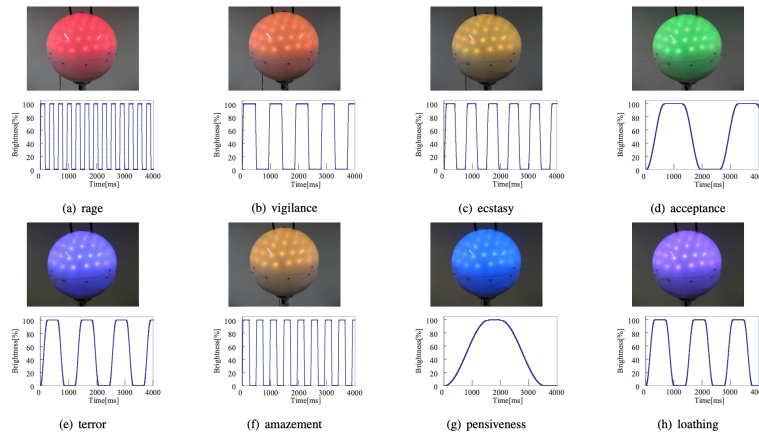
Figure 2.1 Color and waveform for 8 emotions of a robot (Terada et al. 2012)

2.4. Human-Plant Interaction

2.4.1 Plant Sensing and Communication

It is true that plants do not appear to do things that many of us find most interesting about humans and other animals such as moving and communicating with others. Although without a central nervous system and animate impression, plants can sense many aspects of their environments such as light, temperature, touch, or sound and respond with a variety of behaviors. In some cases, they have evolved functions that are similar to those in animals, but in different mechanisms and capacities. Jonathan Silvertown and Deborah Gordon described the behavior as a response to an event or environmental change during the course of the lifetime of an individual (Silvertown and Gordon 1989).

Although people generally assume plants do not feel when they are being touched, they are sensitive to it. They not only adjust their biochemical reactions but also adapt their size, shape, and safety. In addition, different sensations trigger a cascade of physiological and genetic changes, depending on the stimulation the plants are receiving, whether it is rainfall, wind, or touch (Stacey 2199). Speed of response is different for each plant. Some plants have quick and highly noticeable behaviors. One famous example is the shameplant which folds its leaves when they are touched by an external agent. Other plants may react slowly over time so are hard to recognize (Braam 2005).

2.4.2 The Effect of Plants on Human Emotions

Numerous studies have reported on the healing powers of plants and nature. The results of an experiment showed that after being in the room with flowers and viewing a videotape, the subjects' feelings of confidence, composure, and relaxation were all increased compared to their feelings before entering the room with the flowers. In addition, the foliage display generally affected males more positively than females, while the floral display and no plant condition had a more positive effect on females (Lohr et al. 1996). The stress-reducing effects of interaction with indoor foliage plants were studied, and the results showed that participants had positive feelings when interacting with indoor plants. (Lee et al. 2015). An-

other research showed that people experience an unconscious calming reaction to touching a plant (Koga and Iwasaki 2013).

2.4.3 Augmenting Plant with Touch Sensor and Its Application in Affective Communication

Augmented Human-Plant Interaction is a field exploring actual communication modalities of plants and extending them to facilitate and enrich the interaction with humans through different sensory modalities.

Touch sensors have mainly two types: resistive touch type and capacitive touch type. Resistive touch sensor works by the conductor's resistance. When a human touches, the resistivity of the conductor changes, a voltage changes which is detected by the circuit. On the other hand, a capacitive touch sensor works based on the change in capacitance, that is when we touch the sensor the capacitance of the circuit changes. Botanicus Interacticus uses a technology that measures response to touch by exciting the targets with an electrical signal. The system can detect a complex gesture such as sliding fingers along the stem of the plant. Proximity, location of touch happened and amount of touch time was also be recognized (Sato et al. 2012).

One application of augmented human-plant interaction is affective communication. Its primary aim is to embed anthropomorphic characteristics in plants then building empathy towards plants or using plants as a companion to provide emotional support to humans. For example, EmotiPlant presents a use case where augmented plants help elderlies better cope with loneliness (Angelini et al. 2016).

2.5. Related Works

2.5.1 Digital Products

There are many apps that aim to improve couple's relationship. Cobble, main concept is to provide dating ideas for couples. During the pandemic, Cobble has started providing new date ideas that couples can do from home such as movie and TV show recommendations, cooking and baking ideas or home activities. Another

app is Merge that takes aims to reduce the stress of managing houseworks among couples.

Coral, Lasting, Coupleness or Love Nudge are developed for increasing couple relationship intimacy and happiness but in different ways. For example, Lasting and Coral provide various relationship-building sessions from experts. Users can track their journeys, learn communication skills and practice with partners. Daily reminders that help users apply those lessons frequently. Coupleness askes couples about their feelings every day and open up new topics of conversation for them. It also give users a daily rating for their relationships which put users on the right track. Love Nudge is different than others by focusing specifically on how users communicate in the five different categories: physical touch, acts of service, quality time, words of affirmation, and receiving gifts. It prompts users to take quiz identifying these five categories from both partner then give recommendations based on each user personalized goals.

Figure 2.2   Cobble, Coral, Coupleness, Love Nudge app screenshots. (Source: https://fueled.com)

2.5.2 Physical Products

Many products do not directly solve a couple's problems, but play a role in creating opportunities for the couple to interact and communicate. Sway, designed by Markus Krauss, is a rocking chair having an unique design allows for seating for two. By this design, the chair can create space and opportunity for couples to talk together. With the same concept, there are several similar products such as

coupled coffee filters designed by Amelia Roblin in 2013. It can make a pair of drinks simultaneously so the couple can enjoy drinking coffee together.

Figure 2.3 Sway chair for two (Source: https://www.markuskrauss.com)

Some products are not practical but meaningful and for research purpose such as the 'Compass Phone' by Hayeon Yoo, an electronic tracker packaged in a wooden container. It lets users know how far away your significant other is, and in what direction they are heading. The digital display on the outside keeps track of the distance, while the compass on the inside points you in the right direction.

Products that are practical and used frequently are not new, they have been already existed for many years such as board games for couples, or couple journals. While they are nothing new, they still can generally create opportunities for couples to spend time together.

Figure 2.4   Date Night Box, a card game for couple (Source: https://www.amazon.com/Romantic-Couples-Gift-Adventurous-Girlfriend)

2.5.3 Robots

Few robots are designed to improve couple relationships, and the majority focus on long-distance relationship couples. Furfur is a robot pet that couples in long-distance relationships can care together (Chien et al. 2016). The idea of a shared pet is to invite communication and cooperation, as well as create feelings of togetherness for couples. Telepresence robots have the potential to better replicate the qualities of in-person interactions by providing an embodiment for one remote partner who could talk through the robot, so they are also used to explored how it can help to maintain long distance relationships. Using Beam Smart Presence, a study found out a telepresence robot made distance couples feel closer on multiple occasions, allowing for a more natural pattern of communication compared to traditional video chat tools (Yang et al. 2017). Another study used telepresence robots to control the smart devices in the remote location to create a feeling of sharing home life (Yang and Neustaedter 2020). Its findings revealed that having control over a remote home space through a telepresence robot embodiment can create feelings of ownership and belonging. The ability of cleaning remotely, for example, created a chance to share tasks and support over distance. It can maintain the co-location as well as closeness with the local partner.

Figure 2.5   Furfur, a pet for romantic couples in long-distance relationships (Chienet al. 2016)

The robotic couples counselor is a humanoid head developed by Furhat robotics. It has an animated face and can raise eyebrows for emphasis and gaze toward/away from users for turn-taking. The robot's speech is generated using the Windows speech synthesizer, and lip movement is synchronized using text to speech engine. An experiment with the robot was conducted to explore reactions to and acceptance when it takes the role of a couples counselor (Utami et al. 2017). Each 30-minute session begun with the robot introducing itself, asking the couple about the history of their relationship, then introducing two communication skills: active listening and effective speaking. For each skill, the robot first describes, tries, asks the couple to practice the skill with each other, and finally provides feedback on how well they used it. The robot ends the session with a summary and reflection. Results showed that participant couples reacted positively to the robotic couples counselor, expressing high satisfaction with, liking, and trusting in the robot. They perceived the robotic counselor as capable of leading the discussion and getting participants involved in the discussion. Participants also found the interaction enjoyable, and their mood was improved during the interaction. However, this robot does not focus much on listening to the users.
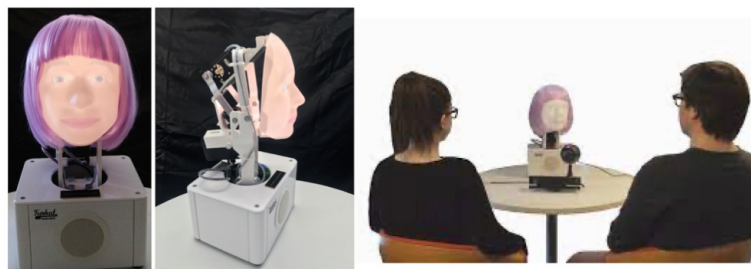
Figure 2.6 Robotic couple counselor (Utami et al. 2017)

2.5.4 Augmented Plants

Pekoppa is a speech-driven embodied entrainment toy robot invented by Sega Toys. It generates communicative motions and actions from speech recognition (Watanabe 2011). For example, Pekoppa will stay inactive until someone communicates with it. For example, Pekoppa will stay inactive until someone communi-

cates with it. Its stem will bend if a user speaks to it. The bending movement is supposed to mimic a human's nod. Ishii and Watanabe used Pekoppa to evaluate the active involvement of audiences motivates the speaker's utterances and have shown that it had a positive impact (Ishii and Watanabe 2019). In other words, the speaker feels more interested when talking to a robotic plant, even though it does not need it to respond with words but just action. However, there is no research showing that robots are effective for couples.

Figure 2.7   Pekoppa (Source: https://techcrunch.com/2008/06/06/meet-pekoppa-the-plant-which-listens-to-your-sorrows/)

The Pet Plant is a hybrid between a plant and a robotic pet. It can respond to a touch by the intensity of the LEDs: green when the user holds the plant pot, red when holding the leaves. It also can respond to a speech by blinking green LEDs according to the volume of the subject's voice. When users stop touching it, the light intensity reduced gradually to its original status. McCalley and Mertens experimented with the robot with four conditions: change and blink light randomly, increase/decrease light intensity gradually and change light conveying a particular character (extrovert or introvert). They discovered that participants attributed emotion to the responsive pet plant. Interestingly, although the electronic controls of the pet plant resided in the pot, participants were able to accept the actions of the pot as reflecting plant response. They also concluded that interactive plants could have the potential to develop further to serve as supportive companions (McCalley and Mertens 2007).

