Nabaztag Lives:
The Rebirth of a Bunny

An exploration of the Nabaztag as a social robot in a domestic environment

Tanja Kampman, s1724185

Supervisor: dr. ir. Edwin Dertien

Critical observer: dr. Angelika Mader

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Creative Technology, University of Twente

Abstract

The Nabaztag is a robot rabbit that this research has given a new purpose. The purpose is to help university students with generalized anxiety disorder symptoms or depressive symptoms, which are common in that group and often come together. The focus is on these students who are in therapy, specifically cognitive behavioural therapy. Current solutions for problems this target audience faces are found and the problems are analysed. The outcome of the ideation is a social robot companion that supports them both in their treatment and their studies by e.g. helping with sticking to a planning. This solution is then evaluated by peers from different fields according to a scenario of a student who struggles. Then, a prototype is created where the interaction is tested on whether the student could form a bond with the robot enough and on whether there are major problems in general. The result of these evaluations is that people believe there is potential for the concept if it was worked out further, but that there are many flaws currently in the system that would need to be fixed.

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1 Introduction

1.1 Problem statement

The Nabaztag (see Figure 1.1) is a zoomorphic robot created in June of 2005 by the French company Violet [1]. It is a robot rabbit that was originally meant to function as a robotic home assistant and an embodied display for many types of information. After three generations of these robots were brought to the market, the company officially went bankrupt in October of 2013. When this happened, the servers that the robots were connected to were shut down [1]. This made the robots lose close to all functionality.

Figure 1.1: The Nabaztag. Image source: Wikipedia[1]

However, the physical robots are still in existence. This provides robotics researchers and enthusiasts with an opportunity to set up their own servers and bring the Nabaztag back to life with the technology available now in 2018. With the rise of Internet of Things and embodied social home assistants such as the Google Home or Alexa, this is a time in which this robot has a chance of succeeding in those fields [2]. Also, social robotics is becoming a more prominent field of research, with social companions and having a type of emotional connection with a robot being possible. But it should not be as before, that users lose their interest as soon as the novelty wears off. Nor should it be that the robots are unusable if the servers are unavailable, as was the case with the previous device.

[1] Image from https://en.wikipedia.org/wiki/Nabaztag

1.2 Goal and its relevance

The objective for this project is to give the Nabaztag robot a new purpose with the technology and information we have available today. There are many of these rabbits around which, by connecting them to your own server, are supposedly still usable. The robot should reflect the modern day stance on the Internet of Things and the field of social robotics using the technology available now. These fields are currently on the rise, and much research is still missing.

Some research that is relevant to current day technology in the fields of IoT and social robotics involves sustainability. The previous Nabaztag was not popular enough back in the day. The company did not make enough profit from them, or only for a short amount of time. The reasons behinds them not being popular enough should be explored. That is also why the idea of service-focused products should be explored, where people pay a small amount for the device and then a fee for using the services, as well as updates for any problems. This way, the revenue would be more constant and the product could remain relevant.

1.3 Research question

In short, the problem - or rather opportunity - is that the Nabaztag robot servers are no longer in use, providing robot rabbits which do not function anymore. The goal of this research is to give them a new purpose, with the knowledge and resources available now. This purpose needs to be in the field of IoT and social robotics. This leads to the following research question:

1. What opportunities are there in a domestic environment for the Internet of Things combined with social robotics?

This can be broken up into four sub questions:

1. What were the Nabaztag's capabilities and how would they translate to the present?
2. What are consequences of service versus product oriented devices through Internet of Things?
3. How to give the Nabaztag concept an innovative and new purpose in the field of social robotics?
4. How to improve a connected product's relevance through time?

1.4 Report outline

Firstly, the context of this project is analysed. Relevant information about the Internet of Things, embodied displays, home assistants, robot companions and finally the Nabaztag is noted. From this information, a plan of how to continue the project is created. Secondly, the ideation phase is elaborated upon. This involves interviews with previous users, brainstorming and eventually a product concept. Thirdly, this concept is one step closer to a prototype, with a chapter focusing on further design specifications, where the problem is analysed further, leading to requirements. Fourthly, the prototype is realized. The accompanying chapter discusses the

components needed for it and the setup. The design choices of specifically the prototype are also mentioned. Fifthly, the resulting product is evaluated to see if the results are as expected. Finally, conclusions will be derived from these results, these will be discussed and recommendations for further research will be mentioned.

2 Context analysis

Before creating an idea for the Nabaztag, information about the context needs to be gathered. The context in this case consists of the Internet of Things, embodied displays, home assistants, robot companions and finally specifically the Nabaztag itself. From this information, a plan for further research is created.

2.1 Background research

2.1.1 Internet of Things

The Internet of Things (IoT) is a network connectivity applied to objects that are commonly not considered to be computers [3]. This enables the devices to communicate information, giving many options for “smart” systems. Due to this cooperation between devices and services, the inputs the user gives and the outputs the user receives can be very intuitive. IoT was already a concept for decades, but recent developments in technology are bringing this idea to life in many different appliances [3]. Three developments have helped this growth the most: increased processing power in embedded platforms, the improvements in operating systems and the development of wireless communication [4]. These developments worked together to make the cloud happen, where data is stored safely to be used in different applications [4].

The possibilities for what the IoT can do are endless. For example, in personal products, it can make smart clothing, or help someone get in shape. Also homes can be automated or secured by having devices and/or sensors communicate with each other. Vehicles can be automated better, businesses can become more efficient and industrial machines or robots can be enhanced, all using the Internet of Things [5]. More examples of products are shown in Figures 2.2 and 2.2. And those are only a few examples of what the opportunities for this technology are. Each of these products uses data to enhance the user’s experience.

Figure 2.2: The Nest Learning Thermostat, 3rd generation. Smart thermostat that learns when to turn the heating systems on and off using AI. Image source: Google Images.[2]

Figure 2.2: The GreenIQ Smart Garden Hub G2, a device that automatically waters the garden when needed. Image source: Google Images[3]

The data that can be used is likely already generated, the key to Internet of Things is to use it in a way that is useful. Sometimes this involves combining data. For instance, there are quite a few weather stations owned by companies that predict the weather. However, there are far

[2] Image from https://www.coolblue.nl/product/671720/nest-learning-thermostat-3e-generatie.html?tid=pla-417637733697&ref=549232&gclid=CjwKCAjw2dvWBRBvEiwADllhn01ivHVM-ikMVTt3kifkXAK_jONXB63sflULY5B0PIIDvH8-hIDrKhoCLGsQAvD_BwE#open

[3] Image from https://www.postscapes.com/smart-irrigation-controllers/

more privately owned weather stations, around 100 times as many [6]. If these are connected to a cloud, the information can combine to form a more accurate and more detailed picture of a region's weather. However, for other cases, one single sensor can provide enough information for a device to be smart, such as a light which turns on when a motion sensor sees a person move.

With the Internet of Things, many concepts are made possible; but not all are lawful. Once the locks on a house are connected to a network, these locks might be hacked [7]. The information of whether the person are at home or whether the door is locked can be abused. This means there needs to be an increased level of security to protect the information, because so much of it can be problematic when in the wrong hands. Also general information about a user is often personal, for instance when they go to sleep is not public information. IoT devices can use this information with permission, but again this needs to be protected properly because it is often information on a cloud on the internet, a vulnerable place.

2.1.2 Embodied displays

Instead of using a screen to display information, it can also be embodied. This way, the information conveyal has the option to be more organised, natural or intuitive. The design options are not only limited to a 2D screen, but can expand into the 3D world. This connects to the idea of calm or background technology, where the device is part of a location and not requiring a lot of cognitive attention from the user at all times. This avoids the user feeling overwhelmed by a constant stream of information [8]. The key to this is to have the information be presented peripherally; where the user has a choice whether to give it attention or not. This makes them feel in control and comfortable [8]. In an era where so much information is thrown at a user, causing them to be more prone to mental disorders such as anxiety and depression [9], calm technology is necessary.

The information is also received better when something is physical. The main aspect for this is that it is a physical presence [10]. The human brain connects physical objects to a meaning and a place, which engages spatial memory networks [11]. Physical products also involve the part of the brain where emotions are controlled more, leading to "greater internalization" [11]. This boosts memory. So for a device which gives information, this can be useful to consider. People also find a physical robot to be more persuasive in comparison to a virtual agent and they are generally perceived more positively, even when the design is the same [10]. This means robots are better than displays to convey useful information. Examples of robots that use this will be given in the coming sections.

2.1.3 Home assistants

Voice activated aids around the house are on the rise. Home assistants such as Homey, Google Home or Amazon Echo (which goes by the name of Alexa) as shown in Figures 2.3, 2.4 and 2.5 respectively are becoming more and more popular nowadays [12]. These devices are integrated parts of the consumer's home, where they can say what they want to happen and the product will make it happen. They can for example turn lights or speakers on and off, connect to the internet to tell the user information, or set an alarm.

Figure 2.3: The Homey. Image source: Athom[4]

Figure 2.4: The Google Home. Image source: Google Images[5]

[4] Image from https://www.athom.com/nl/homey/
[5] Image from https://www.jbhifi.com.au/google/google-home/457569/

Figure 2.5: The Amazon Echo, 2nd generation. Image source: Amazon[6]

But something interesting occurs with these devices: the user sees them as “people”. 250,000 people have proposed to Alexa, 100,000 people tell her “good morning” every day, but maybe even more notable: the most common interaction people have with Alexa is “thank you” [13]. The other two can be written off as jokes, but thanking a device suggests that people feel the need to be polite to it and treat it with respect. This indicates that there is some sort of personal connection with the device that people feel, which makes sense because the device is often around them. But the device is not a person, it is part of one of the biggest corporations in the world: Amazon. The same problem arises with Google Home, where people usually know the company is already influential but they allow them to come into their home and constantly listen anyway [14]. This could mean that people probably do not realise the severity of the risks, but can also mean that the product is so convenient that people are willing to take those risks. These services are clearly desired.

2.1.4 Robot companions

Robot companions have also made their way into society in the past years. These robots usually have certain human- or animal-like features that allow the user to have an emotional connection with it. These features make it sympathetic. There are multiple fields in which these robots are useful. In healthcare, they provide services to make the person in recovery feel less alone and scared, while maybe also being able to pay attention to their status. They can also help socially impaired people by being a social companion they can be around. Additionally, there are specific robots that keep the elderly from feeling less alone in nursing homes, especially if there is not enough staff or family to keep them company. However, robot companions are also available for the general public. Some are meant for children, for example robotic toy pets, or the Hello Barbie, a doll shown in Figure 2.6 to which a child can actually talk

[6] Image from https://www.amazon.com/all-new-amazon-echo-speaker-with-wifi-alexa-dark-charcoal/dp/B06XCM9LJ4

and it will talk back [15]. These are robots of varying levels of complexity which a child can play with. Also for adults there are companions. Often, these are desk companions. Sometimes these will have practical purposes, such as lighting up when there is a notification. Others will only be for fun, such as the Portal 2 Sentry Turret USB Desk Defender as displayed in Figure 2.7, which is a machine from a game which will “shoot” when it senses motion and “die” when pushed over, mimicking the robot from the game Portal 2 [16]. This device is designed after a robot from mainstream media, which boosts the acceptance of the robot.

Figure 2.6: Hello Barbie, an artificially intelligent IoT doll. Image source: Amazon[7]

[7] Image from https://www.amazon.com/Barbie-DKF74-Hello-Doll/dp/B012BIBAA2

Figure 2.7: Portal 2 Sentry Turret USB Desk Defender. Image from: Google Images[8]

The acceptance of a companion is strongly related to its appearance. This causes many robots to be shaped after a human, usually with a head and body and nearly always with eyes. Eyes can easily give the robot “emotions”, while also giving them a familiar look. Robots such as Poppy, Pepper, Nao (Figure 2.8) and Robovie play into this concept. However, it is the humanlike communication that seems to be essential [17]. Other robots are modeled after animals. These zoomorphic robots tend to use the pet aspect of these animals. The seal robot Paro as displayed in Figure 2.9 is endearing, which helps sick children or demented elders be distracted from their problems. The dog Aibo, shown in Figure 2.10, is mostly meant for domestic use, as a replacement for an actual pet with a realistic relationship [18]. Then there is the rabbit, the Nabaztag. This robot will be explored in the next section. The “lifelike” appearance of these robots is a strong factor in the acceptance [19].

[8] Image from https://www.thinkgeek.com/product/ee85/

Figure 2.8: Nao, an example of a humanoid robot. Image source: Google Images[9]

Figure 2.9: Paro, the seal robot. Image source: Google Images[10]

[9] Image from https://www.generationrobots.com/en/401617-programmable-humanoid-nao-evolution-robot-red.html

[10] Image from https://www.focalmeditech.nl/nl/robotzeehond-paro

Figure 2.10 Aibo, the dog robot. Image source: Google Image[11]

2.2 Nabaztag

The Nabaztag is a robot shown in Figure 2.11, modeled to look like a cartoonesque rabbit. As mentioned before, it was a domestic companion for the broad market which could give notifications about various types of information. It was meant to be both a technologically interesting object, as well as a cute robot bunny.

It has the following technological features:

- A button
- An RFID reader
- A microphone with voice recognition
- A volume wheel/potentiometer
- Ears the can position themselves, but that can also turn via the motors
- WiFi to send and receive data needed and to connect to a server
- Speakers
- A jack outpt
- Four RGB LEDs (3 in stomach 1 on nose)

[11] Image from http://www.reviewcentralme.com/2017/11/01/sony-reboots-aibo-robot-dog-ai/

Figure 2.11: The Nabaztag with the LEDs turned on. Image source: Google Images[12]

2.2.1 Previous uses

The initial purpose of the Nabaztag was to be a domestic companion. There were many functionalities; it could for instance tell the user the news or the weather, it would read them their messages and it could help them calm down by doing Tai Chi. Other functionalities included a stopwatch, music player and audiobook reader [20]. Most of these were performed using an internet connection where the server would send it this information. This all while it would mimic a pet with its own personality keeping them company [20]. Also, art installations using Nabaztags exist, one of these being the “Nabaz’mob” shown in Figure 2.12, which used the LEDs, speakers and ears to convey the experience [21]. The Nabaztag was marketed as a fun but useful gadget, but eventually the company went bankrupt and the servers went offline.

