# Poppy as Advanced Rubber Ducky

Creative Technology bachelor thesis of Kasper de Kruiff

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## ABSTRACT

Rubber duck debugging has been a valid method used by computer scientist to find and solve bugs in computer code. Social robots have shown to socially engage people. This study explores both of these paradigms to investigate whether they can augment each other. Seventeen Creative Technology students were asked to solve two programming assignments while explaining their actions to a humanoid robot named Poppy. For one of the assignments Poppy would react non-verbally to what the students explained, for the other assignment Poppy would remain stationary. The test has shown no significant statistical difference between the assignment being made while Poppy was reacting to the student and the assignment being made while Poppy was not reacting. However some participants reported talking to Poppy as being helpful. It can be concluded that the experiment performed as described in this study had a lack of participants. Suspected is that this concept might be useful for some individuals but not conclusively for anyone.

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## 1 INTRODUCTION

This is a bachelor report for the program Creative Technology at the University of Twente. This document reports the findings of a practical assignment, done to finish the bachelor Creative Technology. The rest of the introduction will be describing the context and goal of the assignment, accompanied by the research questions.

### 1.1 Context

The bachelor assignment was given by the faculty of Robotics and Mechatronics (RaM), situated at the University of Twente. RaM focusses mainly on inspection robotics (UAVs, UGVs, UUVs), medical robotics (assistance to surgeons, diagnostics) and service robotics (street cleaning, service to people)[1]. Some of the Projects they have done are: a robot bird that scares away other birds that are near the airport so that planes are not hindered when ascending and descending, and  a robot that is made to roam gas pipes to see whether they need servicing.
The robots that are being developed by RaM are mostly to be used in cases that ask for a solely functional design approach. Their main focus is working there where humans lose interest, find work drudgering or dangerous and thus replace people. Therefore these robots are not designed to interact with, except within the right contexts. However, it seems that there is also a large interest for robots that are more people friendly[2], [3]. To stay ahead of other research groups, RaM profiles itself by expanding their focus to these people friendly robots. These kinds of robots fall under the category of being used in cure, care and companionship. Especially in elderly care, where caregivers are lacking, family and friends are to busy, and it is not recommended to use pets for care or companionship, experiments are done and promising [2]. These robots are usually built in a humanoid form and examples can be found in open source projects.

Poppy[4] is a robot that was initiated in 2012 by a French PhD student named Matthieu Lapeyre. Poppy was originally designed to investigate the role of embodiment and morphology properties on cognition and the learning of sensorimotor tasks. The philosophy of the Poppy project is to empower creativity and bottom up projects while being community centered. Poppy is a humanoid robot, that makes it suitable for being used as a social robot.

Rubber duck debugging has been a valid method used by computer scientist to find and solve bugs in computer code. The goal of “Poppy as an Advanced Rubber Ducky”, is to explore guided self explanation and how this could be augmented using a social robot. By researching the effects of Poppy, RaM is expanding their knowledge about cure, care and companionship in robotics. Poppy will be used as a tool for self explanation where Poppy wil ‘listen’ to people describing a concept making it possibly easier for people, to talk aloud and understand the concept.

## 1.2 Research Question and Hypothesis

To explore if Poppy in this research can fulfill its task as Rubber Ducky, the following research question is formulated:

> *“Is it more helpful and/or pleasant for someone to explain a concept to a socially reactive entity compared to a non-reactive entity for said someone to get a better understanding of the concept?”*

Hypothesized is that talking to a socially acting responding entity, explaining a problem, makes it easier to understand this problem.

## 1.3 Document Outline

First the analysis will contain information about the state of the art and how the idea of advanced rubber ducky came to be. Secondly, it is described how the hardware and software is implemented for performing the experiment. Thirdly, the results and conclusion will be discussed and finally recommendations for future research are given.

# 2 ANALYSIS

## 2.1 State of the Art

### *2.1.1 Introduction*

The objective of this chapter is to find what research already exists, what is still unknown about self-explanation, social robotics and rubber duckies. The research will be used during the ideation phase as inspiration and to give context to the Poppy as an Advanced Rubber Ducky research.

Firstly, this chapter will discuss what self-explanation is, how it has been used and how it works. After that, examples of social robots, what they have been used for, and how socialibity is implemented are given. Thirdly, what position Rubber Duckies take within scientific research will be looked at. Finally, what can be concluded with respect to the Poppy as an Advanced Rubber Ducky research will be discussed.

### *2.1.2 Self-explanation devices and concepts*

The concept of self explanation was first researched by John Sweller & Graham A. Cooper[5] who found that self explaining worked out algebra examples improved solving speed more rapidly than conventional methods. Thereafter, several others including Chi et al. [6], O'Neil et al. [7] and Booth et al. [8] have also researched this concept. Pittsburgh Science of Learning Center defines self explanation as follows[9]:

> *“A self-generated explanation of presented instruction that integrates the presented information with background knowledge and fills in tacit inferences.”*

Furthermore, Wylie and Chi[10] use the definition:

> *“Self-explanation is a domain general constructive activity that engages students in active learning and insures that learners attended to the material in a meaningful way while effectively monitoring their evolving understanding. Several key cognitive mechanisms are involved in this process including generating inferences to fill in missing information, integrating information within the study materials, integrating new information with prior knowledge, and monitoring and repairing faulty knowledge.”.*

The definitions are mostly interchangeable but the definition of Wylie and Chi incorporates more facets of self-explanation, and focuses on the activity rather than the explanation. For this research the definition of Wylie and Chi will be used since the research involves testing the activity rather than how the self-explanations are formed.