EmotiPlant is a plant augmented with a display showing emotions by emoticons and status, including temperature, soil moisture, and light values. In detail, the system is composed of an Arduino Uno board equipped with a light sensor, a

Figure 2.8 The Pet Plant in resting state (McCalley and Mertens 2007)

soil moisture sensor, and a temperature sensor. The emoticon and the histogram are displayed on two 8x8 red/green LED matrixes. Touch detection is realized through an electrode attached to a plant branch, using the Arduino CapSense library. One of its aims is to generate an emotional attachment to the plant to relieve loneliness for older adults. However, the EmotiPlant could not be tested because of its current limitations, such as incorrect sensor values or inaccurate touch detection (Angelini et al. 2016).
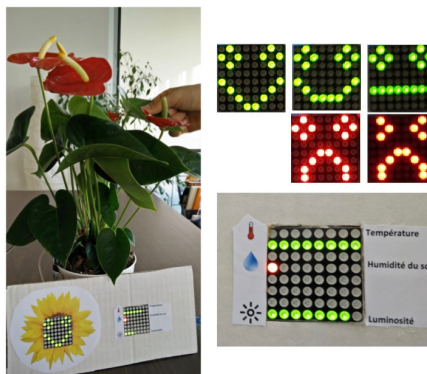
Figure 2.9 EmotiPlant prototype (Angelini et al. 2016)

2.6. Summary

The theory of Emotional Bank Account is proposed to show that it is an important indicator to evaluate a romantic relationship. The difference between happy and unhappy couples is how they manage their Emotional Bank Account. In addition, research suggests that self-disclosure plays a key role in forming strong relationships. This will be the foundation to build my product.

For related works, some physical products for couples are unique but not highly practical, rarely used, and only effective in a specific situation. On the other hand, long-existing products like books or board games are not new. We can see one of the new development directions that is digital products such as mobile apps for couples. These apps aim to improve couple relationships with many features, based on therapist lectures and put into the app. They provide a more convenient approach for users, especially young people can access this type of information. However, the popularity and effectiveness of these products are doubtful, when the number of users is still small, the product itself is relatively complex and focuses more on struggling couples, not ordinary ones. Also, some studies showed that smartphones have a negative effect on relationships (Misra et al. 2016, Rotondi et al. 2017).

Regarding robots, they are mostly designed for long-distance couples. One is a robotic counselor that can teach couples communication skills and had a positive impact on couples. However, it can only be an alternative to therapy, providing a more enjoyable therapist session, but not for long-term and household use. Pekoppa, The Pet Plant and EmotiPlant are only tested to individuals, not couples and they have not seen to apply to improve couple communication. I discuss augmented plants because I think this will be a novelty for this research. As mentioned above, relationship apps may be new for people. If they have too many features that will be a barrier for users to try. I wanted to design a product that has few features, is easy to understand, and is easy to use. It should be in the form of a familiar item in the users' houses so a plant is a suitable choice. Specific design and features of the product will be described in the following section.

Chapter 3
Design

In this section, I will introduce the origin of the research idea. What I was thinking, and why I switched from the old idea to the new one. Then I will introduce the concept of the product, two prototypes, and the improvement from the first to the second one. As mentioned in the previous section Related works, there are no physical products that are innovative and popular among young couples. Therefore, my goal is to create a product that is easy to use and also based on proven studies on improving relationship.

3.1. The Initial Idea

Due to intense competition industrialization and globalization, people have more pressure in their lives and are more likely to have mental disorders. (Evans-Lacko et al. 2013). Furthermore, adults' employment, their family life and mental health can be affected by conflicts between culture and values arising from globalization (Bhugra and Mastrogianni 2004, Colton et al. 2015).

3.1.1 Mental Health in Family

Mental health is connected to other aspects of our health, has a great effect on the way families function and brings a sense of worth and value. In our family, we learn how to understand each other and therefore create deeper connections with other family members and outside communities.

Mental health problems can be distressing for all family members and have a huge effect on a family's finance and emotion. The emotional and behavioral consequences of mental illness have not been taken into account. In contrast, a family breakdown can lead to negative events impacting the mental health of

the family. The parents' mental health history tended to increase the rates of depression and other mental illnesses in children compared with children of parents without any emotional illness (Behere et al. 2017).

3.1.2 Chatbot in Mental Health

A chatbot is an artificial intelligence software that can simulate a conversation with a user in natural language through messaging applications, websites, mobile apps, and the telephone. The first-ever chatbot was Eliza, introduced even before the launch of personal computers in 1966 to study natural language communication between man and machine. The program was designed to mimic human conversation. ELIZA could not, however, react to queries in their full context but only can pass the words that users entered into a computer and then pair them to a list of possible scripted responses (Weizenbaum 1966).

Presently, chatbots are on the rise thanks to the openings of many messaging platforms such as Facebook Messengers, Slack, or Telegram offering the facility to build and run a chatbot. With the development of artificial intelligence and natural language processing, these bots become smarter and can learn over time to respond like humans. It makes a major impact on many industries such as healthcare. A chatbot can be a solution to improve human mental health. It may outperform a therapist in many aspects, for example, storage more information and knowledge, less judgment, and easy to access (Cameron et al. 2017). The use of chatbot can improve people's mental well-being (Lucas et al. 2017, Woodward et al. 2020), increase their self-compassion (Lee et al. 2019), and significantly reduce symptoms of anxiety, depression and levels of stress (Daley et al. 2020).

3.1.3 Family Robot Concept

In order to improve the mental health of modern families, a family robot is supposed to support family members' mental health by consult and advise about all members' worries and concerns. It also should be able to take care of and play with them or helps them connect or build new communities in the neighborhood, children's schools, or parents' companies in the digital society.

A family begins when a couple gets married and passes through six stages:

newlywed stage, parenting stage, middle-age stage, post-retirement stage, nursing-care stage, and lonely stage. The role of a family robot changes from one stage to another. When designing a family robot, we will consider the following five points.

1. Be able to meet the diverse needs of various families

2. Be flexible in responding to the needs of a nuclear family that change with age

3. Support not only in the family but also in the relationship between the family and the communities

4. Respond to the needs of an aging society and a digital society in the future

5. Incorporate the latest AI, advances in robotics, and communications technology to develop a family-robot system

3.1.4 Current Mental Health Chatbots Evaluation

To find out the development direction for Family robot, I will analyze the short-comings of two popular mental health chatbots Woebot and Replika based on reviews from users on several platforms: Google Play, Product Hunt and Facebook Group.

Woebot

Woebot is an AI-powered mental health chatbot helping its users monitor their mood and learn about themselves. It uses a combination of natural language processing, carefully constructed writing, a sense of humor, and psychological expertise in Cognitive Behavioral Therapy. In short daily conversations, Woebot can ask users how they are feeling and how things are going.

Although it is the winner of the Google Play award for standout well-being app in 2019, reviewed by more than nine thousand users on Google Play with 4.7 over 5 stars, it still has many drawbacks. Below is the keyword analysis of Woebot's first 20 1-star reviews on Google Play during 2019 and 2020. 14 times words such

as "same answer", "limited" or "repetitive" appeared, and 19 times words such as "frustrated", "annoying" or "disconnected" appeared (See Figure 3.1).

This result shows that the technology of Woebot still does not meet many of its users' expectations when it is still not able to give appropriate responses. This, on the contrary, not only does not bring sufficient value but also makes users feel worse.

Users' feeling	Woebot's responses
frustrated	same answer
Horrible	same scripts
discouraged	limited
hate	repetitive
frustrating	irrelevant
inhumane	same
bad	generic
frustrating	cliché
patronising	Useless
obnoxious	unrelated
worst	unhelpful
annoying	REPEATEDLY
grating	limited
patronizing	too short
depressed	
tiredness	
disconnected	
depressed	
frustrated	

Figure 3.1 Keywords extracted from Woebot Google Play Reviews 2019-2020

Replika

Replika is also a chatbot companion powered by artificial intelligence which can talk with users like a friend. Replika can learn and develops a personality based on the user's input.

To get more diverse information, I used two channels to find the points where Replika is not doing well, these are Product Hunt, website to share and discover new products, and Facebook Group Replika users community on Facebook. On Product Hunt, Replika has 10 reviews, 5 do not recommend this product. A big

problem that Replika has and is more serious than Woebot is that because of the high customization of the responses, it sometimes provides strange or even hurtful responses which could harm people who have mental health problems and are using the product. For example, it could respond like "I don't care about you", "I want to talk about my rape" or "Humans are not to be trusted."

On the other hand, I asked a question on the Replika community "Which do you think is more important, Replika can talk smart things or Replika shows that it's listening to my sharing?". There were 42 answers and around 20% want a good listener chatbot (See Figure 3.2).
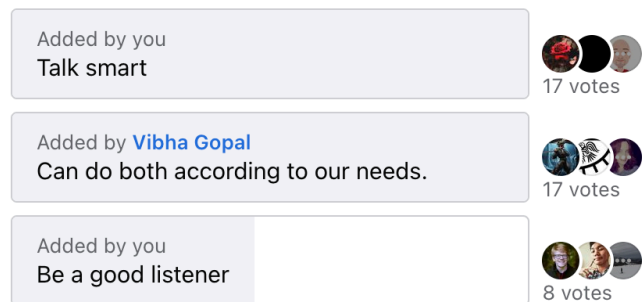
Figure 3.2 Poll on Facebook Group of Replika users

3.1.5 Why from Family Robot to EmoBank

In conclusion, technology has opened a new frontier in mental health support. New ways for people to access help, monitor progress, and increase understanding of mental wellbeing can be provided by chatbots. Despite the convenience and its limited responses which could make users frustrated, a chatbot can create an opportunity for users to share their feelings. Chatbots like Woebot or Replika have been recognized by their users that can make people feel cared for and improve humans' mental health. Therefore, the next direction of a family robot will emphasize the listening ability and be able to create opportunities for family members to share their emotions.

3.2. Concept of EmoBank

Research shows that living together is associated with more conflict than either dating or being married. The reason for this is that while living together, couples deal with the same issues dating couples usually face, such as time spent together, jealousy, or commitment, as well as issues common to married couples such as household contributions, money, or in-laws. When the conflict is ongoing, it creates stress that can negatively affect the health and well-being of both partners. The key is to communicate feelings clearly, listen effectively, and understand the other person's perspective. Our research goal is to encourage couples to communicate their feelings more frequently and do more positive things to each other.

My proposal is EmoBank, a device that users can use to calculate their relationship emotional balance. This balance number is expected to present the couple's relationship health. In other words, EmoBank can digitalize an abstract number which is relationship health, so couples can know when their relationship is in danger to take necessary actions. The balance would be manually inputted by couples by answering a checklist including positive and negative experiences they have during one or few days. For each positive experience, they have had, their balance plus one point. In contrast, for each negative experience, they have had, their balance is minus one point.