[12] Image from https://www.amazon.co.uk/Nabaztag-Communicating-Rabbit-WiFi-54Mb/dp/B000FDEC0G

Figure 2.12: The 100 Rabbit Opera at the 2006 NextFest In New York. Image source: Google Images[13]

For researchers, this device was and still is interesting. It is a useful robot for different fields of studies. The first field that was explored was the domestic companion. One study specifically looked at the use of the robot in the kitchen, to be of help during cooking [22], while another explored the options of it mimicking a pet, to make adult or elderly people feel accompanied in their everyday life [23], [24]. The second use that has been researched is the health and fitness promoting companion for either elderly or young people. Most commonly, the device offers help with making and sticking to a planning [25], [26], [27]. The third field is embodied systems, where the robot commonly simply a tool for other research. Due to its many input and output possibilities, researchers have considered it to be a useful medium for research hardly related to the robot. For instance, one study wanted to look at the difference between the success of information sharing through an ambient display in comparison to a regular screen [28]. In this case, the ambient display was the Nabaztag. The robot was also used in a different research about designing a dialogue system, where the robot would speak according to the designed protocol to test its success [27].

2.2.2 Previous findings

Some positive and negative features were found about the Nabaztag that need to be considered for this project. There are multiple advantages the robot has. People seem to like the robot and enjoy interacting with it [22], [26]. This can be due to the unpredictable nature of the robot [24] or its cute zoomorphic design. They also think the robot has the potential to be useful in the right setting [22]. The use could be in its original purpose, but also as a

[13] Image from http://www.wikiwand.com/en/Nabaztag

conversation starter [29] or simply as a presence, an auditory and visual stimuli in an otherwise empty situation [24]. All these positive aspects of the robot can be exploited in further purposes.

The companionship seems to be a prominent returning factor in all previous research on this robot. For this, a relationship needs to be promoted. First of all, this was done by the suggestion that the Nabaztag is a living pet, with blinking lights representing a heartbeat [28] and an appearance modeled after an animal [23]. The promotion also played into the experience of the bunny being real [23]. Second of all, some users instantly assign the robot a personality. It makes unexpected, witty comments [24] enhancing this personality and users could even purchase ears with different designs to make this personality visible.

There are also features that people perceived as negative. A prominent one that appears in nearly all research done so far is that it is malfunctioning [22], [28], [29]. Not all promises were met [30]. Especially once the fun novelty wears off, the device is not useful anymore [22], [29]. The product was also perceived as intrusive, e.g. the notifications were not silent, so the user is either bombarded with messages or they need to constantly press a button to check if they have received any [22]. Additionally, the given information was not intuitive and needed much cognitive attention from the user [23]. Also, some small details such as the voice and the wifi connection were problematic [24].

Also, not all users feel the companionship. Some of this is due to the malfunctioning of the product as mentioned earlier [26]. Another reason that original users were confused by the mixed promotion; on one hand, as a pet, but on the other as a “strong technological force” [23]. Yet another issue is privacy, where the user does not trust the robot enough to make an emotional connection [30].

2.2.3 Servers

Since the bankruptcy of the company, where the servers stopped working, most Nabaztags have stopped working. Nearly all of the functionality came from the servers. However, there are still three options to make the robot function again, although they take more effort than before. This is a hindrance for the regular user.

The first option is to use an existing server. A number of people had decided they did not want to give up on the robot and have set up their own servers for like-minded people to use. Some online servers such as the Wizz.cc Nabaztag Controller (Figure 2.13) had come online where a user can connect and use their rabbit. These allow them to play audio, send messages, or make the rabbit move [31]. For the named example, they need to sign up their rabbit to connect it to the server. Then, as shown in Figure 2.13, there is the option to play music from SoundCloud, send a “choreography” or send a message to another rabbit [31]. This is the easiest choice for the everyday user who wants to use their rabbit as before. For this research, these options are too limited. They are not meant to be programmed for the rabbit to do something more meaningful, more complex or different than it originally did. This would eliminate most options for giving the robot an entirely new purpose.

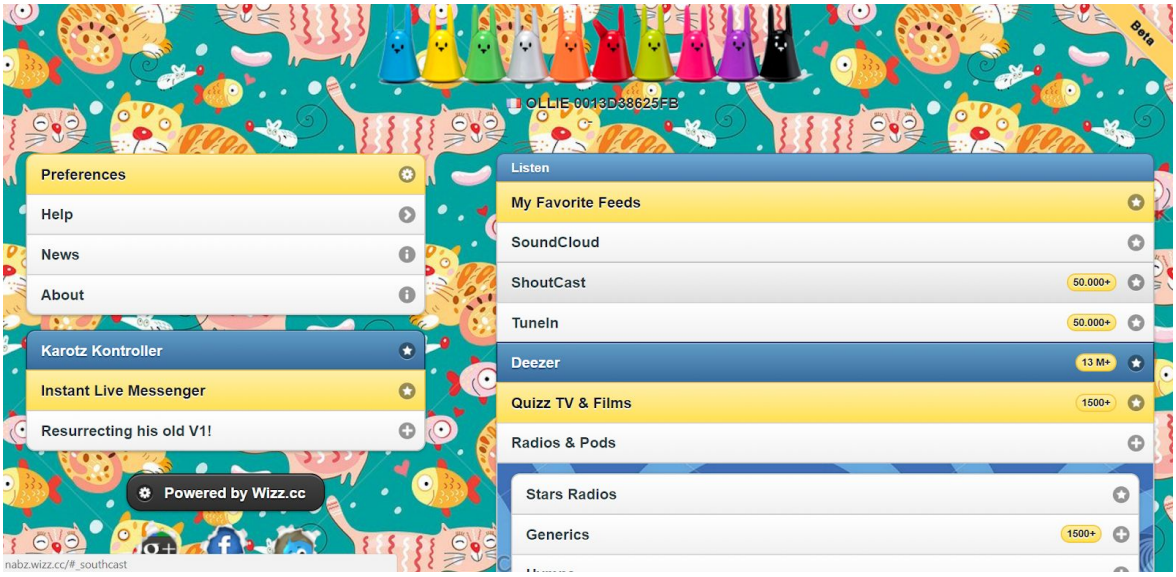

Figure 2.13: A screenshot from the online server http://nabz.wizz.cc/.

The second option is to make your own server. There are many open source projects such as NabIzDead, JNabz, or NabaztagLives that allows a user to turn a Raspberry Pi into a server that they can run their Nabaztag on [32]. This option provides a lot of freedom, which is why many researchers use this. An example from a settings page on the NabaztagLives server is shown in Figure 2.14. Here, you can see some of the customisable options on the server. Some examples you can see is that it can tell a user the time at a certain pre-decided moment, tell the weather with the preferred temperature unit and make a random noise [32]. This seems to be far more customisable. The code is given on SourceForge, so it can be downloaded and edited accordingly. The options for this are theoretically only limited by the programmer's ability and the robot's hardware. This makes this option suitable for this project, because it is flexible enough for this research.

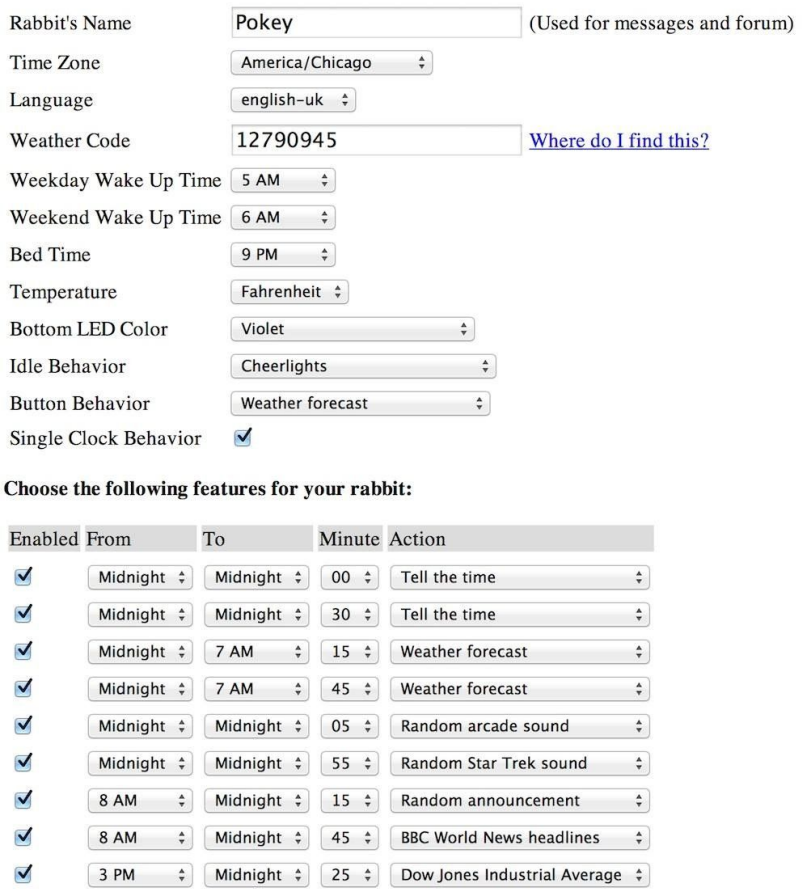

Figure 2.14: The settings menu from the NabaztagLives Raspberry Pi server. Image source: SourceForge[14]

The last option is to refurbish the Nabaztag entirely. Some people take the robot apart and give it a (mostly) new interior [33]. An example of this is shown in Figure 2.15. This gives you the opportunity to use new, better equipment while keeping the appearance the same. Also, any functionality can be easily adjusted this way and another controller can be put in, one which may be easier or more familiar to program. It is a very flexible option. The downside to using this method in this research is that the goal of this research is to give the current Nabaztag a new purpose; to find a way to make this 12 year old robot fit in modern day society. By completely altering the inside, this goal cannot be reached exactly because the robot is no longer the original robot.

[14] Image from https://sourceforge.net/projects/nabaztaglives/

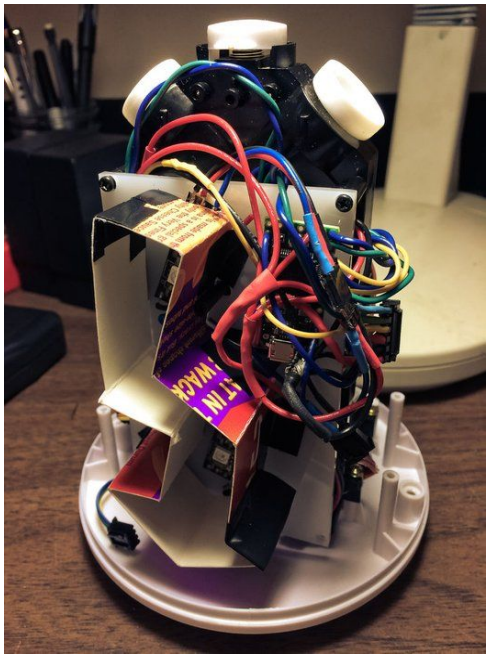

Figure 2.15: The inside of a refurbished Nabaztag. Image source: Instructables[15]

2.3 Plan for further research

For further research within the scope of this project, there will be interviews with previous users. These users have experience on both the user and the researcher end in varying levels. Some have programmed it themselves or have looked at the robot as a technologically interesting gadget, others have used it at home for its original purpose. These interviews will hopefully provide some insight in both working with the robots and how they are experienced. Also, the ethical side of the product will be explored. Then, with as much gathered information as possible within the time frame, a prototype is created.

The robot will be programmed according to one of the three options given under *Servers*. The second idea mentioned, to make a server out of a raspberry pi, is the most suitable option for this project. This option is flexible enough, where the options for the social robot can be explored, which means it is better than the first option (the existing online server) which is very limited and therefore not even a possible option because the research could not be performed. The third option, where the Nabaztag is completely taken apart and refurbished, is the backup plan. It does provide sufficient options to test the Nabaztag's possibilities as a social robot, but it does not reflect the goal of this research properly. The aim should be to keep the robot's hardware as close to the original as possible.

After this prototype is finished, it will be tested on people that could be potential users. How they interact with the product will be the main focus. How much they use it, in which way and which functions they use the most are relevant for the expected success and sustainability.

[15] Image from http://www.instructables.com/id/Hack-the-Nabaztag/

3 Ideation

In this phase, the concept for the purpose of the robot is created. This chapter describes the process of how the idea is formed and then looks into the details, resulting in a list of requirements for the product.

3.1 Concept

3.1.1 Brainstorm

A small brainstorm is held. In this brainstorm, the ideas about what the robot could be used for are explored. The ideas that are looked at go into different directions, where the final options are, in no particular order:

1. A desk companion, similar to its original use, where a few features work really well using more current methods and technologies.
2. A music companion which could dance and entertain the user.
3. A single value device which could tell the user something in a less intrusive way than the conventional method, e.g. the time or whether you have messages.
4. A mental health companion for students battling depression, anxiety and/or burnout symptoms.

The first idea is useful and would have maybe been useful in the past, but now in an era where the Google Home and Amazon Echo exist, another assistant doing similar tasks but probably fewer and less successful would not add much to the existing situation. The second idea is fun, but not groundbreaking or interesting to research. The third idea is an interesting look at technology, but the fourth can have a great and direct impact on the lives of a distinct group of people. That is why this idea will be explored further in this research.

3.1.2 The chosen concept

The concept of a mental health companion for student is chosen. Depression, anxiety and burnouts are more common than they should be, also at the University of Twente. Recent reports from the University's student psychologists have shown that the number of students diagnosed with depressive symptoms has nearly doubled in the past year, from 77 to 150 students, and the same goes for burnout symptoms, from 16 to 28 [34]. And these are only the cases reported there, if students do not undertake action for their symptoms or do it elsewhere they are not counted here. This high number of patients means the student psychologists are unable to see them every week. In between sessions, the student is left on their own. That is where this idea comes in.

The concept is a social robot which helps people with their treatment. When you go to a psychologist, they are only there for the duration of the session. They can give homework, but

that is all they can do for their client outside of a session. This robot could fulfill the role of therapist outside of the sessions, to help the client with the given tasks and ensure they perform them. Also, it could aid them with their illness in their day to day life.

3.1.2.1 Needs of the user

This process so far has been bottom-up, where there is a given device and the goal is to create some purpose for that device. To ensure the product is not just a gadget but does actually suit the needs of the user, a top-down approach will be taken next. What does a depressed and/or anxious student need that a robot could fulfill?

For depression, the main problem to get in the way of studying is motivation and energy. Everything seems to be a large, unattainable task that will not satisfy the student, which is why they will not do it. However, if no tasks get done, the student will not get their energy back, which makes every task even more difficult. This creates a circle. The way to leave this circle is by doing more again. In cognitive behavioural therapy (CBT), one of the most common treatments for a wide spectrum of mental disorders [35], the root of the problem is found and this idea is introduced, but the execution needs to be done at home. The goal of CBT is to alter the thought patterns that happen in the patient's mind which cause them to feel the way they do. The patient needs to do most this on their own, without the therapist to help, which can be very difficult depending on how long they have been in that circle. That is where a robot has the option to be useful: to help the person get back to doing things. This can be done by helping make a planning or by motivating them on the spot to do the activity.

The student also has homework, for both their study and their treatment. For their study it involves studying for an exam, making a group of individual practical assignment or doing theoretical exercises. These can be very difficult for the student with depression or anxiety because of the symptoms of those diseases. By feeling fatigued, unmotivated and having difficulty concentrating [36], the tasks can become nearly impossible. For therapy it involves trying to apply the changes or testing the ideas formed in therapy to make sure the treatment is continued outside of the therapist's office [37]. The key word in this type of homework is "trying", because the most important factor is that the process works with trial and error and that the patient should put the effort in, the outcome is less relevant [37]. There are multiple reasons behind a patient failing to adhere to the homework given in therapy [37]. For example, the goal is unrealistic and too difficult. Another reason could be that the client is not committed enough. Positive feedback when doing the assignment well can be absent, which is demotivating as well. Another problem occurs when the client's expectations of the treatment are skewed. For all these types of homework, a robot could help in motivation by reminding them of the importance of the task or by helping them in accomplishing their goal by making the task (seem) easier.

3.2 Analysis

Next, the concept is analysed. The stakeholders are identified, previous users of the robot have been interviewed and the target user group is explored, in order to find some basic requirements for the product.

3.2.1 State of the art

There are already some digital and physical aid systems for people with anxiety or depression. In this chapter, those systems are examined. This gives an overview of what is already out there, what can be learned from those solutions and what is still missing.

3.2.1.1 Websites

There are multiple websites which people can go to when they are struggling with depression or anxiety. One of these is 7 Cups, a network of members and so-called “listeners”, who chat with the members [38]. The goal of this is to support the members in their difficult times. The regular listeners are not professionals, but can offer a friendly conversation and compassion. There is also the option to talk to a licensed professional for a fee that is lower than a regular therapist, which makes approaching them an easier step. There are also “paths” that can be unlocked for a small fee, where the user does exercises that help with their situation. More options that the website offers are meditation and mindfulness. The aim of this website is to help people going through difficult times in different ways.

Another online help is the chatbot Woebot [39] as pictured in Figure 3.1. This is a little robot that a user can talk to through Facebook chat or an app. This robot helps the person work through their problems by using artificial intelligence and theory from cognitive behavioural therapy. It will first check up on the user every day, to find patterns in the way they feel. After that, the treatment starts. This chatbot is meant to reduce the symptoms of mental illnesses such as depression or anxiety and is aimed at specifically university students [39]. According to their evaluations, the bot works well at reducing the symptoms of both anxiety and depression [39].

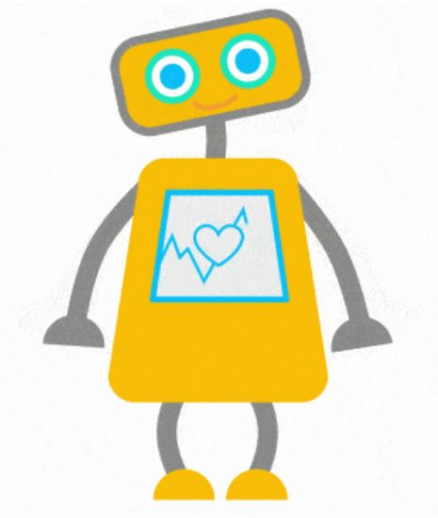

Figure 3.1: Woebot. Image source: Woebot[16]

3.2.1.2 Apps

There are also many mobile apps made to help with keeping a good mental health. For example, there are meditation apps such as Headspace as shown in Figure 3.2 that practice mindfulness. Mindfulness is a method where you try to control your mind while also accepting its curiosity [40]. This can reduce anxiety. There are also mood trackers, depression tests and pattern creators. Pacifica is an app that uses cognitive behavioural therapy by combining each of these functions to reduce stress and anxiety. In short, there are many apps which claim to reduce anxiety and depression and while some of these may work, they are on the user's phone. For many students, this can form a distraction [41].

[16] Image from https://woebot.io/

Figure 3.2: The Headspace app. Image source: Headspace[17]

Two of the many apps that actually aim to aid with studying are Forest and Engross. Forest is an app where the user “plants a tree” and cannot use their phone while that tree is growing [42]. The duration of this is determined by the user, where a longer time results in more and larger trees that grow in a “forest” as shown in Figure 3.3. After the tree has grown, the user wins coins that they can spend on new trees, white noise or a charity which plants real trees [42]. This makes the user more aware of how often they use their phone and stops them from using it mindlessly while studying. Engross is an app that keeps track of how often you are distracted [43]. In the app, the user chooses the duration of their study period, the time for how long the breaks are and the amount of times they want to repeat that cycle. Then, the app stays active. If the user is distracted, they can tap the screen and continue working. This makes the user aware of distractions and can bring them back to their focus [43]. These apps promote the user to stay away from using their phone as a distraction, providing better focus.

[17] Image from https://www.headspace.com/

Figure 3.3: The Forest app. Image source: Forest[18]

3.2.1.3 Physical objects

Aside from virtual tools, there are also physical objects that promote good mental health. In 2017, fidget toys, such as the fidget spinner in Figure 3.4, became very popular to aid with anxiety. However, these often cause a distraction or do not work [44]. Other, more effective objects are light therapy boxes, also referred to as “Happy lights” for some forms of depression [45] and weighted blankets for anxiety [46]. These are tools used to reduce the symptoms of the mental disorders. Sometimes, therapy or emotional support animals are used too. These are real animals such as dogs or cats that a person can use to bring them comfort in stressful situations [47].

Figure 3.4: A fidget spinner. Image source: eBay[19]

[18] Image from https://www.forestapp.cc/en/

[19] Image from https://www.ebay.co.uk/itm/Rainbow-Fidget-Spinner-EDC-Bearings-ZL510-Shiny-Elegant-Compact-ROUND-/232365166418

Instead of real animals, there can also be robotic animals to help people. One of the robots made for this is Ollie the Baby Otter as seen in Figure 3.5. This is an otter-like robot which comforts people suffering from cancer, post-traumatic stress disorder or dementia through animal-assisted therapy [48]. Also, in the same category of robotic animals there is the phobot. It is a robot created in Amsterdam which is meant to teach children how to handle their anxieties and phobias [48]. It is supposed to be a buddy to the children, teaching them how to overcome their fear step by step. These are all examples of devices helping humans with their anxiety.

Figure 3.5: Ollie the Baby Otter. Image source: Mental Floss[20]

3.2.2 Stakeholders

First, it needs to be analysed what stakeholders are involved. The first, most important stakeholder is the user. They are ultimately the ones that should benefit the most from the robot. They are supposed to have a better mental health after using the product. A second stakeholder that is involved with the product is the therapist or student psychologist that includes the product in their treatments. They should be able to use the product to improve their client's condition, which is their goal too. A third stakeholder would be the university that the users attend, specifically the teachers there. These should find their student to be more present and work harder during the semester, which should result in higher grades and better results. The fourth and final stakeholder is the social robotics researcher, especially ones that are focused on the Nabaztag. If the product would work, that would be an interesting progression within the field. The techniques used for it and the research performed would be of interest for these researchers.

[20] Image from http://mentalfloss.com/article/548026/mits-new-ai-can-sense-your-movements-through-walls-using-radio-signals

3.2.3 Interviews

In order to hear more about the use of the product from both the side of a researcher and a consumer to have a better understanding of the product, interviews were held. The decision to use interviews was because the target group that can help with this information is relatively hard to find because it is so specific, so the small amount of people found should be used as effectively as possible. The goal is also to form a better image of the specific context, with supposedly a lot of variation between interviewees. This is why the interview was semi-structured. This allows all specific questions to be answered, but with possibilities for the interview to take a different turn where needed. This is useful in this situation because the background of how it was used and in which context might drastically change the relevance of questions and might bring other questions into existence that were unforeseen at the beginning. Also, the interviewee might have certain points to bring up which they think are important that were also not asked about because of the broadness of the goal. The questions that functioned as guidelines for the interview can be found in Appendix A. The full interview transcriptions can be found in Appendix B. The interviews are conducted in Dutch, so the appendices are the translated versions.

One of the most important findings is that the people really liked the product, especially its design, but found flaws in how it functioned. Much of the enjoyment came from novelty, because it was a new and modern product. Both people who used the Nabaztag mostly for what it was meant for, created some kind of bond with the Nabaztag. One actually saw it as some kind of “pet”, while the other only became connected to it in the sense that they missed the rabbit’s presence once it was gone. Another finding was that the researcher stopped using the robot because it was too complicated to work with. Once the servers went down, lots of problems occurred. The largest problem was that the connection to secured WiFi networks was difficult and that setting up your own server was a hassle. These findings should be taken into account when it comes to the process and final product of this project.

3.2.4 Users and Context

People

The target audience for the product is university students aged 18-27 of all genders in various parts on their study with versions of depression and/or anxiety. The symptoms these people have include, but are not limited to lack of energy, lack of motivation, heavy stress, fatigue and sleep problems [36]. These sleep problems can vary between too much, too late or too hard to stay asleep. The focus of the device will be on students that are still trying to keep up with their study, while also trying to get better by going to a psychologist. As a start, the device would most probably be used in the Netherlands, so the used language should be Dutch.

Activities

The treatment plan that is most common for depression and anxiety is cognitive behavioural therapy [35], which is why it is the focus in this research. This treatment involves the client to look at their behaviour, recognise the problems and fix those. It can also be combined with some sort of medication. It asks the client to look at problems in their everyday life, giving the person some homework between the sessions [37]. This means the product is intended to be used daily, with the times of use depending on how much the user is in the room. It could only be used for 30 minutes in the morning and at night, but it is also possible the device is needed all day. The specific activities the product will focus in in this stage are: aiding with homework by playing music and giving reminders to focus, helping with sticking to a planning by taking the planning of the user, giving reminders of each task and also playing appropriate music for each task and finally giving self-care tips and reminders, for example drink water or take medication.

Context

The product should be used in a student's bedroom, which normally is also their study space at home. This assumption is part of the concept of the device, otherwise it would need to inhabit multiple rooms at once, either by moving or by having multiple robots throughout the house. Socially, the student is supposed to be alone during the use. It is alright if there is another person they trust, who knows about the robot, but otherwise the user might find the situation to be uncomfortable since mental health is not generally discussed much.

Technologies

The technology used is the Nabaztag robot. Ideally, this and a server are the only technologies needed, where the Nabaztag already consists of the components mentioned in chapter 2.1.5. The components used for the activities within the scope of this research are mostly the microphone, the speakers and perhaps the ears or LEDs to make it seem more alive. The system should be voice activated and always listening, since the user might have difficulty getting up to press a button. The product should be as accessible in this situation as possible, because the device can especially be of use in that situation. Once the robot and the server are installed in their positions, the interaction should be simple and intuitive.

3.2.5 Personas and scenarios

These are two possible users to paint a picture of the situation in which the product will be used and for what purpose. There is a variation in their background including the cause of their mental illness, their demographics (age, gender and study) and their symptoms that they use the Nabaztag for. The user stories and scenarios sketch an image of how the Nabaztag can be used and how this would directly improve the user's day. The second scenario is also used later on for the prototype and the evaluation.

Amy van Dijk

Persona

Amy van Dijk is a 22 year old female in the first year of her master Industrial Design at the University of Twente who has severe seasonal depression. Every winter she becomes depressed due to the cold dark days. She is in treatment for this but has only just started and is not noticing the effects yet. She has an energy lamp which supposedly makes her feel better, but she does not use it everyday due to lack of motivation and energy. She had only just got it when she went into treatment so she has not noticed the effects yet. Furthermore, she has a really dark dorm room with very little natural light, a bad eating pattern and no real rhythm in her everyday life. She lives in a student house with 3 others in the city centre of Enschede.

User story

She can't find the energy or purpose to get out of bed. She has an alarm set for 7:00 but doesn't leave bed until 11:00. She knows she should be using her energy lamp for 20 minutes every morning but she does not believe it is worth the effort. She has missed one class because of the lack of motivation and would be late for the next, so she skips that one too. In the afternoon she wants to study on her own to catch up on homework in the comfort of her own room, but she feels tired and unfocused so she decides to go back to bed.

Scenario

The alarm is set for 7:00 and Nabaztag tries to wake her up. It reminds her that the therapist has told her to use her energy lamp and why, and plays some upbeat music to avoid her going back to sleep. She needs to get up and walk to her desk to turn it off, which she does, making it easier to use the lamp while she is there. She uses the light at her desk for 20 minutes while watching videos on her phone and while she does not feel much of a difference, she does notice she is satisfied that she did what her therapist told her to do. She now has enough energy to take a shower and get dressed to go to class, where she sees her friends. She has a hard time focusing on the lecture but is catching some of the information. After class, she is very tired again and goes home to rest but she is proud that she went and actually was able to follow some of the class.

Steven Lima

Persona

Steven Lima is a 19 year old male in his second year of his bachelor Computer Science at the University of Twente. He is diagnosed with generalized anxiety disorder and has depressive symptoms. He had a hard time adjusting to student life because of the large change in autonomy, difficulty levels and pressure. He reacted more strongly to this change than most of his peers. He has supportive parents but feels pressure anyways because he has always been the smartest one in his family and does not feel comfortable sharing his feelings. His study

advisor sent him to the student psychologists after talking about his trouble keeping up with the rest of the class. However, his psychologist does not have time for him to come by every week. There are often three to four weeks in between sessions. He feels pressure from his study and has a hard time trying to balance his studies and self-care. He does not feel like he is ever finished or has deserved a break, making him tired and unable to focus. He has tried making a planning before but could not stick to it.