There are two important design elements of a new idea like EmoBank: curiosity for first-time users and fun enough for encourage users use frequently and for long time. Therefore, although EmoBank can possibly be a mobile application, I decided it should be a physical product. The reason is that in the age of technology, we have the issue of notification overload. We have too many mobile apps, too many notifications, which both distract us and have a negative effect on our health. Therefore, an app not a good idea for a product that has to be used frequently and does not need mobility. We do not need to bring EmoBank to everywhere, and we do not need Internet to operate it either. A study in the British Journal of Health Psychology found that 91% people who planned their intention to exercise would be able to commit exercising the following weeks while only 35% people who read motivational material about exercise, but did not plan would exercise (Milne et al. 2002). Exercise or sharing emotions, both activities take time for

us to form new habits. Therefore, the present of the device is expected to make users always remember to use it and can not ignore.

There are three main functions of this product.

- **Display** In idle mode, the screen shows emotional balance. In counting mode, the screen shows show question numbers for couples to count the positive and negative experiences.

- **Count** Users can use EmoBank to record their emotional balance by manually input the number of positive and negative experiences they have during the day.

- **Reminder** Remind users to record the emotional balance frequently. This reminder can be a LED blink when they come near the device, or it can be subtle like a thing that they usually need to interact frequently such as a plant which they have to water once per few days.

3.3. Design Process

Based on design thinking, my proposed design process consisted of five main steps.

1. Define target user and problems

I was looking for significant and urgent problems that need to be solved. Initially, I chose the family as the target audience because since it is close to me. I can understand my family's needs and problems, and it is not difficult to gather more data from friends or classmates. Families have many of the same problems regardless of country or culture. I have considered making a family robot that can help solve all problems in the house, from assisting with housework, babysitting, and even connecting family members living far away. However, I have narrowed down the audience and the problem because of the time and capacity limitations. In the end, I chose childless couples who have just moved in together under three years as my target user.

When choosing a research subject, at the same time as the coronavirus outbreak was occurring. On social media, "corona divorce" was trending and used to describe the spike in breakups and divorces of couples during the lockdown period.

The problem is how to improve couples' relationships or, more specifically, how to encourage them to express their feelings with their partners.

2. Research previous works

I intend to build a new product based on existing academic findings on relationship stability and satisfaction. There are two main theories I used as a foundation for my research.

- Emotional bank account is made up of the positive, shared experiences that relationship partners have had together. The more deposits are made into a relationship's emotional bank account, the less affected by potentially destructive relationship events or behaviors.

- Sharing feelings with partners brings mental and physical health benefits to couples.

3. Prototyping

After deciding on the basic idea, I create a simple device that met these requirements.

- Can store Emotional Bank Account balance of users

- Can guide couples to share their feelings

4. User testing

I want to test the following assumptions:

1. If the user knows their Emotional Bank Account balance, what impact does the device have on users' relationships?

2. How do their relationships change when the users share their feelings with their partners?

I will try to find couples with different nationalities, such as Vietnamese, Chinese, or Japanese, and occupations such as student or full-time worker to avoid bias.

5. Improvement

Improve the prototype based on data collected from user testing.

3.4. The First Prototype

The first prototype of EmoBank is a low fidelity design with a microcontroller board (Elegoo Uno R3), a screen display (LCD 1602), ultrasonic distance sensor (HC-SR04), and two push buttons. As described in the Concept section, in order to promote the effectiveness of the product, users need to count daily to get the up-to-date emotional balance number. In idle mode, the display light is off. When somebody comes near it, the ultrasonic distance sensor detects and lights up the screen. Then, in order to start counting the emotional balance, users press the Start/Next button. The screen shows Question 1. Users use an emotional balance counting question list, ask each other those 10 questions about positive and negative experiences they have during that day. For each experience, users press +1 button. They can press more than one time according to the number of experiences they have had.

For each positive experience, the emotional balance increases one and for each negative experience, the balance decreases one. Although there is an article indicating that during the conflict, 5 positive interactions to every 1 negative interaction and during everyday life: 20 positive interactions to every 1 negative interaction. The reason for this difference is because when couples are in the heat of conflict, they are already in a negative state of mind, so the added negativity is to be expected. This 5:1 ratio does suggest that you still need to say and do five positive things for every negative thing, even during an argument. On the other hand, when you're going through your day and you're suddenly interrupted by a negative interaction with your partner, it has a much bigger impact on your Emotional Bank Account. Positive interactions are small, consistent deposits, but negative interactions are big withdrawals, and too many of them can erase a positive balance. However, there is no sufficient study to prove this ratio. Therefore, to make it simple, this prototype uses 1:1 ratio, which means one positive experience equals one negative experience.

After finish all questions, the screen shows the emotional balance. For example,

if the balance is +10, their relationship is good. But if it is -10, it means their relationship is in danger, and the number tells users to do necessary actions to save their relationship.

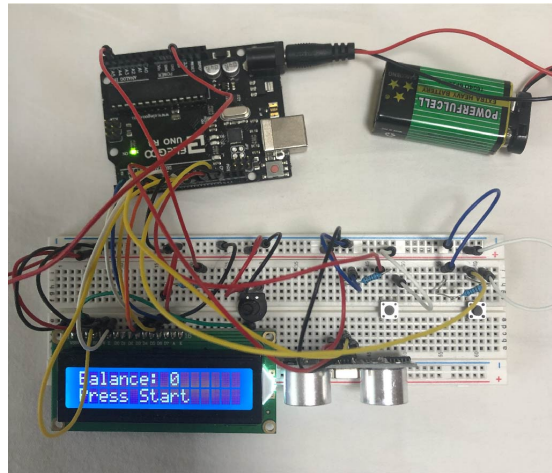
Figure 3.3 The first prototype EmoBank

How to use

To be effective, user is expected to use the product regularly, so EmoBank has a distance sensor. It can detect when somebody come near it and lights up the screen to remind users counting their emotional balance.
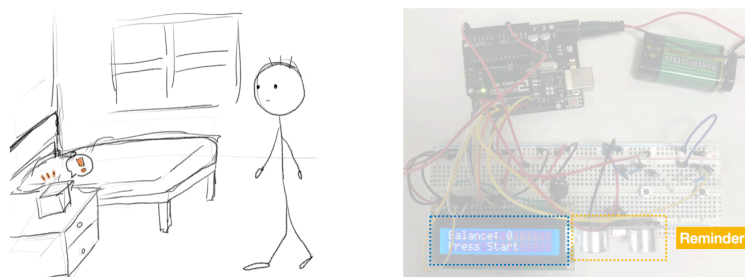
Figure 3.4 Trigger to use the product

In order to calculate the emotional balance, users will use question list, and ask

each other questions and count number of positive and negative experience they have that day. When users are ready, they can press the Start button to start the counting. The screen will show the question number. Users check according question on printed question list, then ask each other those 10 questions. For each experience they have had, they press +1 experience button. Press Next button to move to the next questions.

Figure 3.5 Counting emotional balance

After finish all question, the screen shows balance number. If the balance number is low, users know their relationship is in danger and they should add more positive deposit to it.

Figure 3.6 Emotional balance is showed

3.5. The Second Prototype

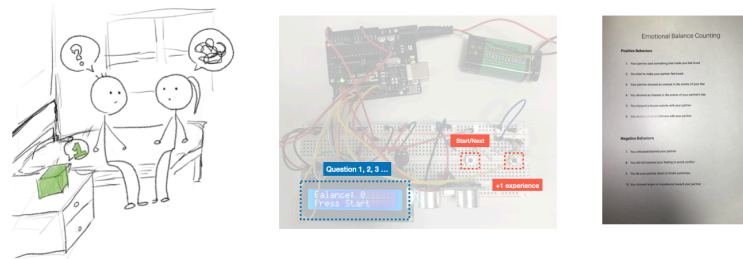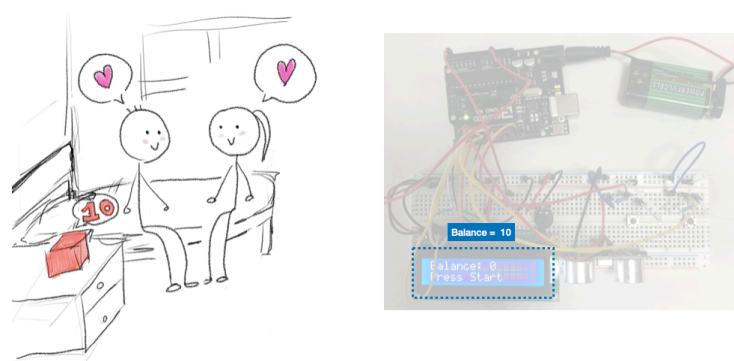The second prototype is an upgraded version of the first prototype. There are three primary changes: display, appearance and interaction. The LCD 1602 from the first prototype is show more characters but it still could not show the full sentence of questions, and dark. The unique point of this product is that users can see their emotional balance number every time so it is better to have a brighter screen. In this version, 8x8 LED Matrix has been used which can present number more clearly. The second change is appearance, an augmented plant. With this prototype, instead of pressing buttons, users can touch twice the plant leaf to start the system or move to next questions and touch once to add one experience. For each positive experience the user records, the plant will react by lighting the green LED and for each negative one, the plant will light the red LED. This is based on how robot can express emotions through colors (Terada et al. 2012), red means vigilance and green means acceptance. Similarly, my humidifier sends me a message when it wants to warn me that the house is dirty by red light, and the house is clean by green light (See Figure 3.7). I think it can speak more than just a notification. In this case, EmoBank wants to say that users' relationship is good if for each positive experience they have and warn them for each negative experience.
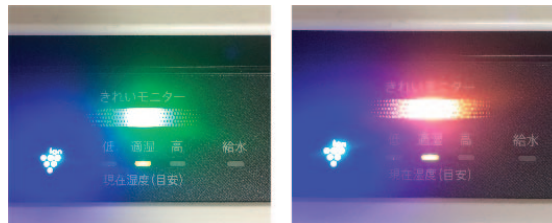
Figure 3.7 My humidifier sent me messages

There are several reasons why I chose the appearance of the prototype as a plant. Firstly, a plant is a metaphor for the relationship. If watered regularly, the plant will live well, if not watered, it will die. Similarly, in a relationship without making efforts, without doing positive things, it will die, even in a long relationship. Secondly, target user of EmoBank is young couples while interest

in houseplants among 20s 30s is increasing with sales said to be up as much as 500% in recent years. Millennials and GenZers are waiting longer to start families or are choosing to not have children. Humans have an innate need to nurture something. Plant is easier to take care than pets or children, and still fulfill the need for nurturing. Finally, in literature review section, many studies showed that plants are healthy for human 's physical and mental well-being.
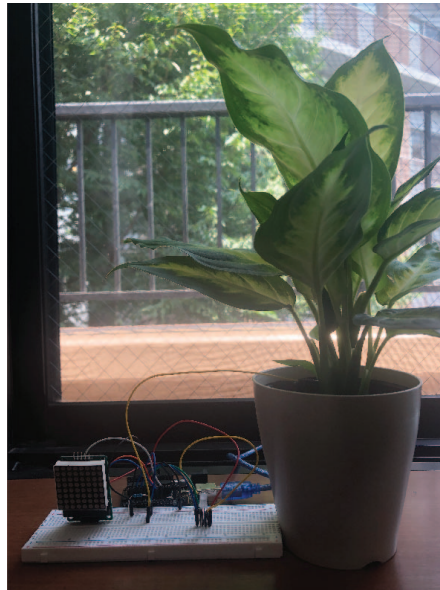
Figure 3.8 The second prototype of EmoBank

How to use

With the second prototype, users can use the same process as the first one. There are some small changes. Instead of pressing Start button to start the counting, users can touch the plant leaf twice then the screen will show the question number (See Figure 3.9). Using the same question list, they count positive and negative experiences they have had. For each experience, users can touch the leaf once. From question from 1 to 6, for each positive experience is recorded, the LED green lights and balance plus one. From question 7 to 10, for each negative experience is recorded, the LED red lights and balance minus one (See Figure 3.10). After finish all 10 questions, the emotional balance will show on the screen (See Figure 3.11).
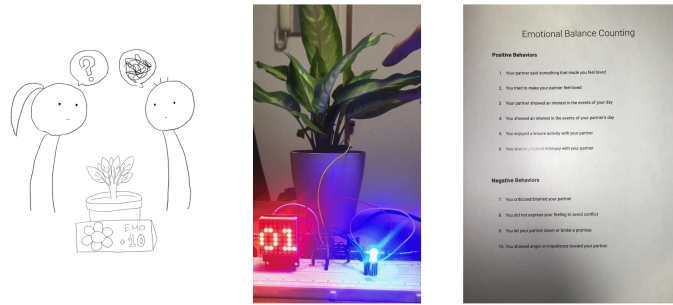
Figure 3.9 Start the system and ask questions
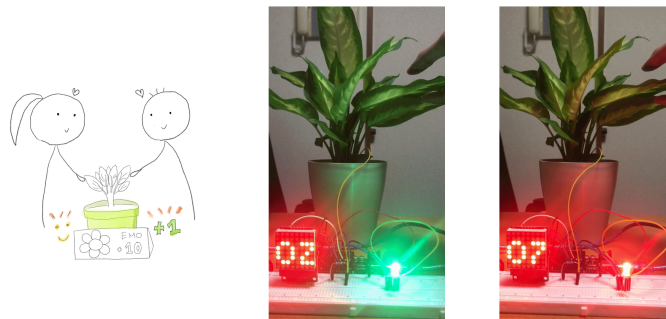
Figure 3.10 Record the number of positive and negative experiences
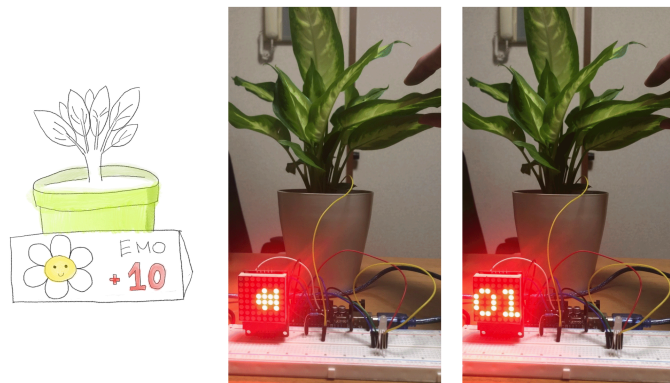
Figure 3.11 Finish and show the emotional balance

3.6. Scenario Design

Target Persona

See the Figure 3.12 and Figure 3.13

Figure 3.12 Persona 1

Figure 3.13 Persona 2

Use Case

Sai and Ellen are in a relationship, and they moved in together two years ago. Recently, due to the COVID-19 pandemic, they spend more time at home and face more conflicts. They want to try Emotional Bank to see if it can help to improve their relationship. They put the device in the bedroom, on a bedside table. Every day, before going to bed, they enter the bedroom, trigger the ultrasonic distance sensor, which lights up the display and remind them to use the product (Image 1, Figure 3.15). Then, they sit together, press the Start button, open the questionnaire that came with the device, and ask each other the following questions (Figure 3.14).
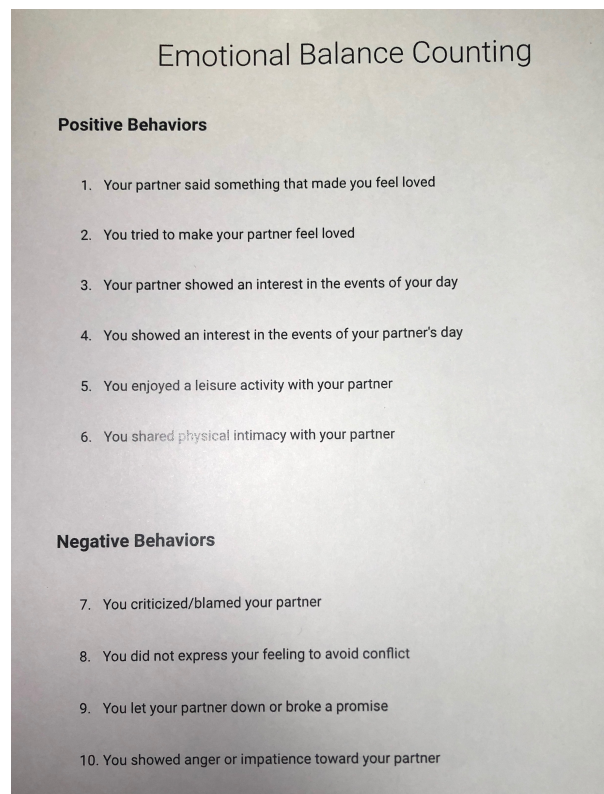
Figure 3.14 Emotional Balance Counting Question

They pressed Yes with the number of experiences they had on that day for each question. Then press Next to move to another question. Keep doing this

activity until finishing all ten questions to calculate the emotional balance of the day (Image 3, Figure 3.15).

They can see their relationship status through the emotional balance number. It is expected to encourage users to do more positive things to their partners if they see the balance is too low (Figure 3.16).
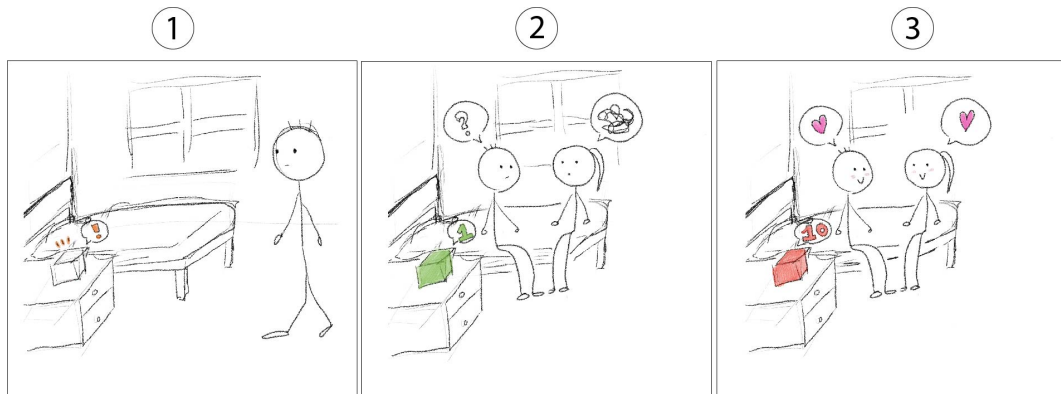
Figure 3.15 Use case 1
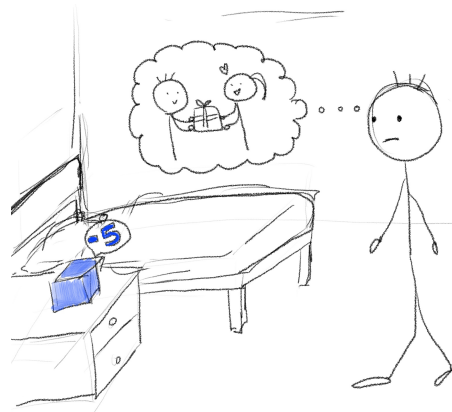
Figure 3.16 Use case 2

Chapter 4
Evaluation

In the previous chapters, the concept of EmoBank was discussed based on the original idea of a family robot. This chapter covers the prototype validation process, including methodology, participants, experiment setup, and results. The goal is to test the effectiveness of Emobank on romantic couples.

4.1. Methodology

In order to evaluate the design, a qualitative evaluation is conducted on how the EmoBank influences couples' relationships. Qualitative research can help understand needs, feelings, values, and perceptions that underlie and influence behavior on a deeper level than close-ended quantitative measurements (Gelo et al. 2008). It is especially useful to gauge reactions and perceptions of new ideas since there are no measurement scales developed in such situations (Sherman et al. 1986). For example, qualitative evaluation has been applied to examine the impressions of participants to a robot counselor (Utami et al. 2017). The evaluation consists of two stages, which will be elaborated on in the Experiment Setting section. After each experiment, semi-structured interviews were conducted with each partner separately. A few pre-determined questions were asked, including "How did you feel after talking about positive experiences?" or do you think it actually helps your relationship and why?", while the rest of the questions were based on users' responses. Sample interview questions are posted in the Appendices.

4.2. Participants

Participants are five couples (i.e. 10 people) who were recruited through my network. Their age ranges between 24 and 33. The mean age for male partners and female partners is 27.2 and 28.2 years old, respectively. The average level of education is a master's degree. On average, couples have been romantically involved for 5.6 years and living together for 1.2 years. They are all living together and are either unmarried or married for less than a year in both partners' first marriage.

1. Couple A. Both of them are Vietnamese and studying in Japan, one as a master's and the other as a Ph.D. student. They have been in a relationship for nine years and have been living together for two years. The male partner is a KMD student.

2. Couple B. Both of them are Chinese. The man is working full-time, and the woman is a master's student. They have been in a relationship for five years. Both of them are KMD students.

3. Couple C. Both of them are Chinese. The man is a student, and the woman is working full-time. They are in a relationship and have been living together for more than a year. The male partner is a KMD student.

4. Couple D. The man is an American student, and the woman is a Japanese full-time worker. They have been in a relationship and have been living together for about one year. The male partner is a KMD student.

5. Couple E is a Vietnamese man and a Japanese woman. They are the only newlywed couple and have been living together for one year, although they have been in a ten-year relationship.

4.3. Experiment Settings

The experiment is divided into two phases.

In the first phase, all five couples used the first prototype. The prototype was handed to couples to use at home. At the end of each day, they use the prototype to evaluate their relationship score of that day.

Participants were given the prototype and emotional balance counting question list and instructed on how to use the device. Before going to bed, couples used the device. They started by pressing the Start button, then used the question list to ask each other ten questions. For each question, they could press the +1 button once for each experience they have had. They could press more than one time. After finishing all questions, the emotional balance was saved to the device and displayed on the screen.

Each couple used the prototype for a total of seven days. The first phase experiment schedule was as follows:

1. April 9 - April 16: Couple A

2. April 17 - April 24: Couple B

3. April 25 - May 2: Couple C

4. May 13 - May 20: Couple D

5. May 24 - May 31: Couple E

In the second phase, one couple used the second prototype. The basic process is similar to the first phase experiment. However, instead of pressing the button, the couple touched the plant leaf to record the emotional balance.