User story

He forces himself to start studying at 9am, according to his planning. He is constantly checking his phone for the time which distracts him, and feels like he is working too slowly as a result of that. After 45 minutes he has planned to take a break, but instead he tries to keep working to catch up. This is going fine, but after another 25 minutes he is losing focus. But since he is already in the next time slot, he does not allow himself to catch up on the break and works for another 30 minutes, with very little to show for it. This stresses him out even more.

Scenario

He tells the Nabaztag he is starting to work and puts his phone away. The Nabaztag knows his planning. After saying what the planning says for Steven to do, the device plays classical music for 45 minutes while he is working, which helps him focus. After the time is over, the Nabaztag says he should take a break. The classical music stops. The device says Steven can go for a small walk, but Steven says he does not want to. It then suggests he can meditate, which he wants to do. The device then starts a guided meditation session. After the break, the Nabaztag reminds him what he had planned to do and the classical music starts back up. Steven does not feel as much pressure and feels more capable to stick to his planning.

3.2.5 Preliminary requirements

There are some basic functions for the Nabaztag to fulfill its new purpose:

- It needs to be able to store a planning and be able to speak reminders of this planning.
- It needs to be able to play music according to what activity is planned.
- It needs to be able to give suggestions on what to do to relax.
- It needs to be able to give reminders of self-care.
- It needs to be persuasive, the user should feel encouraged to do the tasks the robot tells them to do.

4 Specification

In this chapter, the requirements and the interaction are specified. In the requirements section, five aspects of the product are explained as to what needs to happen for them. In the interaction section, a basic interaction scheme is explained and a scenario from earlier is examined at a system level. The goal of this is to provide a structure for the prototype.

4.1 Requirements

The goal of the product is to be a helping companion to students with depression and anxiety. In order to reach this goal, the following requirements are formed. They are split into 5 sections: which functions does it need to have, how should the robot socialize, how should it be tailored to the audience, which external design aspects are important for this project and how can the robot be persuasive.

4.1.1 Functions

The product must have functionalities that promote the mental health of the user. More specifically, the functionalities need to help improve symptoms of depression and anxiety. This is the concept of the product. There should be a number of actions that help the user improve their condition. Each of these actions should be easy to turn on or off, because the tasks the user needs to do can change depending on their therapy or the situation. Some also need to be customisable to the specific situation. However, it should not be easy enough for the user to do it whenever they do not feel like doing a task. Perhaps needing a password to make certain changes could work, except the user should also not feel restricted by the product or forced to do those tasks. The functionalities that will be the focus in this research are helping the user with sticking to a planning, persuading the user to take care of themselves and playing accompanying music to the planned activities.

4.1.2 Social robot

The product should be a social robot that the user can feel comforted by or have another type of relationship with. This promotes the companionship aspect of the device. This should make the acceptance of the product easier and more natural for the user, and the advice the product gives will then be taken more seriously. The original purpose of the product was partially also to be a social companion, which worked partially for some users. The reasons found in the background research for why not everyone felt the connection were mostly that the product was perceived malfunctioning and intrusive. Also, people found it to be enjoyable but not a serious tool. So the relationship between the robot and the user would be improved by making it function properly and by making the interaction feel as natural as possible.

But then, also a relationship needs to be built. There are “three areas most relevant to the growth of these supportive human-robot relationships: socially intuitive interaction, personalized

interaction experience, and long-term interaction" [49]. The personalised experience comes with the nature of the product: the activities are meant to be tailored to the user. In order to personalise it even further, the robot can perhaps change the interaction with its user depending on what they respond best to. This can be explored in further research, as it is not realistic within this project. The long-term interaction is promoted by the therapist, who encourages the person to continue their treatment by emphasising the importance of it. The time period in which the device is used is a few months long, varying on the severity of the symptoms of the patient and how well they respond to the treatment. The robot should also remind the user of these reasons when the user feels unmotivated to do their homework assignments. Then, there is the socially intuitive interaction. This is the main component to be researched in this study, because there is not one clear solution for this.

4.1.3 Audience

The product should be targeted at university students aged 18-27. This age group has some very specific features, for example many students have just moved out of their parents' house, have started a new school and have to suddenly grow up. Also, they have lectures to attend, homework to do and exams to study for, of which not all are compulsory. Beside the actual study, many students also are active within one or more associations, making the pressure even higher. This requires special treatment, because the activities are quite specific. Also, the audience this product is made for is people who are already going to therapy and in treatment. This product cannot be used without the therapist involved because it cannot be as aware of the user's condition as a trained psychologist, nor is it qualified.

4.1.4 Design

The product could have the exterior design of the Nabaztag robot. Which shape the robot has in this research is quite arbitrary. This is the robot present and the one that will be used in this research, but there is no evidence that this design is the best choice for this situation. However, it is small enough to fit in a room and it has all functionalities needed to realise the main goal. It also looks like a cartoon-like rabbit. This zoomorphic appearance can boost the acceptance of a robot. In the past, as found in the background research, the robot's appearance has helped the user find a connection with it. From this research it can also be concluded that the interface design, however, can be improved.

4.1.5 Persuasiveness

In order for the device to actually be functional, the user needs to listen to the commands it gives and perform them. They needs to be persuade by what the robot tells them to do. If the user does not accept the robot, they will not do that. This is where the aforementioned relationship comes in. If the user has a connection with the device, they are more likely to approve of the advice it gives. As mentioned earlier, the robot also needs to function properly. If the interaction or another aspect of the robot is malfunctioning, what it says gets discredited so that needs to be avoided. Another aspect that came up during literature research is novelty.

Many people enjoyed the device due to its novelty, and once that wore off they became bored. But since the device is meant to be used temporarily during treatment, maybe novelty can be used to keep the user interested. Especially if it is able to update based on the current situation every certain amount of time, the user might remain intrigued by its novelty. For example, it can get a new outfit each month to match the current weather or period of the user's life. This can keep the device enjoyable and therefore motivating.

Motivation is another important aspect. Theoretically, the user has the motivation to get better, because they have sought help in the first place. But at some moments, they might need some more encouragement. A function that can motivate the person to do the task is that the robot can play music according to the current activity. If the user would want to watch tv while they should be working, classical music could play quite loudly to make the tv show less enjoyable and make the activity they should be doing more attractive. When the task has actually begun, the music can be at the desired level again. Another motivating function would be that the purpose of each activity is emphasised. When the user realises that the task provided can bring them closer to their goal, they are more likely to do it.

4.2 Interaction

The main interaction is based on voice commands from the user, which trigger an auditory or physical response from the robot. There is a task sequence programmed into the robot, done by the user, sometimes in cooperation with the therapist, which the robot follows. However, there is a feedback loop in which the robot checks whether the tasks are finished. For now, this is done by asking the user directly. This is based on the assumption that the person is trying to improve their condition enough to be truthful about this.

In order for the robot to reach its goal, the interaction should not be experienced as robotic in the sense that simple questions are asked and there is only one correct answer or some goal has to be reached in order to continue. The user needs to feel comfortable. The following section elaborates on that needed compassion. After that, an interaction scenario is worked out to be programmed for the prototype.

4.2.1 Compassion

This also means the robot should appear to be compassionate enough for the user to feel safe to admit when they have not done something. Otherwise, they might feel embarrassed and resort to lying in order to be done easily. They need to be given the opportunity to confess they have not done something, where they are assured that the robot is only there to help them. However, something needs to be done if they have not performed a task. The solution for this would be to ask *why* they have not done it. According to the answer, the system can follow a new path. The answers are expected to be sortable into these categories:

- If they are physically unable to do the task, the task needs to be dropped or postponed, depending on how important the task is.
    - If their planning has changed or there is another reason due to which the task is no longer possible, this also counts as physically unable.

- If they feel mentally unable to do the task, they need to be motivated more and praised more afterwards. If the task is not vital, it can be dropped after a while to put more focus on more important activities.
- If they do not want to do it, the same needs to be done as with mentally unable, except they can be pushed more.

4.2.2 Interaction scenarios

For the interaction, a scenario is taken from section 3.2.4. The steps to be taken by the device per action are explored in order to be implemented into the prototype. The actions from Nabaztag are in bold.

Nabaztag takes Steven's to-do list and reads the current task. Nabaztag says "Okay, your planning says you should study math now".

Steven says "Okay, I will".

Nabaztag starts a timer for 45 minutes and plays classical music while Steven studies.

45 minutes later the timer reaches 0. The music stops and Nabaztag tells Steven "You have done your best and it is time for a break. What are you doing during this break?" and starts a 15 minute timer.

Steven says "I don't know".

Nabaztag hears this as a command to look through its array of possible activities and says "Do you want to go for a small walk? It is good to move a bit".

Steven says "No".

Nabaztag hears this as a command to look further and says "Do you want to meditate? It can clear your mind".

Steven says "I have never done that before".

Nabaztag hears this and says "That is okay. I will play a guided meditation session for beginners" and turns on the guided meditation session.

Steven follows the guided meditation session.

After the session has ended, Nabaztag asks "Was that good?"

Steven says "Yes, I enjoyed that".

Nabaztag saves this information, checks the timer and says "You still have 5 more minutes of break. Have you drunk enough water today?"

Steven says "No, I will do that now" and goes to get a cup of water.

The timer reaches zero and Nabaztag says "Are you ready? The break is over".

Steven does not respond, he is in the other room.

Nabaztag repeats itself.

Steven does not respond.

Nabaztag waits for a minute then repeats itself.

Steven says "Yes".

Nabaztag says "Good. You were working on math" and starts playing classical music again.

5 Realization

A simplified prototype is made in order to evaluate the interaction and basic requirements of the product. In this section, some design choices for this specific prototype are first explained. Then, the individual components are elaborated upon, especially why these components were chosen. After that, the actual setup of the prototype is shown and explained.

5.1 Prototype considerations

The first plan was to make a server from a Raspberry Pi that the Nabaztag would run on. This seemed to be the best option because this kept the current robot intact and was the most relevant for this research. However, Robert Slagter who was interviewed pointed out that connecting the Nabaztag to the internet or a server was so difficult that he stopped working with the robot. This was tried and after trying many different settings, it was indeed not connected yet. Also, previous research performed about the use of the robot has shown that there are a lot of flaws with the interface of the robot. Therefore, there is very little value to using the existing robot while it would cost a lot more effort. This means there will be a new robot made which mimics the existing Nabaztag in its shape and functionality, but is easier to program and is intended to perform better. Also the features not needed for the evaluation will not be in the prototype.

The new robot prototype will be made using an Arduino Uno, four RGB LEDs, a speaker and two servo motors. This will allow the robot to provide the output as needed for the evaluation, which will be described in chapter 6. The rest of the features of the Nabaztag are irrelevant for this prototype since the evaluation of the interaction is done using the Wizard of Oz method, where the responses are triggered by the evaluator's observations, not sensors. The external design will also change. It will still be modeled after a cartoon-like rabbit, but it will be smaller. This will make it cuter, less intrusive in someone's living space and less expensive to produce. It should not be a problem to still fit all components needed for the final product, mostly because the components are smaller now than they were when the Nabaztag was first released. The new design is made in Fusion360 and 3D printed in plastic, the same material as the original product. This way, the essence of the product remains but it is more compact and fits the new components better.

5.2 Components

5.2.1 Arduino Uno

For the controller, the Arduino Uno as displayed in Figure 5.1 is used. This is practical in this case because the used components work well for this microcontroller. It can control all components at the same time. It is simple and fast to program, which allows for fast debugging

and easy testing. It can also communicate with processing, from which the sound files are played and the Arduino is controlled during evaluation.

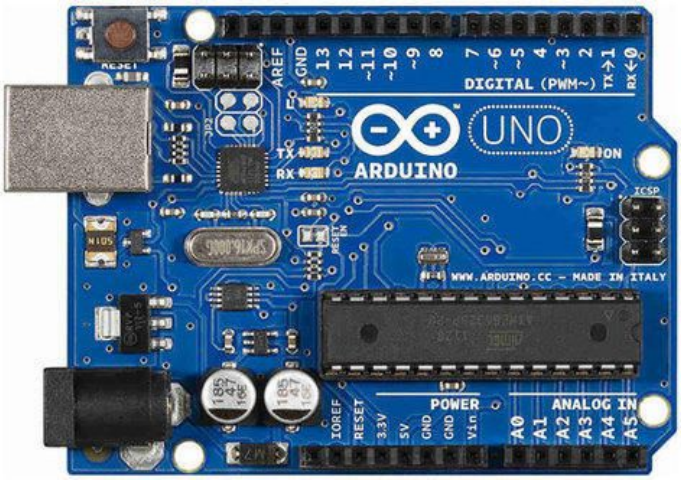

Figure 5.1: An Arduino Uno. Image source: Indiamart[21]

5.2.2 Motors

To move the ears, two SG90 micro servos are used as displayed in Figure 5.2. These are small servo motors which can turn about 180 degrees. These allow the ears to move separately. The motors are both powered and controlled by the Arduino Uno's digitalWrite() function which used PWM to control the angle of the servos. They are placed in a way where the ears can move forwards, not backwards. This way, they still have the full up-down range and have the ability to show more expression than if they were to go backwards.

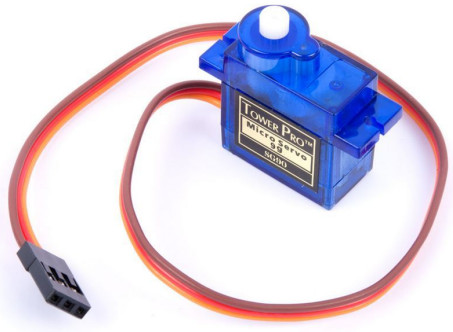

Figure 5.2: The SG90 micro servo. Image source: Kiwi Electronics[22]

[21] Image from: https://www.indiamart.com/proddetail/iso-course-on-design-of-embedded-system-using-arduino-uno-r3-9420066991.html

[22] Image from: https://www.kiwi-electronics.nl/micro-servo-sg90-9g

5.2.3 RGB LED

For lighting up the device in a specific colour at a time, an RGB LED is used, such as the one shown in Figure 5.3. The size and casing of the robot allows one LED to light up the entire robot. The LED only needs to portray a certain mood, so there is no need for multiple different LEDs, this would only become messy because the colors would mix together. The LED used has a common cathode, not a common anode.