The second phase experiment schedule was as follows:

1. June 5 - June 12: Couple A

The remaining four couples watched a video of the prototype.

4.4. Relationship Baseline

To compare the effectiveness of EmoBank before and after use, couples were asked to judge their relationship status before prototype usage. They were instructed to recall their relationship in the past three days up until using the prototype,

then count the number of positive and negative experiences as presented in the emotional balance counting list. Based on this result, the couples were divided into three categories: Bad, Normal, Good. The specific criteria for each category are as follows:

1. Bad: They have on average fewer than 3 positive experiences and more than 2 negative experiences each day in three days before the test.

2. Normal: They have on average fewer than 6 positive experiences and less than 2 negative experiences each day in three days before the test.

3. Good: They have on average more than 6 positive experiences and less than 2 negative experiences each day in three days before the test.

The classification result is as follows:

Couple A: Normal Couple B: Normal Couple C: Bad Couple D: Normal Couple E: Good

4.5. Results and Discussions

The interview results were coded to find out participants' perceptions of the prototype as well as its effects on their relationships. Each participant was marked using their couple code and gender. For example, the woman in Couple A is AF and the man is AM, and so on.

4.5.1 Perceptions of Physical Prototype

In the first phase, the couples were introduced to the first version of the prototype. Results show that this prototype was not well-received, as users failed to see its value. All participants (100 percent) commented that the first version of EmoBank was too simple, and they could use alternative solutions like a paper or a smartphone note to do it easily: "Seemed like a pointless prototype. Maybe better to make an app to keep track of data" (DM) or "This prototype is critically lacking features. The prototype has very little to no impact on the experience we had. I think a phone application would be preferable" (EM).

However, in the second phase, the plant prototype left good impressions on all participants. After watching the video prototype, all 6 out of 8 participants (75 percent) found it interesting and wanted to try it. One participant who actually tried the product commented: "It is a new experience, interesting and I feel connected with the plant" (AM). Contrary to the suggestion of using a smartphone as an alternative, they noted that the plant form is better at motivating them to try than a mobile application: "If it's an app, I won't download it. I don't use data to balance my relationship. But for a plant, I will probably try because it's interesting" (BF) or "Of course I prefer a plant to an app. Because we need a visible device which could not be ignored" (CM). Users' willingness to try the second prototype of EmoBank is an important finding. Their preference of the physical prototype to a mobile application is in line with past literature on perceptions of digital versus embodied agents. According to a meta-analysis by Li, physical robots were reported to have a positive impact such as being more persuasive, more arousing, perceived more positively, and result in better performance than digital ones (Li 2015). Similarly, the physical embodiment of the prototype in this study triggered participants' curiosity. However, their dislike of the first prototype suggests the importance of embodiment type. Compared to the first prototype, which is a physical embodiment consisting of push buttons and a display, the second prototype is a organismoid embodiment, which is a fusion between a living organism (plant) and an artificial one (counting system). Past literature reveals that plants are effective in reducing human stress (Lohr et al. 1996, Lee et al. 2015, Koga and Iwasaki 2013). Specifically,touching a plant can reduce stress and interacting with plants can have positive feelings on human. Therefore, participants' willingness to use the plant prototype illustrates that design is a major factor in overcoming the adoption barrier. This is significant since hesitation to adopt is a major challenge for a novel idea such as the concept of using a device to share feelings.

4.5.2 Perceptions of Emotional Balance Mechanism

All participants commented that they rarely or had never talked about their emotions with their partners. When the concept of EmoBank was introduced, a female participant said: "I felt embarrassed at first glance because these are some ques-

tions I don＇t ask very often＂ (BF) and another reacted: ＂Will I have to ask questions like this?＂ (CF). One reason is they may not have grown up in an environment where being open with feelings was rewarded or encouraged. The majority of participants are Asian, which is often considered a high-context culture (Hall 2000), where the communication style is less direct. The expression of feelings, therefore, may become more difficult. In addition to the culture factor, personality can also affect the ability to talk frankly about feelings. Opening up requires us to take risks since it makes us exposed and vulnerable. Therefore, those with high risk avoidance or introverted tendencies may find it more difficult to share feelings citegoldberg1990alternative. Regarding the counting of emotional balance, participants expressed interest, saying it is less demanding than talking about emotions: ＂Describing feelings accurately is quite demanding right? So counting emotional balance may not be better, but definitely easier＂ (CM). Moreover, the counting activity was perceived as more casual and participants found it less stressful. This suggests that the simplification of relationship status as emotional balance reduces the barrier of usage. More importantly, the counting mechanism can act as a preventative method. In other words, while opening up is challenging, simply counting the score and having it displayed can convey the relationship status to couples, with low scores acting as a warning bell and trigger deeper conversations: ＂If I read about something that can add to our relationship I will try, but only when there's really a problem. So from this point of view, the process of counting my own feelings can probably be a way to prevent the problem from actually happening＂ (BF). In addition, the pre-determined emotional balance counting list helped guide participants＇ conversations. One noted that while the act of talking about feelings is encouraged, it was difficult to know what to discuss: ＂On the internet they say you should share feelings, but there are few specific guidelines, only abstract. The emotional balance list is clearer＂ (AM). The list also acted as a trigger for couples to expand their conversation: ＂There was an item that said ＇You criticized/blamed your partner＇ but we could not agree if his behavior was a criticism or not. I felt he was criticizing me, but he said he did not intend to. So we talked a lot about how to convey disagreement without making the other upset.＂ (AF).

4.5.3 Differences Between Demographics

Although the sample size did not permit a robust quantitative analysis, there were different tendencies between demographic groups regarding the acceptance of the prototype. Four participants were skeptical of the EmoBank: "I would question the usefulness of such a simple device" (CF) or "Will we have to talk in front of a plant? This is strange, isn't it?" (EM). All of them are non-KMD students. This reflects past literature, according to which people are more accepting of new technological innovations if they have more prior experience with technology (Dedehayir et al. 2020). Therefore, it is not surprising that KMD students, who underwent a curriculum focusing on innovative ideas and technological creations, were more open to the idea of the EmoBank. In addition, four female participants showed concern with the appearance of the prototype, suggesting it could be made more attractive to increase their purchase intention: "The appearance of the device needs to be improved so that it can attract girls" (EF) or "Make it cuter" (CF). On the other hand, male participants were less focused on appearance and more with functionality. However, the four women noted that, given the improved design, they would be the one deciding to buy and use the product instead of their male partners. This suggests that, in addition to functionality, designing the EmoBank in the way that appeals to female preference is important for actual purchase and usage of the product.

4.5.4 Effects on Relationships

For couples in Good condition

Couple E was in Good condition, which means they had more positive experiences and fewer negative ones than Normal and Bad condition couples before the experiment period. The couple reported that their relationship did not change after using the EmoBank. "Before and after using the product, there is no difference. We only tried in one week. Two of us still live, eat, and talk the same thing". (EM).

EmoBank is supposed to encourage couples to share their feelings and show the emotional balance demonstrating how good their relationship is. However, Couple E's comment suggests that if the couple is already in good condition, they have

few or even no negative experiences to share, so they cannot learn anything new. This explains their perceptions of lack of improvement. However, they noted that the act of talking about positive experiences reminded them of how well they were doing, which they considered a value of the prototype: "The questionnaires gave us the opportunity to review our day together, making effort to spend more time and express our affection to each other" (EM). This finding suggests that talking about emotions brings value not only when the couple faces problems, but also when things are going well, as it enhances the positivity in the relationship.

For couples in Normal and Bad conditions

Compared to Couple E in Good condition, couples in Normal or Bad relationships had fewer positive experiences and more negative experiences. They had one common result with the couple in Good condition, which is that the counting of emotional balance reminded them of the positivity in the relationship: "There were things we did for each other that both of us took for granted or ignored. so it's good to be reminded of that on a daily basis" (BM) and "I felt good and interesting. Since one day is not a very long time span, all these memories are super fresh, especially on a day that nothing special happened. But it's still interesting to go deep into some detailed moments. it's a good thing to hear verbal confirmation" (BF). Again, the discussion of what happened during the day proved to be helpful even if it did not center around things that need to be improved.

Moreover, couples in Normal or Bad relationships perceived that EmoBank helped improve their relationships, through visualization of their relationship status and triggering conversation.

First, by counting positive experiences, EmoBank can make couples realize the small number of positive experiences they have had with their partners recently, and encourage them to increase these numbers. For example, a participant was busy during the time he used EmoBank. Therefore, although his partner tried to tell him about her day, he did not react much. After a few days with 0 points for the item "You showed an interest in the events of your partner's day", he realized that he was careless, and tried to show more interest to his partner in the following days (AM).

Counting negative experiences also proved to be helpful. Although couples in Normal condition did not have as many negative experiences as those in Bad condition, the prototype served as a preventative opportunity to discuss negative feelings that they had had toward their partners before too late: "It was a nice opportunity to resolve problems before they grew into something" (DM). In addition, the recording of negative experiences was a chance to reflect on their attitudes and behaviors in the relationship: "He didn't judge me a lot. But I said many negative points. I realized that he was very tolerant towards me. So I tried not to judge him so harshly afterward" (BF).

Second, using EmoBank triggered conversations for couples. One participant in the Normal condition noted: "Sometimes both of us tend to hide our feelings and guess what each other thinks which often becomes a fight. So It helped to express true feelings and avoid conflicts." (BM). Couples in the Bad relationship condition expressed similar sentiments. One male participant said that using EmoBank is "a good way to end cold wars" (CM), while the woman in that couple said she "got rid of many negative thoughts" (CF). It made her realize what her partner actually thought: "It helps! The device gives us the opportunity to communicate at regular times" (CF).

These results suggest that EmoBank not only visualizes relationship status, reminding couples of how good or bad their relationship health is, but also creates a chance for couples to talk about previously hidden negative feelings. While the prototype does not act as a mediator during the conversations, its counting mechanism proved to be useful in improving relationships for Normal and Bad condition participants.

Co-parenting experience

As mentioned in the Literature review, pet ownership was linked to greater willingness to engage in relationship maintenance behaviors, commitment to the relationship and couple identity (Cloutier and Peetz 2016). There is a phrase in Japanese that is 子は鎹 (ko ha kasugai). It means that children are a bond between parents. Preivti and Amato suggested that couples perceived their children as an important factor in the stability of their relationship (Previti and Amato 2003). Therefore, it can be assumed that sharing the plant EmoBank can lead to similar

bonding between partners. However, such effects were not observed in this study.