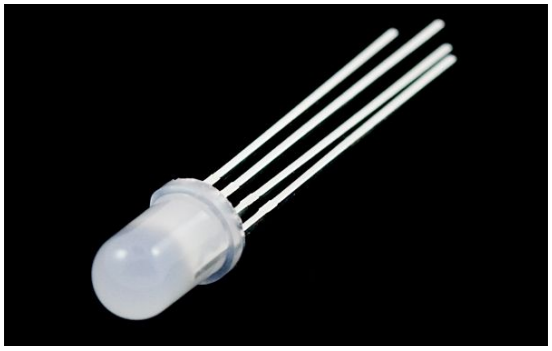

Figure 5.3: an RGB LED. Image source: SparkFun[23]

5.2.4 Speaker

For sound, a small bluetooth controlled speaker should be used. This can fit in the robot, so there is no confusion about where the sound comes from or what it means. It makes it more obvious that it is meant to be the robot talking. This also makes talking back to the robot more intuitive, because then you talk back to the sound. The speaker should be of high enough quality for the user to understand what it says. The speaker used in this prototype is the JBL Clip 2 speaker, displayed in Figure 5.4. It is slightly too large to fit the casing, but by placing it behind or underneath the robot still gives a relatively decent effect of the robot making the sound. This speaker is connected directly to the laptop controlling the prototype, so the Arduino does not need to control this. The sound bytes for the talking are made using the website http://www.fromtexttospeech.com/, where you type a text and it converts it to MP3. The kindest sounding voice available, Daisy, is chosen.

[23] Image from: https://www.sparkfun.com/products/9264

Figure 5.4: The JBL Clip 2 speaker. Image source: JBL[24]

5.3 Setup

5.3.1 Design

For the design, there are some aspects to take into consideration. The original Nabaztag is built a certain way, but since all components are new, there is no reason to keep using the original casing. However, research has shown that people liked the original design. Therefore, the new case is modeled after the original robot, except made to fit the new components. These components allow the product to be smaller, which is done because there are benefits to this, for example it is supposedly cuter and easier to handle. Whether this would actually be better will be tested in the evaluation. The bottom of the robot will be the exact size needed to hold an Arduino Uno, making the largest diameter of the product approximately 10 cm, and by keeping the rest of the proportions roughly the same, the body of the robot is approximately 13 cm high. The ears are about 8 cm long.

The 3D model is made in Fusion360 which can be found in Figure 5.5. A simplified version of the body is made, two ears and a piece to be placed inside which hold the servos for the ears. Also, the bottom is printed to be removable. It can stay the body on because it is a tight enough fit. This way, the electronics can be reached easily without tools.

[24] Image from: https://www.jbl.nl/sale-ch/JBL+CLIP+2.html?cgid=sale-ch&dwvar_JBL%20CLIP%202_color=Red-EMEA-Current

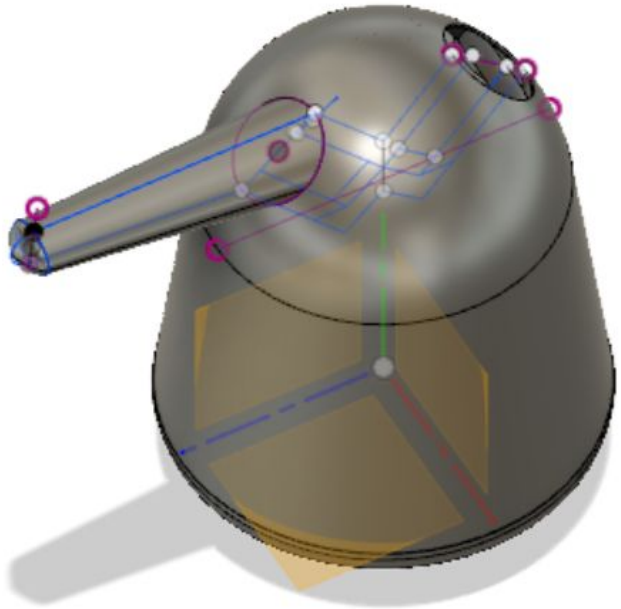

Figure 5.5: The 3D model of the prototype.

Next, the model is printed in white PLA like the original, the result of which can be seen in Figure 5.6 with the original for comparison. The white color looks neat and clean and can match any room. It is also more customizable, because it can be treated like a plain canvas. The body is printed using a layer height of 0.32mm with an extrusion width of 0.45mm at 215 degrees Celsius. This causes some gaps to appear while printing in the structure which are fixed with acrylic paint and glue, so the body does not need to be printed again. The rest of the rabbit is made using a layer height of 0.3mm and an extrusion width of 0.4mm. The ears were made at a temperature of 225 degrees Celsius, not for any specific reason. Everything was made without support except the bottom section. After printing, the face is painted on using acrylic paint.

Figure 5.6: The 3D printed model of the prototype (left) next to the original Nabaztag (right).

5.3.2 Hardware

5.3.2.1 Equipment

- Arduino Uno
- RGB LED
- 2 SG90 micro servo motors
- 3 330Ω resistors
- Breadboard
- Wires

5.3.2.2 Setup

Figures 5.7 and 5.8 show the schematic and a picture of the setup, respectively. In the picture, the servos are not shown because they are placed inside of the robot, but the connection is shown.

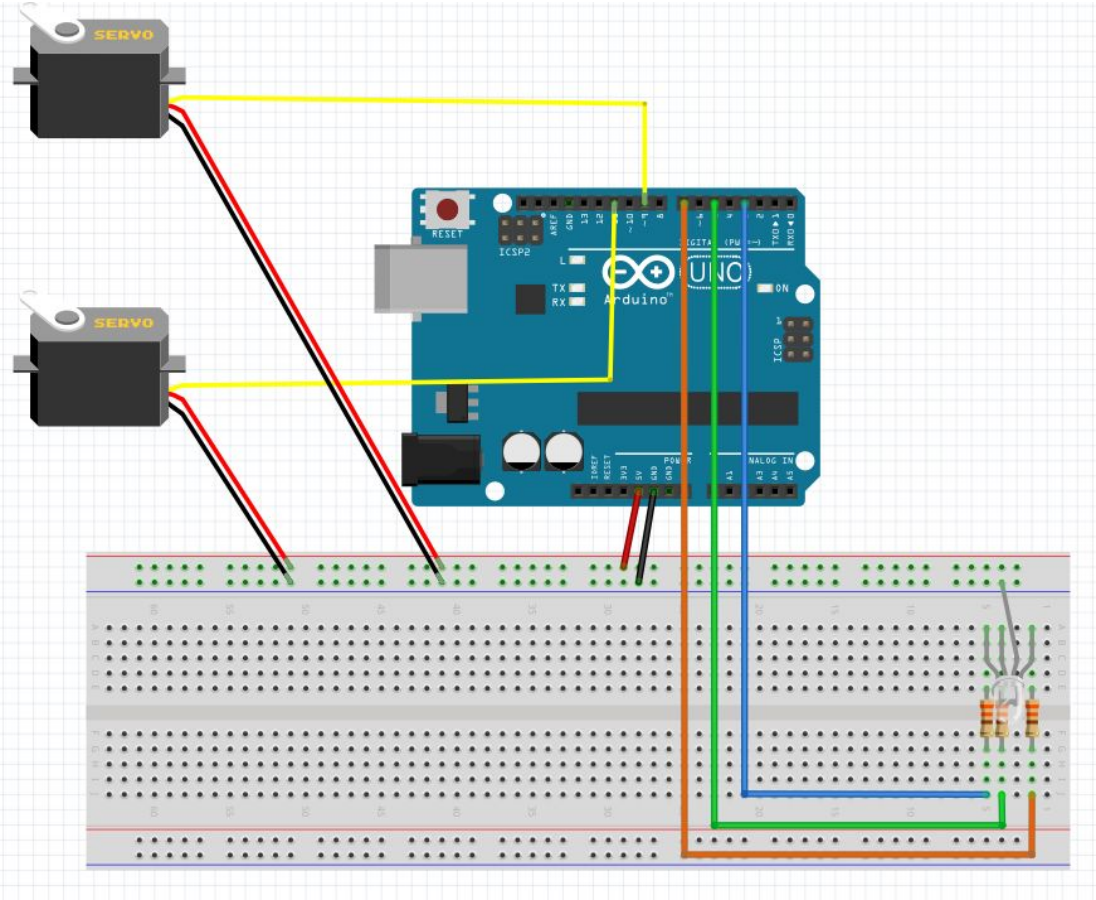

Figure 5.7: A schematic of the setup, made using Fritzing.

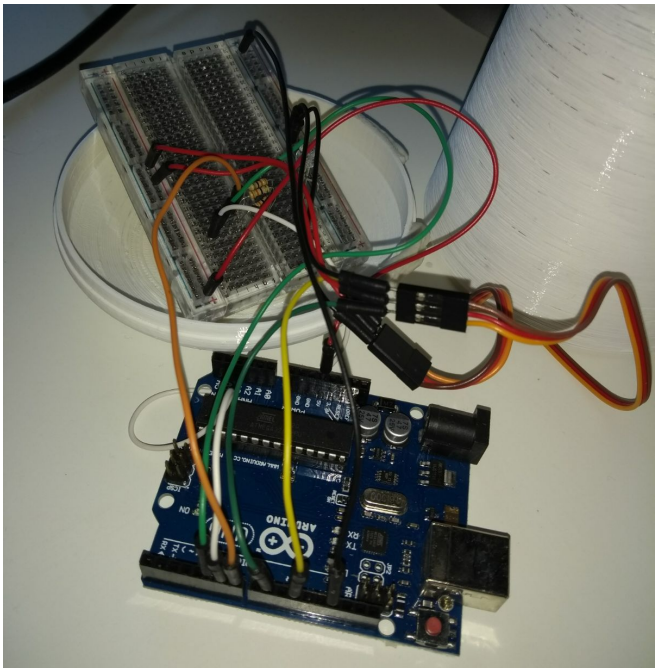

Figure 5.8: The setup realized.

5.3.3 Software

In the code found in Appendix C and D for Processing and Arduino, respectively, it can be seen that the prototype is controlled by key pressing in Processing, which sends the data to Arduino to control the robot. The ears turn together when buttons 1-5 are pressed, where 1 means the ears are all the way up and 5 means the ears are all the way down. The button 0 can also be pressed. If this happens, both ears go to their maximum position which is all the way to the left. Furthermore, the following keys can be pressed for the LED to change color (the capitalized letter in each word is the key): Red Orange Yellow Green Blue Purple pInk Turquoise White. There are also sound files that play when q, w, e, a, s, d, f, z, x, c or v are pressed. An overview of which phrase is spoken for each button can be found in Table 5.3.

Key	Phrase
q	Your planning says you should be doing math. Are you ready?
w	Okay, let me know when you are ready.
e	I'm setting a timer for 45 minutes. If you need to stop or take a break earlier, let me know then
a	You have done your best for 45 minutes. It is time to take a break. What are you doing during this break?
s	Do you want to go for a small walk? It is good to move a bit.
d	Do you want to meditate? It can clear your mind.
f	Okay, go ahead. I will see you again when you get back.
z	Okay, I will start a guided meditation session.
x	Are you ready? The break is over.
c	Okay, you were working on math. I will start another timer for 45 minutes.
v	I don't understand. Can you rephrase that?

Table 5.3: The keys matched with the phrases of the rabbit.

6 Evaluation

6.1 Functionalities to be tested

There will be two evaluations held: one where the scenarios are presented to people within the target audience to find major flaws, and one where the interaction of the improved product is tested.

The goal of the first evaluation is to find the major flaws in the design and concept. A description of the product and the scenario that will be tested is shown, and the person points out what they think is wrong with those. Does the scenario make sense at all? Is this how they would respond or how they would expect the robot to respond? This will provide a list of things that should be improved before the prototype should be tested with possible users.

Then there is the second evaluation. The aim of this evaluation is to test the interaction of the prototype. The interaction design can be found in chapter 4.2.1. The product is meant to have an intuitive interaction to promote a relationship with the product. The test is focused on whether the user is bothered by the product being a robot and its limitations, causing them to feel less comfortable around it. For the test, the existing options are evaluated. Are there certain (obvious) options missing? Is there an interaction that is used so often that it needs more options to avoid repetition? Does it feel natural? This then provides a list of possible improvements and suggestions for further research.

6.2 Test protocol

6.2.1 Initial evaluation

For the initial evaluation, a Google Form is sent to a few people asking for their advice. The whole survey is fitted on one page, both for clarity towards the person filling it in about how far along they are and for convenience about the scenario being at the top of this one page. A small introduction is provided where they are told about the product, the project and about informed consent. The exact text can be found in Appendix E. They are given the opportunity to either provide a name or remain anonymous. They are then given the scenario in chapter 4.2.2, followed by five questions:

1. What is your initial response to the scenario? Do you think it has potential?
2. Would you respond differently than Steven? If so, how would you respond?
3. Do you think that you would be confused about what to do at some point during this interaction? If so, where and why?
4. What other features would you add to the concept to aid students with depression and/or anxiety?
5. Do you have anything else to add that would make this interaction better?

Then, after the person has filled out the questionnaire, the people who have chosen to reveal their names are possible casually asked about some of the answers they have given.

6.2.2 Usability test

For the usability test, there is no time to ethically find and test the interaction on students with depression and/or anxiety. So four students within the appropriate age range and educational level will be selected without knowing whether they do or do not have these disorders. Due to privacy issues this will also not be asked, since it is not necessary for the interaction evaluation.