Two reasons can account for this result. First, plants show emotions differently than pets or humans. Although research showed that plants not only have emotions but also intuition (Tompkins and Bird 1974), it is not easily perceived by humans. Therefore, it is uncommon that humans become emotionally attached to plants, although such instances are not entirely impossible. However, with plant augmentation techniques, plants' sensing modalities can be hacked and embodied so humans can have more types of interactions with a plant (Angelini et al. 2016). As mentioned in the Design section, in this design, a green LED is lit when a user adds a positive experience and a red LED appears when there is a negative experience. This is because past literature suggests green expressed by a robot is associated with acceptance while red is related to anger   (Terada et al. 2012). Participants of this study perceived the green LED as safe, accepted, or good while the red LED as signifying danger, anger, or warning. Although the specific interpretation varied between participants, this demonstrates a connection between colors and emotions. However, this association did not necessarily lead to the perception that the plant was trying to express emotions, with only four participants (40 percent) thought the plant prototype tried to express emotions in some ways.

Second, the duration of the experiments was too limited for the effects to be observed. In this study, Couple A used the plant EmoBank for one week while the others watched a video of the prototype. This condition may not have been sufficient for the couples to perceive emotions from the plant or develop attachments with it. A longer experiment design may show effects similar to past literature.

Chapter 5
Conclusion

Modern conveniences and technology help us save hours of weekly household chores and connect with people far away anytime via social media. However, many couples still feel they have little time for each other and feel disconnected even when together. In this context, Emo-bank is proposed with the mission to connect couples in busy life. The device can show the balance of a couple's emotional balance and provide a chance for couples to count the number of positive and negative experiences they have had.

The unique point of EmoBank is visualizing the relationship health of a couple, an abstract indicator. EmoBank provides a chance for couples to count a daily number of positive and negative experiences they have had together. Throughout this activity, they not only share feelings with their partner but also know their relationship balance. By looking at the balance number, the couple can know when their relationship is in danger and take necessary actions to keep the relationship healthy.

The EmoBank concept was tested with five couples to assess if the device have effect on couples' relationships. The results showed that the first prototype was not well-received by participants but the second one had positive impressions. A new way of sharing feelings, which is counting the emotional balance also had positive effects on couples. They indicated that it is an easier way to share feelings with their partners. The demographics also affected how users perceive the product since the participants include KMD and non-KMD students, as well as both male and female gender. In general, the product had more effects on normal and bad relationship couples than good relationship couples.

5.1. Limitations

Sample Selection

This study has used sample who are in my friend network, and half of them are currently studying at Graduate school of Media Design where people are familiar with innovative products. Therefore, their responses to the survey questions may be bias and the study had limited ability to gain access to the diverse type of participants.

Lack of Prior Research Studies

Very little research has been done to measure emotional balance, so the current formula could not measure accurately the couple relationship health.

Long Term Impact

The experiment duration is only one week. If there were not many changes in the relationship, it is not easy to see the effect of the product. Further study with a longer time frame is necessary to assess the effectiveness of the prototype fully.

5.2. Cognitive Bias

5.2.1 Sampling Bias

Sampling bias can occur when I recruit participants from my friend network. They might answer in a way that pleases me. They can say that it is good even if it is not. However, when looking at the interview results, it can be seen that they have comments that the product had few impact on their relationship, or the first prototype is too simple and ineffective. In future works, it will still be necessary to recruit people from different backgrounds to reduce the bias.

5.2.2 Social Desirability

Participants tend to answer in a way they deem socially accepted instead of stating their true feelings and opinions. In this situation, because all participants are my

acquaintances, it is possible that they are afraid of being judged if the relationship is not good, so they might ignore to count the negative experiences even if they have had them, to make a good emotional balance.

5.2.3 Least Effort

This kind of bias describes participants' tendency to answer in a way that they assume will terminate the test in the quickest possible way. Because I have similar tasks for seven days, so participants might skip some questions or some days, or they try to answer the interview as quick as possible. It leads to wrong or insufficient data for the user testing. The solution is asking participants every day to make sure they do the experience and interview them to see any changes among their answers, instead of waiting until the test ends.

5.3. Future Works

In Japanese, there is a phrase 子は鎹 (ko ha kasugai). It means that a child is like a tie that holds parents together. Even if there is a misunderstanding or conflict between the couple, it is not easy to break up when they are caring and thinking of their child. This is the future development of EmoBank. Since the target audience of EmoBank are young people living together, and as discussed, they get married later than previous generations and may choose not to have children. However, in the previous generation, with the joint family, when the couple argued, maybe parents, grandparents, or children would be the ones to intervene, now, couple relationship become more vulnerable. EmoBank can show emotions, or status based on the couple's relationship health, to remind them to always make efforts. For example:

- EmoPlant can show its emotions by moving its stems, or by emoticons.

- Create a watering system that connects to balance counting system. The plant will have enough water if couple relationship gets more positive experiences, and it could die if the relationship gets worse for a long time.

References

Altman, Irwin and Dalmas A Taylor (1973) *Social penetration: The development of interpersonal relationships.*: Holt, Rinehart & Winston.

Angelini, Leonardo, Stefania Caparrotta, Omar Abou Khaled, and Elena Mugellini (2016) "Emotiplant: Human-plant interaction for older adults," in *Proceedings of the TEI'16: Tenth International Conference on Tangible, Embedded, and Embodied Interaction*, pp. 373–379.

Arhant-Sudhir, Kanish, Rish Arhant-Sudhir, and Krishnankutty Sudhir (2011) "Pet ownership and cardiovascular risk reduction: supporting evidence, conflicting data and underlying mechanisms," *Clinical and Experimental Pharmacology and Physiology*, Vol. 38, No. 11, pp. 734–738.

Behere, Aniruddh Prakash, Pravesh Basnet, and Pamela Campbell (2017) "Effects of family structure on mental health of children: A preliminary study," *Indian journal of psychological medicine*, Vol. 39, No. 4, pp. 457–463.

Berscheid, Ellen, Mark Snyder, and Allen M Omoto (1989) "The relationship closeness inventory: Assessing the closeness of interpersonal relationships.," *Journal of personality and Social Psychology*, Vol. 57, No. 5, p. 792.

Bhugra, Dinesh and Anastasia Mastrogianni (2004) "Globalisation and mental disorders: overview with relation to depression," *The British Journal of Psychiatry*, Vol. 184, No. 1, pp. 10–20.

Braam, Janet (2005) "In touch: plant responses to mechanical stimuli," *New Phytologist*, Vol. 165, No. 2, pp. 373–389.

Cameron, Gillian, David Cameron, Gavin Megaw, Raymond Bond, Maurice Mulvenna, Siobhan O'Neill, Cherie Armour, and Michael McTear (2017) "To-

wards a chatbot for digital counselling," in *Proceedings of the 31st International BCS Human Computer Interaction Conference (HCI 2017) 31*, pp. 1–7.

Chien, Wei-Chi, Marc Hassenzahl, and Julika Welge (2016) "Sharing a Robotic Pet as a Maintenance Strategy for Romantic Couples in Long-Distance Relationships. An Autobiographical Design Exploration," in *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pp. 1375–1382.

Chuah, Stephanie Hui-Wen and Joanne Yu (2021) "The future of service: The power of emotion in human-robot interaction," *Journal of Retailing and Consumer Services*, Vol. 61, p. 102551.

Cloutier, Anika and Johanna Peetz (2016) "Relationships' best friend: links between pet ownership, empathy, and romantic relationship outcomes," *Anthrozoös*, Vol. 29, No. 3, pp. 395–408.

Colton, Tamara, Bonnie Janzen, and William Laverty (2015) "Family structure, social capital, and mental health disparities among Canadian mothers," *Public health*, Vol. 129, No. 6, pp. 639–647.

Corso, Regina (2011) "Pets Really Are Members of the Family," *The Harris Poll*, Jun.

Daley, Kate, Ines Hungerbuehler, Kate Cavanagh, Heloísa Garcia Claro, Paul Alan Swinton, and Michael Kapps (2020) "Preliminary evaluation of the engagement and effectiveness of a mental health chatbot," *Frontiers in digital health*, Vol. 2, p. 41.

Dautenhahn, Kerstin (1997) "Biologically inspired robotic experiments on interaction and dynamic agent-environment couplings," in *Proc. Workshop SOAVE*, Vol. 97, pp. 14–24, Citeseer.

Dautenhahn, Kerstin (1998) "Embodiment and interaction in socially intelligent life-like agents," in *International Workshop on Computation for Metaphors, Analogy, and Agents*, pp. 102–141, Springer.

52

Davis, Celeste (2016) "No time together? Take the 10 minute DAILY connect for busy couples challenge!," *Marriage Laboratory*, Jul.

Dedehayir, Ozgur, Roland J Ortt, Carla Riverola, and Francesc Miralles (2020) "Innovators and early adopters in the diffusion of innovations: A literature review," *Digital Disruptive Innovation*, pp. 85–115.

Diggory, Katherine (2019) "Communication Is the Key," *Explore Life*, May.

Evans-Lacko, Sara, Martin Knapp, Paul McCrone, Graham Thornicroft, and Ramin Mojtabai (2013) "The mental health consequences of the recession: economic hardship and employment of people with mental health problems in 27 European countries," *PloS one*, Vol. 8, No. 7, p. e69792.

Fong, Terrence, Illah Nourbakhsh, and Kerstin Dautenhahn (2003) "A survey of socially interactive robots," *Robotics and autonomous systems*, Vol. 42, No. 3-4, pp. 143–166.

Friedmann, Erika, Aaron H Katcher, James J Lynch, and Sue Ann Thomas (1980) "Animal companions and one-year survival of patients after discharge from a coronary care unit.," *Public health reports*, Vol. 95, No. 4, p. 307.

Gelo, Omar, Diana Braakmann, and Gerhard Benetka (2008) "Quantitative and qualitative research: Beyond the debate," *Integrative psychological and behavioral science*, Vol. 42, No. 3, pp. 266–290.

Gottman, John M, Janice Driver, and Amber Tabares (2002) "Building the sound marital house: An empirically derived couple therapy.."

Gottman, John Mordechai (1999) *The marriage clinic: A scientifically-based marital therapy*: WW Norton & Company.

Gould, Lucy Stewart (2021) "Stories of our Times: Lucy Gould speaks about the spike in divorces and breakups," *Stewarts*, Feb.

Hall, Edward T (2000) "Context and meaning," *Intercultural communication: A reader*, Vol. 9, pp. 34–43.

Headey, Bruce and Markus Grabka (2011) "Health correlates of pet ownership from national surveys.."

Hicks, Angela M and Lisa M Diamond (2008) "How was your day? Couples' affect when telling and hearing daily events," *Personal Relationships*, Vol. 15, No. 2, pp. 205–228.

, "Facts Statistics: Pet Ownership and Insurance," *III*.

Ishii, Yutaka and Tomio Watanabe (2019) "Development of an Embodied Group Entrainmacent Response System to Express Interaction-Activated Communication," in *International Conference on Human-Computer Interaction*, pp. 203–211, Springer.

Kaufman, Lawrence (2019) "Reasons Why People Delay Seeking the Services of a Couple Therapist," *Kaufman Counseling*, Nov.

Koga, Kazuko and Yutaka Iwasaki (2013) "Psychological and physiological effect in humans of touching plant foliage-using the semantic differential method and cerebral activity as indicators," *Journal of physiological anthropology*, Vol. 32, No. 1, pp. 1–9.

Laurenceau, Jean-Philippe, Lisa Feldman Barrett, and Paula R Pietromonaco (1998) "Intimacy as an interpersonal process: The importance of self-disclosure, partner disclosure, and perceived partner responsiveness in interpersonal exchanges.," *Journal of personality and social psychology*, Vol. 74, No. 5, p. 1238.

Laurenceau, Jean-Philippe and Niall Bolger (2005) "Using diary methods to study marital and family processes.," *Journal of Family Psychology*, Vol. 19, No. 1, p. 86.

Lee, Min-sun, Juyoung Lee, Bum-Jin Park, and Yoshifumi Miyazaki (2015) "Interaction with indoor plants may reduce psychological and physiological stress by suppressing autonomic nervous system activity in young adults: a randomized crossover study," *Journal of physiological anthropology*, Vol. 34, No. 1, pp. 1–6.

Lee, Minha, Sander Ackermans, Nena Van As, Hanwen Chang, Enzo Lucas, and Wijnand IJsselsteijn (2019) "Caring for Vincent: a chatbot for self-compassion," in *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, pp. 1–13.

Li, Jamy (2015) "The benefit of being physically present: A survey of experimental works comparing copresent robots, telepresent robots and virtual agents," *International Journal of Human-Computer Studies*, Vol. 77, pp. 23–37.

Lohr, Virginia I, Caroline H Pearson-Mims, and Georgia K Goodwin (1996) "Interior plants may improve worker productivity and reduce stress in a windowless environment," *Journal of environmental horticulture*, Vol. 14, No. 2, pp. 97–100.

Lucas, Gale M, Albert Rizzo, Jonathan Gratch, Stefan Scherer, Giota Stratou, Jill Boberg, and Louis-Philippe Morency (2017) "Reporting mental health symptoms: breaking down barriers to care with virtual human interviewers," *Frontiers in Robotics and AI*, Vol. 4, p. 51.

McCalley, Teddy and Alain Mertens (2007) "The pet plant: Developing an inanimate emotionally interactive tool for the elderly," in *International Conference on Persuasive Technology*, pp. 68–79, Springer.

Milne, Sarah, Sheina Orbell, and Paschal Sheeran (2002) "Combining motivational and volitional interventions to promote exercise participation: Protection motivation theory and implementation intentions," *British journal of health psychology*, Vol. 7, No. 2, pp. 163–184.

Misra, Shalini, Lulu Cheng, Jamie Genevie, and Miao Yuan (2016) "The iPhone effect: The quality of in-person social interactions in the presence of mobile devices," *Environment and Behavior*, Vol. 48, No. 2, pp. 275–298.

Mitchell, Alexandra E, Angela M Castellani, Rachael L Herrington, Jana I Joseph, Brian D Doss, and Douglas K Snyder (2008) "Predictors of intimacy in couples' discussions of relationship injuries: An observational study.," *Journal of Family Psychology*, Vol. 22, No. 1, p. 21.

Moric, Mollie (2020) "US Divorce Statistics During COVID-19," *Legal Templates*, Jul.

Pfeifer, Rolf and Christian Scheier (2001) *Understanding intelligence*: MIT press.

Previti, Denise and Paul R Amato (2003) "Why stay married? Rewards, barriers, and marital stability," *Journal of Marriage and Family*, Vol. 65, No. 3, pp. 561–573.

Rotondi, Valentina, Luca Stanca, and Miriam Tomasuolo (2017) "Connecting alone: Smartphone use, quality of social interactions and well-being," *Journal of Economic Psychology*, Vol. 63, pp. 17–26.

Rusbult, Caryl E and Bram P Buunk (1993) "Commitment processes in close relationships: An interdependence analysis," *Journal of social and personal relationships*, Vol. 10, No. 2, pp. 175–204.

Rusbult, Caryl E, Julie Verette, Gregory A Whitney, Linda F Slovik, and Isaac Lipkus (1991) "Accommodation processes in close relationships: Theory and preliminary empirical evidence.," *Journal of Personality and social Psychology*, Vol. 60, No. 1, p. 53.

Santamaría-Bonfil, Guillermo and Orlando Grabiel Toledano López (2019) "Emoji as a Proxy of Emotional Communication," in *Becoming Human with Humanoid-From Physical Interaction to Social Intelligence*: IntechOpen.

Sato, Munehiko, Ivan Poupyrev, and Chris Harrison (2012) "Touché: enhancing touch interaction on humans, screens, liquids, and everyday objects," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, pp. 483–492.

Savage, Maddy (2020) "How Covid-19 is changing women᾽s lives," July.

Shadish, William R and Scott A Baldwin (2003) "Meta-analysis of MFT interventions," *Journal of Marital and Family therapy*, Vol. 29, No. 4, pp. 547–570.

Shatto, Rachel (2020) "Here᾽s What To Do If Your Partner Never Opens Up To You," *Elite Daily*, February.

56

Sherman, Robert R, Rodman B Webb, and SD ANDREWS (1986) *Qualitative research*: Citeseer.

Silvertown, Jonathan and Deborah M Gordon (1989) "A framework for plant behavior," *Annual Review of Ecology and Systematics*, Vol. 20, No. 1, pp. 349–366.

Song, Sichao and Seiji Yamada (2017) "Expressing emotions through color, sound, and vibration with an appearance-constrained social robot," in *2017 12th ACM/IEEE International Conference on Human-Robot Interaction (HRI*, pp. 2–11, IEEE.

Stacey, David, "News Archive," *Plants are 'in touch' with the world around them : Archive Page : The University of Western Australia.*

Sweet, Joni (2021) "How Has the Pandemic Affected Your Relationship? Readers Weigh In," *Verywell Mind*, Feb.

Terada, Kazunori, Atsushi Yamauchi, and Akira Ito (2012) "Artificial emotion expression for a robot by dynamic color change," in *2012 IEEE RO-MAN: The 21st IEEE International Symposium on Robot and Human Interactive Communication*, pp. 314–321, IEEE.

Tompkins, Peter and Christopher Bird (1974) *The secret life of plants*, No. QK50. T65I 1973.: Penguin books England.

Utami, Dina, Timothy W Bickmore, and Louis J Kruger (2017) "A robotic couples counselor for promoting positive communication," in *2017 26th IEEE International Symposium on Robot and Human Interactive Communication (RO-MAN)*, pp. 248–255, IEEE.

Walsh, Courtney M, Lisa A Neff, and Marci EJ Gleason (2017) "The role of emotional capital during the early years of marriage: Why everyday moments matter.," *Journal of Family Psychology*, Vol. 31, No. 4, p. 513.

Walsh, Courtney Michelle (2016) "The role of emotional capital during the early years of marriage: it's about the little things," Ph.D. dissertation.

Watanabe, Tomio (2011) "Human-entrained embodied interaction and communication technology," in *Emotional Engineering*: Springer, pp. 161–177.

Weizenbaum, Joseph (1966) "ELIZA—a computer program for the study of natural language communication between man and machine," *Communications of the ACM*, Vol. 9, No. 1, pp. 36–45.

Wieselquist, Jennifer, Caryl E Rusbult, Craig A Foster, and Christopher R Agnew (1999) "Commitment, pro-relationship behavior, and trust in close relationships.," *Journal of personality and social psychology*, Vol. 77, No. 5, p. 942.

Woodward, Kieran, Eiman Kanjo, David Brown, Thomas M McGinnity, Becky Inkster, Donald MacIntyre, and Thanasis Tsanas (2020) "Beyond mobile apps: a survey of technologies for mental well-being," *IEEE Transactions on Affective Computing*.

Yamashita, Yuji (2020) "Survey: 20% of married couples cite better ties amid pandemic," *The Asahi Shimbun*, Nov.

Yang, Lillian and Carman Neustaedter (2020) "An Autobiographical Design Study of a Long Distance Relationship: When Telepresence Robots Meet Smart Home Tools," in *Proceedings of the 2020 ACM Designing Interactive Systems Conference*, pp. 129–140.

Yang, Lillian, Carman Neustaedter, and Thecla Schiphorst (2017) "Communicating through a telepresence robot: A study of long distance relationships," in *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pp. 3027–3033.

Ziemke, Tom (2001) "Disentangling notions of embodiment," in *Workshop on Developmental Embodied Cognition*, p. 83.

Appendices

A. The First Prototype Code

Configuration File for Detecting Failures

```
#include <LiquidCrystal.h> //Load Liquid Crystal Library
#include <Servo.h>

Servo servo;
LiquidCrystal lcd(10, 9, 5, 4, 3, 2);  //Create Liquid Crystal Object called LCD
int balance = 0;
const int butp = 12;
const int butn = 13;
int statebutp = 0;
int statebutn = 0;
int ranno, pos, distance;
int count = 0;
const int trigPin = 6;
const int echoPin = 7;
long duration;
const int lcd_light = A4;
int lcd_time = 10000;
unsigned int currentLcdLightOnTime = 0;
unsigned long lcdLightOn_StartMillis;
boolean isLcdLightOn;

void setup() {
  lcd.begin(16,2);
  Serial.begin(9600);
  servo.attach(8);
```

```
  pinMode (butp, INPUT);
  pinMode (butn, INPUT);
  pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
  pinMode(echoPin, INPUT); // Sets the echoPin as an Input
  pinMode(lcd_light, OUTPUT);
  digitalWrite(lcd_light, LOW);
  isLcdLightOn = false;
  lcd.setCursor(0,0);
  lcd.print("Balance: ");
  lcd.print(balance);
  delay(10);
  lcd.setCursor(0,1);
  lcd.print("Press Start");
  delay(10);
}


void loop() {
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
  duration = pulseIn(echoPin, HIGH);
  distance= duration*0.034/2;

  statebutn = digitalRead(butn);
  statebutp = digitalRead(butp);
  Serial.print(distance);
  if (distance < 100){
    count_time();
  }
  //If press Start/Next button
  if (statebutn == HIGH){
    delay(300);
    count += 1;
    lcd.setCursor(0,0);
```