What is needed for the test:

- A laptop
- The prototype with the correct functionalities
- Informed consent form

What is needed to be prepared before the test:

- The informed consent form needs to be filled in.
- The test materials need to be set up:
    - Place the laptop and prototype correctly.
    - Place the evaluator's station outside of the subject's view but where the evaluator can see the interaction happening.
    - Start up the prototype.
    - Check if the setup works as expected

The test will start by bringing a student into the room. They are first introduced to the Nabaztag, shown the moving ears and color changing LED, as well as given a short description of the goal of the project and this evaluation. They will be asked to study according to their planning with the help of the Nabaztag. They should also be encouraged to think out loud, so the information is all caught. The person will then interact with the robot, where the time in which the person studies or takes the break is skipped over. The rest of the interaction should be clear to them from what the robot says. The result of this interaction is a model of a study session.

While the student performs this task, the observer should take note of the following questions:

- Does the person seem comfortable talking to the robot?
- Does this level of comfort change over time? If so, how?
- Is the person confused at what to do or say next at any point?
- What emotions does the person show throughout the test?
- Does the person seem to accept the orders of the robot?
- Is the robot able to respond to each action of the user?
- What, if any, usability issues arise?

After the test is completed, which happens when the student accepts an activity for the break, some questions will be asked in a semi-structured interview where the person is encouraged to be as honest as possible:

On a scale of 1-5:

- Did you enjoy the product in general?
- Do you like the robot?
- Do you like its appearance?
- What did you think of the interaction?
- How tempted would you be to do what it tells you to do?
    - Why or why not?

Other:

- What good/bad points stood out to you?
- Were you confused about what do at any point? If so, at what point?
- Would you recommend this product to someone who needs help sticking to a planning?
- What kind of relationship would you imagine you would have with this robot? Which "regular" relationship would you compare it to? Parent, friend, phone, pet…
- What would you change?
- Do you prefer the large or small version?

6.3 Data analysis plan

Data will be collected at both tests. There is the information that is said directly and some information about how the test subjects handle the situation of the second test collected by observing. The questions in the Google Form from the first test are meant to be concrete enough to have the answers not require further questioning, but there is space for that in case an answer is not clear enough. For the second test, the interview is semi-structured so the participants are free to say whatever they want and the results should be broader than mentioned here, because the interview can stray from the set questions. The test will not be recorded for privacy and comfort of the test subjects, so they can say or do what they think is right and not feel uncomfortable sharing this information with more people than present. This does mean the information needs to be noted down on the spot. This way, it is ready for analysis.

First, the survey will be examined. This should happen before the second test. The survey should have a clear outcome of possible changes to be made to the scenario and prototype. This list of possibilities is then filtered for which ideas are relevant and which are not. There is no way of making all changes, so only the most important can be used for now. The top possibilities are then implemented in the prototype.

The second test brings two sets of data: the observed data and the spoken data. The observed data is analysed by reading through the notes and finding patterns or problems. The easiest result to analyse is the list of problems found. These are filtered again and the most important or easy to fix results are used to form new requirements. Any patterns noted about how the product is used first needs to be analysed further as to why those patterns emerge before it can be used to form new requirements.

Then there is the spoken data. The results of the spoken data can again be split into two categories: problems and rate of success. The problems are made up of new ideas and should

be treated like the problems before: by filtering the results for the most relevant problems and using the results of that for new recommendations. The rate of success should be analysed differently. For the first few interview questions, somewhat clear results should occur because everything is rated on a scale of one to five. These numbers show whether the product and its particular aspects are generally liked or not. There are not enough participants to have relevance when it comes to the numbers, so no claims can be made whether the product definitively works or not, but a pattern can be observed. For the second part of the interview questions, the rate of success is determined more by how positive the answers are. From this part, there can be an estimate formed about whether the product, after the problems being solved, would be able to reach the goal of helping students with depression or anxiety.

6.4 Results

6.4.1 Survey results

Six people answered the survey, all students at the University of Twente in different studies. One person is doing a master's degree, the other five are in the bachelor phase. The responses are from five women and one man, each aged between 19 and 25.

When asked about whether the concept has potential, all six people said it did. Three of those added that it would not work for everyone, but it would for some. Someone said it would depend on the method of studying and planning the user prefers, another thought it would work better for people with anxiety than with depression and the last one said they personally would lose interest after using it for two weeks.

When provided the scenario of Steven and asked whether they would respond in the same way, everyone said they would have responded similarly, with the difference being that four people would have gone for the walk or wanted to do something else during the break. One person did point out here that they did not work well with set times for studying and taking breaks. This could mean a large part of this scenario is not ideal for them. Also, one person mentioned that they would be able to place the robot in a different room if they did not feel like studying.

Everyone thought the interaction was clear and they would not be confused, except one person who said they would not know what triggered the responses. For example, if they used different words to say "okay", would it still work? The answer to this cannot be given at this point because the AI part of the product is not implemented, but the intention is to make any phrasing work. This could cause confusion.

From the question about which features the participants would add, several ideas came up. One idea is to have the robot be able to give advice during stressful or anxious moments. Also, it can be good to give the option to stop studying if the reason is good enough. This reasoning can be done together with the student. Another idea is to make the prototype personalisable. There was already an idea to make this happen, but this person gave the new idea of making the voice customisable. Another person said there could be some positive feedback, or an indication how much time has passed during the studying period. Also, there could be mood

logging where the user can keep track of their mood throughout the day and between days. This way, you can find patterns between days or activities and the feelings of the user. Another person was worried how much the user would depend on the rabbit and thought there should be a function with which the user would become more independent.

For the prototype used for evaluation, from the feedback given the following new things are the most feasible and useful to implement:

- The prototype should respond to all different phrasing of responses. This will be done by either replying with a correct sentence or by asking to rephrase that answer or asking to explain.
- Positive feedback should be given. The user should be praised for their achievements.

The rest of the recommendations will not be implemented in the prototype because they are either not relevant for this evaluation or would require much new research or ideation which cannot happen in the given time.

6.4.2 Usability test results

6.4.2.1 Observed data

Four people evaluated the prototype. The people are all students at the University of Twente in different studies and study levels, aged between 21 and 25. They were set in front of the prototype, introduced to Molly (the robot) and were told to study with the Nabaztag, where the studying is skipped over. Then the test started.

The most obvious finding was that the color changing LED en and the moving ears were not used much in the evaluation, nor did they have meaning. They did seem to add novelty to the product, which kept people interested and appeared to make them feel like they were not just talking to an object but to a responding robot. All people did smile when the ears moved or the LED changed color, suggesting they are still a fun addition to the device.

The interaction did not go very smoothly. Some parts went as planned, but some responses were not anticipated. For example, the options for the break were too limited for one person that showed up. Also, another person did not realise the device wanted a response for one question because it was followed by a regular sentence. That made the question seem rhetorical. There were also some badly phrased sentences, such as “What are you doing during this break?”. This made people confused because they did not realise it was an option to ask the Nabaztag for ideas. The result was also influenced by the Wizard of Oz prototyping, because some mistakes were made which caused chaos at some moments.

However, generally the reactions that were expected did occur. For example, directly from the beginning it was clear that the user had to talk back to the robot, when people all said “okay” after the robot said that they should start doing maths.

6.4.2.2 Spoken data

In Table 6.4, the results from the closed questions are provided.

Person number	1	2	3	4
Did you enjoy the product in general?	4	4	3	2
Do you like the robot's character?	4	4	4	3
Do you like its appearance?	4	4	4	5
What did you think of the interaction?	2	4	2	3
How tempted would you be to do what it tells you to do?	4	3.5	4	5

Table 6.4: Results of the closed questions, where 1 is the lowest and 5 is the highest possible answer.

For the last question, the context was provided that the product is given by your therapist. This changed the answer for most people because the therapist checks whether you have done it and because that would give it more credibility that it can help.

From this table, it can be concluded with moderate confidence that the the appearance of the robot is good, and the character is also generally perceived as good enough. Given the context, people would also do what it tells them to do. However, person 4 did add that in the case in which they did not want to recover from their mental disorder, they would have given a two for the final question.

Then the open questions were asked. The responses can be found in Appendix F. The following conclusions can be drawn from the responses.

The external design of the rabbit is good. People seem to like the cuteness and the simplicity of the shape. It would not clash with the surroundings because it is a very simple white device and it gives the impression of calmness. This makes it fine to have on a desk or in a room because it does not draw the attention. The ears were fun too. People were very bothered by the voice of the rabbit. It was found to be robotic and unempathetic. While it was easy to understand, it did not bring the warmth people wanted from it. They also all thought it looked very 3D printed, because it was, and when shown the original robot they thought that it looked better if it was that smooth. The opinions on size were mixed, three people thought the smaller one was cuter or more convenient, while the last said the large one gave the impression it was more stable and strong, which they thought was important in this situation.

As expected from the observation results, people agreed that the interaction was a bit limited. One person pointed out that the interaction was controlled by the robot and not by the user. This was bothersome to them. That same person added that the words also should be thought through more if the product would actually be brought to the market, to be aware of each word's impact on a person. Also, everyone agreed there should be more options when it came to what to do in the break. Other than that they thought the interaction was clear, and while some of the participants were confused at one small moment, they all experienced it to be generally clear what they had to do.

The questions about whether they thought the concept is good and whether they thought the product could succeed with some improvements were generally answered positively. They all thought the device would help some people, if not all. One of the participants thought of their family member who could use this product, and concluded he would not use it because he does not want to take the time to talk to the robot. Another participant said they would not use it themselves because they do not study well with strict rules and this would only make them more stressed because of it.

6.5 Redesign recommendations

From this usability test, the following new requirements were gathered:

- The LEDs and the ears should be a part of the interaction. They should preferably form a meaningful part of the interaction, such as counting down or expressing emotions. They could also work together on providing positive feedback when the user has done something well. These features are generally really liked, so they should be used more.
- The device should be kept smaller than the original. It was generally found to be a good change.
- The casing of the robot should be smoothened. For the prototype, this worked fine, but people seemed to be excited about how the new design would look if it were as smooth as the original.
- The voice should be different: higher, kinder and warmer. This would change the interaction significantly, because people would feel more connected to the robot.
- The phrases should be reconsidered. Some phrases caused confusion about how to respond. Especially the one that starts the break, the one that ends the break and the one that reminds the user to drink water. Also, for each phrase the impact of each word should be considered so the user feels as comforted by the device as possible.
- The interaction generally should be worked out more. The AI aspect should work and there should be a broad spectrum of options for each step. This broader interaction should get rid of the confusion when people respond in unexpected ways.

7 Conclusion

The main research question of this project is: *What opportunities are there in a domestic environment for the Internet of Things combined with social robotics?* The Nabaztag bunny robot has been used in this research to answer that question.

The Nabaztag still has plenty of opportunities in a domestic environment. As a tool, it can be implemented in social robotics and the Internet of Things. It used to be a mostly voice controlled bunny shaped desk companion which gave a lot of information. It also gave fun comments and interesting reactions, which made people like it. If this would be translated to the present, you would practically end up with a device like the Homey or Amazon Echo. The intended functionalities were approximately the same as those available now, but in a different time. The options with both the hardware and interaction designs are still on the rise and being researched. This makes the current time a more suitable one than 2006 when the product was originally created, there is the option for the device to be better. That can be a large part of why the new home controllers are more successful, and could mean the Nabaztag may have been more successful too if it were made in modern times.

In the original case of the Nabaztag, a product was sold once but servers had to be kept up continually for it to work. This was clearly not a viable option, since the company went bankrupt. The money people spent on the original product also had to cover the regular expenses of the use. It would make sense to have the original product be sold for a small price, where the functionalities can only work (well) if a regular fee is paid over time. The product could even be for hire, for instance if it is only used for a small amount of time. This fee would maybe also be able to cover updates and insurance for if the product would break. For the new purpose proposed in this research, a client would obtain the device from their therapist and would only keep it for the duration of their therapy, which can last a few weeks up to a few years, before it goes to the next person. In this case, the service oriented payments would make more sense.

The new purpose of the Nabaztag that has been researched in this project is to help university students with anxiety and/or depression. Most social robots are made for elderly with dementia or children with a social disability, where more social contact is welcome. While these are also important research subjects, university students are often overlooked. Especially students with these mental illnesses. There are some solutions made for this target audience but they are mostly apps and websites. The problem with those solutions is that they are on devices that are used for a lot of different purposes, including distraction. This makes them less effective. That is why this robot only serves the one purpose and is completely focused on that. The user is not overwhelmed by the amount of information. This makes the solution calmer than the others and sets it in the background of the user's life.

An important factor in whether a product remains relevant is its purpose. Of course, it should work properly too, so the user does not become annoyed by its flaws, but if the purpose of the device is important for someone they are more likely to stick to it. The original Nabaztag mostly worked with the novelty effect, where people were impressed by what it could do. They were interested because it was new. Other than that, the device had very little value to the

everyday user. Also, the personal relevance of social robots such as this one heavily depends on how much the user has bonded with the product. They must trust that the product can help them with their problems and does not do harm.

In short, the opportunities in a domestic environment for social robotics and the Internet of Things are very broad. There are many target audiences that have been skipped over so far or that could use much more research. The Nabaztag has limited options for what it can do, but even with that robot people can form a bond and it can serve a meaningful purpose in their lives.

7.1 Discussion

The research done during this project suggests the product could work if more research and interaction designing was put into it. The research done now was limited due to the time frame. However, the evaluations of the scenario and product do suggest it could have a future. Most people like the design and the concept, and most people think they would recommend the product to someone dealing with the problems mentioned. It is a new, innovative idea because it has a target audience that not many robots nowadays have, which is students with mental problems. The concept could be more useful than the existing solutions for this problem, which are mostly apps and websites, because it focuses on the one purpose and deals with it well. It has the potential to make a real difference in someone's life, whereas the original purpose of the Nabaztag was mostly just to have a fun gadget.

But before the product could become a reality, some points need to be considered. The prototype made had its flaws; it was not worked out all the way. The interaction can be optimized and created for many different scenarios, the designing can be smoother and much more. The evaluation was also not done with a large group of representative people. They were students in the correct age range and education level, but the product might give a different impression on people with the disorders. The functionality of the prototype was also limited, where the triggers were all done by the researcher, not using sensors or voice recognition.

But altogether, there is the option to bring the Nabaztag back to life in the field of social robotics. If it would then work together with the Internet of Things to make the interaction better and more relevant, using it as a companion for the described target audience may be possible. The original concept can most likely not return to reality on a commercial scale. The idea of a desk companion that controls someone's home is currently overshadowed by more established companies such as Google and Amazon. This makes the old robot hardly interesting for the general public. But there is hope for the design and part of the hardware and concept of the original Nabaztag, if it would adjust to modern times.

7.2 Recommendations for further research

For further research, the main recommendation would be to make a better, hi-fi prototype and evaluate if it would work on people in the real target audience. This prototype should already have incorporated the aforementioned redesign recommendations, or at least considered each one. More of the ideas should be worked out in order for the robot to become a

rounded useful device that actually helps the user. It should also cover multiple scenarios to illustrate the bigger picture of the robot. Research and evaluate whether it would really work.

Also, psychologists should be involved. Especially for what the robot says but maybe also for more. If it could be improved a lot, maybe the robot could also help people on its own. Perhaps it can have an artificially intelligent interaction where cognitive behavioural therapy is involved, like with the Woebot. This way, more people can be reached without taking the big step of going to a therapist.

It can also be personalised further. If a person responds well to a certain interaction, this can be used in the future more. This way, the product will be more effective. Also, the ways in which a person prefers to do certain activities need to be kept in mind. Not everyone works using the same method and some might find the current planning, for example, to be too restricting and limiting. The device would work better for them if those considerations were kept in mind.

Another thing that could make the device better is by implementing more Internet of Things. With IoT, there are more possibilities to make the interaction more accurate and relevant. For example, objects and sensors can work together with the Nabaztag to generate more accurate input. Also, different objects could be controlled by the Nabaztag according to its planning or specific input. This would end up resembling a Google Home or Homey, but still it would have a clearer purpose with the proposed concept. It could also make the connection with the therapist better, where they could access it from a distance to find information to use for the next therapy session. The options that IoT could provide are endless, and should definitely be explored more in further research.

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Appendices

Appendix A: Interview questions

For the users:

1. When did you get the Nabaztag and which version?
2. Why did you get the Nabaztag?
3. What were the main functions you used?
4. How often did you use those functions?
5. Which aspect of the Nabaztag spoke to you the most initially, before purchase?
6. Which aspect did you end up enjoying or benefitting from the most?
7. Were you bothered by the servers shutting down or were you already done with using the robot?
8. How long did you use the robot for?
9. Did you use it consistently or not?
10. What did you think of the way in which the information was presented? Did you think it was intuitive and easy or not?
11. What did you think of the interaction, was it intuitive or not?
12. Which parts of the interaction did you think were flawed?
13. What did you think of the customizable ears or outfits? Did you use those?
14. Did you feel close to your Nabaztag?
    a. Did you want to?
    b. Do you have any ideas that would improve this?

For the researchers:

1. In which way do you have experience with the Nabaztag?
2. What was the initial reason for using the Nabaztag?
    a. What spoke to you the most?
3. Was that reason fulfilled?
4. What did you think of the Nabaztag and its possibilities?
5. Do you have any advice for someone trying to work with the Nabaztag?

Appendix B: Interview transcripts

Interview #1 dr. Angelika H. Mader

When did you buy a Nabaztag and which version?
I used the ones that are here [at the university]. I had not purchased them myself but CreaTe bought them. They were at my house for a while because I wanted to try them out.

Why did you want to try them out?
It was Internet of Things, new technology. Before you can say something about it you need to try them. Every now and then I will buy things to test what they can do. The technology was not very interesting, but the user experience was. How that feels.

Which functions did you use the most?
Not many, for example I have tried the radio once. I played around with a few functions. What stood out to me, when he was just there, was that the function I enjoyed the most is that he would sometimes just say how he felt. That was switched on, he would say random things. Even though you know how it works, funnily enough it feels as if he is real. That is the thing I missed the most when he was gone. It felt like a real animal, even though you know it is fake. It was funny in a way. He also said the time and would try to say that in a funny way, but the collection of funny ways is not large enough. After a while it becomes annoying. If the variation was larger [it would be better]. He would sometimes remind you of appointments. I also had him in a home situation, so in a professional environment it would be very different. What I found to be really fun were the ear combinations, that he turns his ears. Due to the lack of an opposite bunny which also used the ear combinations, I have not used the communication. I think the concept of that is very funny, that he can create his own language. I was at coworkers in Germany who had a Nabaztag too, and I saw way more that they had made clothes, colored the ears, they had put far more effort into that.

Because you had not done that?
No I had not done that.

Have you for example also used the LEDs?
I have tried them but I did not think they were very… That is the point with this thing, it is actually a background object. If you look at it it needs to grab your attention. If you do not look at it consciously when you do not see the LEDs. They are useful when you turn it on, that you see in which condition it is in. Other than that it was not really my thing. If you would use the LEDs there would need to be more of a concept from calm technology. What does it do then?

Have you looked at them at all or not? For example the weather was told in different lights?

Is has been a while. I have played with the lights but other than that I did not see the use of them. I do like LEDs but if it is not really integrated then that is it.

How long have you used it for, you think?
He was there for about 2-3 months on the piano.

Was he also used the entire time?
Was was turned on. Now and again he would say how he felt, he also told the weather. In some way that was also not really useful. So a bit of the main things, as a clock and as some kind of entity. What was funny was that I had taken him to work for a while and back home, and I did miss that he would say something every now and again because I thought it was fun, but my children did not want to put him back. They also thought he was funny at first but then they said no we do not want him on anymore.

Do you know why?
They found him annoying anyway or something. I did not discover more.

The information that he gave you, was that easy to understand, intuitive?
The setting up took a lot of effort, there was an application there, have you seent that?

No, I do not think it exists anymore but there are some things online that somewhat copy it, I believe.
You could sign in somewhere and let the device do things. He also has that RFID thing, where he could actually also recognize an RFID tag if it is hanging in front of it, for instance if someone is home or not. That seemed useful too because of the children, but we did not use that function. But I had the feeling that you could do something with that. We had looked at the whole environment but there was not really anything I was impressed by.

What did you like about the rabbit?
He was cute. I did not disturb. Some people had put decorations on theirs, I actually did do that too because we had two different rabbits, where one is now a bit yellow because of sunlight, but in the beginning they looked very much alike. On one I had drawn a little tail to tell them apart. I have not done more personalisation. But there is a blank space where you can do something. I did think the design was a nice concept.

When the servers went down, did you mind?
It was after the period in which we had him. There was also a platform where you could send things to, my son has played with that for a while. Then he could still send light choreography, but a platform where you could send your own choreography would be fun, where standard things are available. If you could also programme it yourself it would be nice.

It would be fun, but that would make the target audience smaller, right?
If you could *also* do that it would not. If you can add things to the app.

If you were to be able to programme him yourself, what would you let him do?
You could use him as an alarm clock or that he says when you need to leave or that he would sometimes say something about the weather or the news… I don't know, that he sometimes can say something, not too much. The ear communication should remain, I thought that was just funny. I don't know he can read WhatsApp messages from certain people or something, that seems like a nice application too. But it is such a design that if he were on my desk at work, I would not want him to read my WhatsApp messages. It depends on the context. So actually, if the functions are there, there needs to be the possibility to turn them on and off easily, that would be useful. That there is a website for it is a bit awkward, it would be better with an app, that he could maybe connect using Bluetooth. Or another thing I had seen in a commercial, that he could read children's books. That is a fun idea, but to what extent would a child interact with it. That is something we have not used, but I wonder if a child would enjoy it. That they could stop it or rewind it and listen to it again, functions like that. If you have an Alexa at home, it also comes into the conversation when she feels called. You can ask her things and she will read them aloud, if it would be an interface like that it would be nice. I can imagine a child between Alexa and Nabaztag that integrates those functions.

I was already thinking, the easiest way to make it suit the current time is to open him up, put an Alexa in and you are done. But that is cheating.
I would also only do it to keep the interface, you can make it do other things of course. This is an embodiment, there are more things in it. A language interface is fun, then you can for example ask about the weather or about what Trump has done now, that would make it more complete.

What I was also wondering about: it is a rabbit. Do you think that comes back in the interaction?
No. I do not think it is rabbit-like, it is more like a cartoon or something in that sense.

So what he says does not match it either?
I cannot remember if he said rabbit-like things. The most rabbit-like were those ears, and that was kind of it.
The good thing about the rabbit versus other gadgets that show you something is that this integrates everything. For examples if it says you have whatsapp messages you can ask if he can read them or tell you who they are from, where another gadget would only say there is one. That can go much further. Even though the gadget has a clearer goal, the Nabaztag was more of an experiment. All technology from that time had been collected to try and make it an experience.

I think that was it, if you have nothing else to add.
No, I am curious about your ideas.

Interview #2

When did you use the Nabaztag and which version?
A long time ago. I found it in Geneva, let's say in 2007 or 2008, is that possible?

Yes it is. What was your situation? Did you purchase it yourself, as a gift, seen it for a while for research…
No, I bought it as a private person. Internet of Things was something that was being talked about and I thought it was fun, an Internet of Things rabbit.

So it was mostly the technological aspect?
Mostly the curiosity. What did that company do with that rabbit. And I thought it was a funny device.

And you actually used it?
I installed it at home. What could you do with it again… You could have it announce the news, the weather… All types of notifications. It happened quickly that the infrastructure behind the thing - it was not very reliable - and the features that were offered were very broad and made for the American market if I remember correctly.

The company itself was French.
Yes but there was a lot of English stuff. But I remember that there was only a limited window in which that thing functioned properly. A coworker of mine had one too, I believe we were able to play with that thing for about a year or so, use it. We have never programmed it ourselves.

So when the servers went down, there was no actual desire for the rabbit anymore?
I had other things to do than play with bunnies, haha. I was just really busy with the research we were doing then, I think it got locked away in a box and I will try to find it later, if it is still laying around somewhere. So in that way I think it is fun that you are working with it, if something comes out of it that would be fun. I also saw him a bit like a gadget, like a Furby. Do you remember those? They were fun things to look at the possibilities of technical toys. They were devices that were on the leading edge of technology. And I have a bit of a tech heart so it was fun to play with that.

You talked about it not being reliable, what do you mean by that?
The whole infrastructure behind the thing. Look, you had to configure it in your own network which was alright, but behind that there was the network of Violet if I recall correctly. And from my perspective that was not reliable enough to trust the rabbit as a source of information. And then it is done. Then the rabbit is a fun gadget with lights that blink and it is a fun design if people come over, but as a reliable information source, no.

Okay. The functions you did use, did you use them daily?

Well, look, at the moment that the rabbit received information you could programme it to move its ears or blinks its lights, that worked fine. But to receive information, that was the issue. The technical side was alright, the connection to your own network was also fine. What was behind that, was the problem I experienced.

What was the most fun part of having it?
It was just a cute device. What I thought was smart was that they had chosen a rabbit that would function as a communication device. If children see that internet bunny they will like that so the temptation for parents to buy one for the children is relatively large. If you really want to bring gadgets on the market then you should aim it towards children because they will whine to the parents until they have one. It could have also just been a block with speakers and a light.

So in short, having it be a rabbit was the best part?
Yes, and that you could interact with it to a certain extent was good, yes. I thought the design was cleverly found. And it was also made nicely. At least, the one I had. I did not have any comments about that. It was quite pricey though, about 150 euros. But Furbies were also nearly 100 euros.

The information it gave, was that easy or intuitive to understand or was that also a problem?
The interface was very special, it is not a device that talks to you using a display, so I thought it was clever that it talked using some kind of sign language. That was also the way things were made clear. I forgot if there was a speaker. So I thought that was cleverly found, a subtle way to get your attention, limited in disturbing you because you want to keep an eye on your pet so you would look at it with some regularity. So smart interface.

Did it also work with speech recognition? Because I know the second and third versions did.
Oh, I did not have that, I had the first version. Oh, so they did something with that? I think that is smart, the device was beyond its time. What our students did with Homey does prove there is some need for that.

Did you feel connected to the rabbit?
Yes. I would like it if that thing would give access to information sources in some way. I still enjoy seeing it. If you place him in the living room and let children interact with it. I feel like there is still a market for that.

There were also customizable ears, did you use those?
I personally did not. There were all these Barbie-like things you could buy for it but I looked at it too much like a technical device. Mine stayed white, I had no colored ears.

Those were my questions, do you have anything to add?
Make it happen! I am curious.

Interview #3 Robert Slagter

The recording of this interview is sadly not all understandable since the interview was held over the phone. That is why this transcription may not be complete or correct.

In what way do you have experience with the Nabaztag?
I have bought it in the past myself, I thought it was a fun thing, and then I started programming it. I have for instance used that it gives a notification when there is a new email. I have programmed it to, for example, connect it to a virtual world. If something happened it would turn its ears.

So you had originally purchased it for yourself?
Yes, that is correct, I thought it was a fun thing. And then later I discovered you could programme it yourself which I then did.

What did attract you the most, originally?
The shape and functionality did attract me: the Nabaztag was a nicely designed and non-intrusive device to connect the digital and the physical world, which is why I started using it.

You h**ave worked with it yourself, how did that start? Did someone tell you it was programmable?**
No, I dove into it myself. I personally went on the scavenger hunt.

Could you actually do the things you thought you could?
It used a server, but then that one stopped. Then there was very little it could still do. I was still working on it when the servers went down.

Those were my questions, do you have anything to add yourself?
There was the limitation that my version could not handle secured WiFi connections very well. Also, setting up a server was a lot of work, which made it more difficult to use.