60

```
lcd.print("Balance: ");
lcd.print(balance);
delay(10);
lcd.setCursor(0,1);
lcd.print("Number ");
lcd.print(count);
lcd.print("   ");
delay(10);
count_time();
}


//If press Yes button
if ((count > 0) && (count < 7)){
 if (statebutp == HIGH){
 Serial.print("Pressed");
 lcd.setCursor(0,0);
 lcd.print(":) <3     ");
 delay(800);
 balance += 1;
 lcd.setCursor(0,0);
 lcd.print("Balance: ");
 lcd.print(balance);
 lcd.print("     ");
 delay(10);
 lcd.setCursor(0,1);
 lcd.print("Number ");
 lcd.print(count);
 lcd.print("    ");
 delay(10);
 count_time();
 }
}
if ((count >= 7) && (count <11)){
if (statebutp == HIGH){
 lcd.setCursor(0,0);
 lcd.print(":(         ");
```

```
  delay(800);
  balance -= 1;
  lcd.setCursor(0,0);
  lcd.print("Balance: ");
  lcd.print(balance);
  lcd.print("       ");
  delay(10);
  lcd.setCursor(0,1);
  lcd.print("Number ");
  lcd.print(count);
  lcd.print("      ");
  delay(10);
  count_time();
  }
 }

if (count > 10){
count = 0;
lcd.setCursor(0,0);
lcd.print("Balance: ");
lcd.print(balance);
lcd.print("        ");
delay(10);
lcd.setCursor(0,1);
lcd.print("Press Start");
delay(10);
}


 if(isLcdLightOn){
    currentLcdLightOnTime = millis() - lcdLightOn_StartMillis;

    if(currentLcdLightOnTime > lcd_time){
      isLcdLightOn = false;
      digitalWrite(lcd_light, LOW);
    }
```

```
 }
  Serial.print("Lcd light on time: ");
  Serial.println(currentLcdLightOnTime);
}

  int servofunc(){
    ranno = random(60,120);
    for (pos = 0; pos <= ranno; pos += 1) {
    servo.write(pos);
    delay(15);
    }

    for (pos = ranno; pos >= 0; pos -= 1) {
      servo.write(pos);
      delay(15);
    }
    Serial.print(ranno);
  }

int count_time(){
    lcdLightOn_StartMillis = millis();
    currentLcdLightOnTime = 0;
    isLcdLightOn = true;
    digitalWrite(lcd_light, HIGH);
}
```

B. The Second Prototype Code

```
#include <CapacitiveSensor.h>
#include <LedControl.h>


CapacitiveSensor   cs_2_4 = CapacitiveSensor(2,4); // 1M resistor between pins 2 & 4, p
int DIN = 10;
```

```
int CS =  9;
int CLK = 8;
int tens=0;
int units=0;
int question;
int balance;
    //Facial Expression
    byte smile[8]=   {0x3C,0x42,0xA5,0x81,0xA5,0x99,0x42,0x3C};
    byte neutral[8]= {0x3C,0x42,0xA5,0x81,0xBD,0x81,0x42,0x3C};
    byte sad[8]=     {0x3C,0x42,0xA5,0x81,0x99,0xA5,0x42,0x3C};

    //Moving car
    byte b1[8]= {0x00,0x00,0x00,0x00,0x18,0x3C,0x18,0x3C};
    byte b2[8]= {0x00,0x00,0x00,0x18,0x3C,0x18,0x3C,0x00};
    byte b3[8]= {0x00,0x00,0x18,0x3C,0x18,0x3C,0x00,0x00};
    byte b4[8]= {0x00,0x18,0x3C,0x18,0x3C,0x00,0x00,0x00};
    byte b5[8]= {0x18,0x3C,0x18,0x3C,0x00,0x00,0x00,0x00};
    byte b6[8]= {0x3C,0x18,0x3C,0x00,0x00,0x00,0x00,0x18};
    byte b7[8]= {0x18,0x3C,0x00,0x00,0x00,0x00,0x18,0x3C};
    byte b8[8]= {0x3C,0x00,0x00,0x00,0x00,0x18,0x3C,0x18};

    //Numbers
    byte zero[] = {B00111000,B01000100,B01000100,B00111000,B00111000,B01000100,B0100010
    byte one[] = {B00000000,B01000100,B01111100,B01000000,B00000000,B01000100,B01111100
    byte two[] = {B01100100,B01010100,B01001100,B00000000,B00000000,B01100100,B01010100
    byte three[] = {B01000100,B01010100,B01101100,B00000000,B00000000,B01000100,B010101
    byte four[] = {B00110000,B00101000,B01111100,B00000000,B00000000,B00110000,B0010100
    byte five[] = {B01011100,B01010100,B01110100,B00000000,B00000000,B01011100,B0101010
    byte six[] = {B01111100,B01010100,B01110100,B00000000,B00000000,B01111100,B01010100
    byte seven[] = {B01100100,B00010100,B00001100,B00000000,B00000000,B01100100,B000101
    byte eight[] = {B01101100,B01010100,B01101100,B00000000,B00000000,B01101100,B010101
    byte nine[] = {B01011100,B01010100,B01111100,B00000000,B00000000,B01011100,B0101010
int cnt=0;
int in = 2;
int out = 4;
int state = HIGH;
```

```
int r;
int p = LOW;
long time = 0;
int clicks = 0;
unsigned long timePress = 0;
unsigned long timePressLimit = 0;
LedControl lc=LedControl(DIN,CLK,CS,0);

void setup()
{
  Serial.begin(9600);
  pinMode(4, INPUT);
  /*    LED Outputs   */
  pinMode(5, OUTPUT);
  pinMode(6, OUTPUT);
  pinMode(7, OUTPUT);
  lc.shutdown(0,false);
 lc.setIntensity(0,15);       //Adjust the brightness maximum is 15
 lc.clearDisplay(0);
}
void loop()
{
 r = digitalRead(4);
if (r == HIGH){
    Serial.println("Button Pressed");
    delay(200);

    if (clicks == 0) {
    timePress = millis();
    timePressLimit = timePress + 500;
    clicks = 1;
    }

    else if (clicks == 1 && millis() < timePressLimit){
      Serial.println("Button Pressed twice");
```

```
//Double Press Action
 digitalWrite(5, HIGH);
 delay(500);
 digitalWrite(5, LOW);
 delay(300);
 digitalWrite(6, LOW);
 digitalWrite(7, LOW);

//Start or Next Question


//set variables back to 0
 timePress = 0;
 timePressLimit = 0;
 clicks = 0;

//show question number
question ++;
Serial.println(question);
if (question < 10) {
   units = question;
   tens = 0;
 }
else if (question == 10){
   units = question % 10;
   tens = (question /10) % 10;
}
else {
   if (balance < 10) {
     units = abs(balance);
     tens = 0;
   }
   else {
     units = abs(balance) % 10;
     tens = (abs(balance) /10) % 10;
   }
```

```
        question = 0;


      //Moving car
    printByte(b1);
    delay(200);
    printByte(b2);
    delay(200);
    printByte(b3);
    delay(200);
    printByte(b4);
    delay(200);
    printByte(b5);
    delay(200);
    printByte(b6);
    delay(200);
    printByte(b7);
    delay(200);
    printByte(b8);
    delay(200);
     }
    //Display Balance after finishing 10 questions
      ondisplay();
    }
     //If pressed once
}
      if (clicks == 1 && timePressLimit != 0 && millis() > timePressLimit){
       Serial.println("Button Pressed Once");
       timePress = 0;
       timePressLimit = 0;
       clicks = 0;

       //Single Press Action
       //Turn on LED and Update balance
       if (question > 0 && question < 7){
        digitalWrite(5, LOW);
        digitalWrite(6, HIGH);
```

```
        delay(500);
        digitalWrite(6, LOW);
        delay(300);
        digitalWrite(7, LOW);
        balance ++;
      }
      else if (question > 6 && question < 11){
         digitalWrite(5, LOW);
         digitalWrite(6, LOW);
         digitalWrite(7, HIGH);
         delay(500);
         digitalWrite(7, LOW);
         delay(300);
         balance --;
      }
       Serial.println(balance);

  //Facial Expression
      }
}


void ondisplay() {

if (tens < 1) {
  for (int c=0;c<4;c++) {
  lc.setRow(0,c,zero[c]);
}
}
if (tens == 1) {
 for (int c=0;c<4;c++) {
 lc.setRow(0,c,one[c]);
 }
 }
if (tens == 2)  {
  for (int c=0;c<4;c++) {
  lc.setRow(0,c,two[c]);
```

```
 }
}
if (tens == 3)  {
  for (int c=0;c<4;c++) {
  lc.setRow(0,c,three[c]);
 }
}
if (tens == 4)  {
  for (int c=0;c<4;c++) {
  lc.setRow(0,c,four[c]);
 }
}
if (tens == 5)  {
  for (int c=0;c<4;c++) {
  lc.setRow(0,c,five[c]);
 }
 }
 if (tens == 6)  {
  for (int c=0;c<4;c++) {
  lc.setRow(0,c,six[c]);
 }
  }
if (tens == 7)  {
  for (int c=0;c<4;c++) {
  lc.setRow(0,c,seven[c]);
 }
 }
 if (tens == 8)  {
  for (int c=0;c<4;c++) {
  lc.setRow(0,c,eight[c]);
 }
 }
 if (tens == 9)  {
  for (int c=0;c<4;c++) {
  lc.setRow(0,c,nine[c]);
 }
```

```
 }


if (units == 1) {
  for (int c=4;c<8;c++) {
  lc.setRow(0,c,one[c]);
 }
}
if (units == 2)  {
  for (int c=4;c<8;c++) {
  lc.setRow(0,c,two[c]);
 }
 }
if (units == 3)  {
  for (int c=4;c<8;c++) {
  lc.setRow(0,c,three[c]);
 }
}
if (units == 4)  {
  for (int c=4;c<8;c++) {
  lc.setRow(0,c,four[c]);
 }
}
if (units == 5)  {
  for (int c=4;c<8;c++) {
  lc.setRow(0,c,five[c]);
 }
 }
if (units == 6)  {
  for (int c=4;c<8;c++) {
  lc.setRow(0,c,six[c]);
 }
  }
if (units == 7)  {
  for (int c=4;c<8;c++) {
  lc.setRow(0,c,seven[c]);
```

```
 }
 }
if (units == 8)  {
  for (int c=4;c<8;c++) {
  lc.setRow(0,c,eight[c]);
 }
 }
if (units == 9)  {
  for (int c=4;c<8;c++) {
  lc.setRow(0,c,nine[c]);
 }
 }
if (units==0) {
  for (int c=4;c<8;c++) {
  lc.setRow(0,c,zero[c]);
 }
 }
}


void printByte(byte character [])
{
  int i = 0;
  for(i=0;i<8;i++)
  {
    lc.setRow(0,i,character[i]);
  }
}


\section{Emotional Balance Counting List}
\textbf{Positive Experiences}
\begin{enumerate}
  \item Your partner said something that made you feel loved
  \item You tried to make your partner feel loved environment
  \item Your partner showed an interest in the events of your day
  \item You showed an interest in the events of your partner's day
  \item You enjoyed a leisure activity with your partner
```

```
  \item You shared physical intimacy with your partner
\end{enumerate}


\textbf{Negative Experiences}
\begin{enumerate}
  \item You criticized/blamed your partner
  \item You did not express your feeling to avoid conflict
  \item You let your partner down or broke a promise
  \item You showed anger or impatience toward your partner
\end{enumerate}


\section{Sample Interview Questions}
\begin{enumerate}
  \item What did you think when you hear about the prototype?
  \item How did you feel after talking about positive experiences?
  \item How did you feel after talking about negative experiences?
  \item In general, do you think it actually helps your relationship?
  \item Is there anything you want to tell after experimenting?
\end{enumerate}
```