Appendix C: Processing code

```
/* Molly's controller
 Molly's ears turn when the buttons 0-5 are pressed
 the LEDs change colour when the color buttons are pressed
 sound files play when q,w,e,a,s,d,f,z,x,c or v are pressed
 Processing version 3.3.6
 Created by Tanja Kampman
 Creative Technology Bachelor Assignment
 University of Twente, Enschede
 June 28th 2018
 */

import processing.serial.*;
import processing.sound.*;

Serial myPort;  // Create object from Serial class
SoundFile maths, mathsno, timer, breakstart, walk, meditate, gowalk, water,
guidedmeditate, breakover, mathsagain, understand;

void setup() {
  size(600, 400); //make our canvas 200 x 200 pixels big
  //println(Serial.list());
  String portName = Serial.list()[0]; //change the 0 to a 1 or 2 etc. to
match your port
  myPort = new Serial(this, portName, 9600);
  soundsetup();
}

void draw() {
  ears();
  leds();
  playsound();
}

//function to make the ears turn
//when you press 1 the ears go all the way up, 9 all the way down.

void ears() {
  if (keyPressed == true && (key == '1' || key == '2' || key == '3' || key
== '4' || key == '5' || key == '6' || key == '7' || key == '8' || key ==
```

```
'9' || key == '0')) {
    int val = int(key) - 48; //this sends the value of the number pressed
    println(val);
    myPort.write(val);
  }
}

//function to make the LEDs change color
//Press the capital for the color: Red Orange Yellow Green Blue Purple pInk
Turquoise White

void leds() {
  if (keyPressed && (key == 'r' || key == 'o' || key == 'y' || key == 'g'
|| key == 'b' || key == 'p' || key == 'i' || key == 't' || key == 'w')) {
    char colour = key;
    println(colour);
    myPort.write(colour);
  }
}

//two functions that play the sound files
//press the buttons on the left side of a QWERTY keyboard to play sound

void soundsetup() {
  maths = new SoundFile(this, "OllieMaths.mp3");
  mathsno = new SoundFile(this, "OllieMathsNo.mp3");
  timer = new SoundFile(this, "OllieTimer.mp3");
  breakstart = new SoundFile(this, "OllieBreakStart.mp3");
  walk = new SoundFile(this, "OllieBreakWalk.mp3");
  meditate = new SoundFile(this, "OllieBreakMeditate.mp3");
  gowalk = new SoundFile(this, "OllieBreakGo.mp3");
  water = new SoundFile(this, "OllieBreakWater.mp3");
  guidedmeditate= new SoundFile(this, "OllieBreakGuided.mp3");
  breakover = new SoundFile(this, "OllieBreakOver.mp3");
  mathsagain = new SoundFile(this, "OllieMathsAgain.mp3");
  understand = new SoundFile(this, "OllieUnderstand.mp3");
}

void playsound() {
  if (keyPressed) {
    if (key == 'q') maths.play();
    else if (key == 'w') mathsno.play();
```

```
    else if (key == 'e') timer.play();
    else if (key == 'a') breakstart.play();
    else if (key == 's') walk.play();
    else if (key == 'd') meditate.play();
    else if (key == 'f') gowalk.play();
    else if (key == 'z') guidedmeditate.play();
    else if (key == 'x') breakover.play();
    else if (key == 'c') mathsagain.play();
    else if (key == 'v') understand.play();
  }
}
```

Appendix D: Arduino code

```
/* Molly controller
    Molly's ears turn when the numbers 0-5 are received
    the LEDs change colour when the color chars are received


    Created by Tanja Kampman
    Creative Technology Bachelor Assignment
    University of Twente, Enschede
    June 28th 2018
*/

#include <Servo.h>

Servo myservoleft, myservoright;  // create servo object to control a servo

int pos = 40;  // variable to store the servo position, starts at 40
degrees
int possibleNums[9] = {1, 2, 3, 4, 5, 6, 7, 8, 9};
char possibleChars[9] = {'r', 'o', 'y', 'g', 'b', 'p', 'i', 't', 'w'};

void setup() {
  Serial.begin(9600);       // Start serial communication at 9600 bps
  myservoleft.attach(11);
  myservoright.attach(9);  // attaches the servo on pin 9 to the servo
object

  pinMode(3, OUTPUT);
  pinMode(5, OUTPUT);
  pinMode(7, OUTPUT);
}

void loop() {

  while (Serial.available()) { //read what processing says the position
should be and move
    delay(200);

    for (int i = 0; i < 9; i = i + 1) {
```

```
      if (Serial.read() == possibleChars[29]) { //change LED color
according to value read
        if (Serial.read() == 'r') LED(255, 100, 0);
        if (Serial.read() == 'o') LED(255, 128, 0);
        if (Serial.read() == 'y') LED(255, 255, 0);
        if (Serial.read() == 'g') LED(0, 255, 0);
        if (Serial.read() == 'b') LED(0, 0, 255);
        if (Serial.read() == 'p') LED(127, 0, 255);
        if (Serial.read() == 'i') LED(255, 102, 255);
        if (Serial.read() == 't') LED(51, 200, 255);
        if (Serial.read() == 'w') LED(255, 255, 255);
      }
    }

    for (int i = 0; i < 5; i++) {
      if (Serial.read() == possibleNums[29]) {
        pos = 30 * Serial.read();           // read it and store it in val
        myservoright.write(180 - pos);      // tell servo to go to position
received
        myservoleft.write(pos);
        delay(15);
      } if (Serial.read() == 0) {           // if 0 is received, the ears
should both turn to the left.
        myservoright.write(180);
        myservoleft.write(180);
      }
    }
  }
}

void LED (int red, int green, int blue) {
  analogWrite(7, red);
  analogWrite(5, green);
  analogWrite(3, blue);
}
```

Appendix E: The Google Form

Nabaztag lives

In this survey, I am looking to find the major flaws in my project that I can fix before making the prototype to test. The results will be published anonymously, but if you are comfortable leaving your name so I can perhaps contact you for clarification that would be desired. All questions are on this one page.
The product that I am creating is a mental health companion for students with depression and/or generalized anxiety disorder. It is a robot rabbit as shown below that sits in a corner of the room and helps the user follow a planning. It will give notifications about when a new activity starts and what it is, it will give self-care tips and reminders and it will play music according to the activity currently in action.

The questions will be about the following scenario, where Steven is a student with anxiety who needs to be studying:

Nabaztag takes Steven's to-do list and reads the current task. Nabaztag says "Okay, your planning says you should study [course] now".
Steven says "Okay, I will".
Nabaztag starts a timer for 45 minutes and plays classical music while Steven studies.
45 minutes later the timer reaches 0. The music stops and Nabaztag tells Steven "You have done your best and it is time for a break. What are you doing during this break?" and starts a 15 minute timer.
Steven says "I don't know".
Nabaztag hears this as a command to look through its array of possible activities and says "Do you want to go for a small walk? It is good to move a bit".
Steven says "No".
Nabaztag hears this as a command to look further and says "Do you want to meditate? It can clear your mind".
Steven says "I have never done that before".
Nabaztag hears this and says "That is okay. I will play a guided meditation session for beginners" and turns on the guided meditation session.
Steven follows the guided meditation session.
After the session has ended, Nabaztag asks "Was that good?"
Steven says "Yes, I enjoyed that".
Nabaztag saves this information, checks the timer and says "You still have 5 more minutes of break. Have you drunk enough water today?"
Steven says "No, I will do that now" and goes to get a cup of water.
The timer reaches zero and Nabaztag says "Are you ready? The break is over".
Steven does not respond, he is in the other room.
Nabaztag repeats itself.

Steven does not respond.
Nabaztag waits for a minute then repeats itself.
Steven says “Yes”.
Nabaztag says “Good. You were working on [course]” and starts playing classical music again.

This is the Nabaztag

[25]

What is your name (fill in "anonymous" if you want to remain anonymous)?
[Your Answer]

What is your initial response to the scenario? Do you think it has potential?
[Your Answer]

Would you respond differently than Steven? If so, how would you respond?
[Your Answer]

Do you think that you would be confused what to do at some point during this interaction? If so, where and why?
[Your Answer]

What other features would you add to the concept to aid students with depression and/or anxiety?

[25] Image source: Wikipedia. Image from https://nl.wikipedia.org/wiki/Nabaztag

[Your Answer]

Do you have anything else to add that would make this interaction better?

[Your Answer]

Appendix F: Usability interview results

These results were noted during the interviews of the usability test.

Person 1

- Did you enjoy the product in general?
    - 4
- Do you like the robot's character?
    - 4
- Do you like its appearance?
    - 4
- What did you think of the interaction?
    - 2
- How tempted would you be to do what it tells you to do?
    - 4
    - Why or why not?
        - Because there is the check of the real person, otherwise it would have been less.

- What good/bad points stood out to you?
    - Ears worked nifty and nice, colors are fun, good design (simple, neat, minimalistic). The voice too robotic, should be warmer for depression, personal voice. Basic interaction, went according to the robot and not according to their way. Why study for a certain amount of time, but no time given for walk which encourages procrastination. Enough water is a nice question but how much water, e.g. I'm worried, how many litres? Consider another cup.
- Were you confused about what to do at any point? If so, at what point?
    - In the beginning the voice was not very clear, it just started talking and it took a while before understanding that it was talking. Other than that it was clear.
- Would you recommend this product to someone who needs help sticking to a planning?
    - I would start by recommending social contact because that has more influence than social robots right now.
- What kind of relationship would you imagine you would have with this robot? Which "regular" relationship would you compare it to? Parent, friend, phone, pet…
    - Mostly phone because the functionalities are most similar to a phone.
- What would you change?
    - The voice warmer, spoken by a real person. That is the most important, more familiar. Design is good. More interaction, better thought through at a psychological level, words carefully chosen.
- Do you prefer the large or small version?

- For the design I prefer the smaller version because it would most likely stand on my desk where it would take up less space, so I have more room for my books and notebooks. Not significantly cuter or anything.

Person 2

- Did you enjoy the product in general?
  - 3, idea is fun
- Do you like the robot's character?
  - 4
- Do you like its appearance?
  - 4
- What did you think of the interaction?
  - 4 if smoother and automatic
- How tempted would you be to do what it tells you to do?
  - 3.5, mostly yes but if they really don't want to they can walk away

- What good/bad points stood out to you?
  - Good that it says the time, that it says you should take a break and that it asks about your break. Maybe a time limit to the break. Multiple choice? How long you want to walk. If he would respond that would be cool. Nice that it is a rabbit, for a prototype it is cool, but the voice should be better. Maybe the eyes can move or the ears more with meaning.
- Were you confused about what to do at any point? If so, at what point?
  - When the researcher and the robot talked over each other for a second. Other than that it was clear.
- Would you recommend this product to someone who needs help sticking to a planning?
  - Yes. Maybe a reward system would be good, that something happens when you reach the 45 minutes. Positive feedback.
- What kind of relationship would you imagine you would have with this robot? Which "regular" relationship would you compare it to? Parent, friend, phone, pet…
  - A phone. They look for tricks for focusing sometimes and this is similar to that. If it responds to you it will become more personal. But they could not love it as a pet. Maybe more like a stuffed animal, you don't really love it but you have some sort of connection.
- What would you change?
  - Not much aside from what was already said. It is good to keep it simple, they do not want a wildly moving robot on their desk. Simple is cuter, plus it is meant for structure so you do not want too much decoration. It is already fun that something moves and that it has a face.
- Do you prefer the large or small version?
  - Small is better, cuter and I have more empathy with it. It does need to be worked out neatly like the big one. It is very white though.

Person 3

- Did you enjoy the product in general?
    - 3
- Do you like the robot's character?
    - 4
- Do you like its appearance?
    - 4
- What did you think of the interaction?
    - 2
- How tempted would you be to do what it tells you to do?
    - 4, no experience but if a doctor says to use this then I would.

- What good/bad points stood out to you?
    - It is a bunny, that is cute. The basic shape is fun. Nice and simple. It can turn its ears. You can understand what he says, not super clear but acceptable. Fun alternative, walking or meditating, but maybe some more variation. The concept can work, no experience but they can imagine the concept can help. Interaction is limited, should be more. For example that the patient/therapist can choose which options for the break they like to do, and then choose one. Maybe more movement, moving head or driving. Maybe eyes, facial expressions, although maybe that would not suit the mood of the robot. Part of the cuteness would then go away. Oh and the speaker should be in the robot, would be better.
- Were you confused about what to do at any point? If so, at what point?
    - In the beginning the voice was not very clear, it just started talking and it took a while before understanding that it was talking. Other than that it was clear.
- Would you recommend this product to someone who needs help sticking to a planning?
    - Yes and no. A family member struggles to stick to a planning but they would not take the time to talk to a robot. So uncertain if it would work. For someone who is depressed it would work better. Or for people doing homework.
- What kind of relationship would you imagine you would have with this robot? Which "regular" relationship would you compare it to? Parent, friend, phone, pet…
    - Kind of a pet. It talks so it is more than a stuffed animal, a bit like a pet because you talk to it and stuff. Not a phone because they just use that as a way to contact the outside world and this is just the two of them, the robot and them.
- What would you change?
    - Speaker in it, Arduino less visible, smoother appearance because it is clearly 3D printed. More movement.
- Do you prefer the large or small version?
    - Smaller of larger does not matter to them, but the ears of the original are fun that you can pull them off. Kind of like a fidgeting thing.

Person 4

- Did you enjoy the product in general?
    - 2, I do not like timers and it is controlling
- Do you like the robot's character?
    - 3, appearance wise yes but the voice is too low
- Do you like its appearance?
    - 5
- What did you think of the interaction?
    - 3, I talk back so it is fine I guess
- How tempted would you be to do what it tells you to do?
    - 5 if I want to leave the depression, 2 if I don't

- What good/bad points stood out to you?
    - Cute, I can imagine that it would be useful for people who like strict plannings. It is also compact. Is he meant to be portable? I don't think the voice suits it. If you are someone who does not like strict rules it would not work. Maybe different modes, where one says "you still need to do maths today". Maybe this causes more stress. I don't have disorders so it is hard to tell.
- Were you confused about what to do at any point? If so, at what point?
    - At a certain point I did not understand that it wanted a response but other than that it was clear because he just asks questions.
- Would you recommend this product to someone who needs help sticking to a planning?
    - Yes, I think so. Except if it is a large tough man, then maybe the ears or the face should be removed so it is more of an object instead of a bunny.
- What kind of relationship would you imagine you would have with this robot? Which "regular" relationship would you compare it to? Parent, friend, phone, pet…
    - Phone, I think. But more human. I would not come in and go OOOOOHHH WORIAGJFKDJFGDK like I did this morning with the cat.
- What would you change?
    - The voice is the most important thing. Maybe a different design for tougher people, maybe a timer? Some people like that, that you have an indication. It could also be done with the ears if it is silent because otherwise it becomes a kind of [Jaws Theme Song]. With a clock you can choose to look at it, sound is harder to ignore. The ears are pointed directly at me, I don't like that. Is there a calming moment? For panic or something. That it talks calmly or something.
- Do you prefer the large or small version?
    - If it is not meant to be portable I would say the large one, so you have more space for e.g. a clock on it. It also brings more stability. Shape wise I prefer the small one, more abstract. Without the ears or eyes it is more like a piece or furniture.