Self explanation has been used in several different ways. The two ways that will be discussed are prompted self-explanation[6], [7] and corrective self-explanation[8]. With prompted self-explanation the person who performs the self-explanation is asked during or in between the learning process to self-explain. With corrective self-explanation a person is given incorrectly worked out examples with the task to explain how and why they are incorrect.

### *2.1.3 Sensitive Artificial Listener*

It is a framework for virtual agents that are made to listen and react to a person talking with verbal and nonverbal communication. It has been developed with natural human computer interaction in mind. It has for instance been used for data collection for emotion recognition.[11]

### *2.1.4 Thinking aloud pair problem solving (TAPPS)*

An interesting method of problem solving is Thinking aloud pair problem solving, or TAPPS developed by Lochhead and Whimbley[12]. It is a method which requires a pair of people to sit together and at least one of the people to talk aloud while solving the a problem and the other has to keep its partner talking and asks for elaboration on certain aspects. This causes the person explaining to grasp certain concepts quicker.

### *2.1.5 Social robots Effectively conveying emotions*

There are a lot of social robots today, some of them are 3d printed open source designs like, inMoov, ASPIR and Poppy. These robots are made to advance the field of robotics by the community and make the robot space more accessible for education and makers. These robots can be used to socially interact with humans. A well-known method of adding social abilities is with displaying emotions.
There are several methods in literature that are used to have robots convey emotions. How the emotions are perceived could be divided into three main factors: based on visual cues, based on audible cues and depending on the context. McColl and Nejat[13], Erden[14] and Sial et al.[15]all make use of the visual cues with body language. McColl and Nejat try to make the body language of the robot portray that of a human actor while Erden tries to optimise recognition by designing body language specifically for a specific robot. Erden on the other hand uses only the movement properties of the robot (acceleration curve and speed). In this way the robot can still perform tasks without having to invest in extra indicator parts, keeping the cost low. Erden has the most effective method as it come to recognition rates (75% against 42% and 61%) However the method of Sial et al. makes it possible to still perform the tasks it was designed for. McColl and Nejat's method might be in theory the most human like. Another effective way of communicating emotions is by using facial expressions. For facial expressions it is beneficial to be able to make them asymmetric [16] and the mouth seems to be more important for interpreting emotions correctly then the eyes [17]. If a robot needs to convey more complex emotions with facial expressions you can't just mix the different aspects found in human facial expressions [18]. Different colored lights with the help of RGB-LEDs can also be used, but they are only effective to increase the intensity of certain emotions[19].

To convey robotic emotions another way is to use audible cues. Jee et al. [20] discuss how this can be done with the use of music, Crumpton and Bethel [21] discuss how emotion is implemented in synthesized speech and Fernandez De Gorostiza Luengo et al. use emotive sounds[22]. Crumpton and Bethel write that using modern open source speech synthesizer solutions that you can have people recognize certain emotions better than chance just by intonation. They also discuss the fact that certain words within their test data may have influenced they results. This could mean that if a robot would use words with a negative connotation (cried, sad, greed) that its emotions are assumed to be negative. Fernandez De Gorostiza Luengo et al. have found that when using emotive sounds, often the sounds within the same category get confused. The sounds for Agreement, Encouragement and Greeting were mistaken for each other sometimes. Jee et al. experimented with music as the robots' emotions. They only designed music for 4 emotions: Happy, Sad, Fear, and Dislike. The participants of the study reported that the music caused the emotion to be perceived stronger then with facial expressions.
Also, an important aspect for conveying emotions correctly is the context. For instance, Thimmesch-Gill et al. [23] have looked into the perception of robot emotions while under stress. Where, for instance, low arousal poses where rated with relatively higher arousal and high arousal poses where rated with relatively lower. Li and Chignell [24] have also tested the context and found that emotions were better understood in the appropriate context.
Fernandez De Gorostiza Luengo et al. [22], Haring et al. [25] and Breazeal [26] all agree that implementing multiple ways of communicating social cues is beneficial for the understanding of the emotion of the robot.

### *2.1.6 Rubber duckies*

A rubber ducky is a floating toy made in the shape of duck. The original design was from Peter Ganine and made its first appearance in mid to late 19th century. He patented the toy and sold over 50 million of them. Since then the rubber duck has been popular amongst different people and media. An example of rubber duckies being used in research is the case where a big load of rubber duckies fell from a cargo ship and then the rubber duckies where used to track ocean currents[27].

### *2.1.7 Conclusion*

Based on current research the idea of a physical reactive listening agent is an interesting and viable concept. Based on anecdotal evidence rubber duck debugging seems to be helpful for some people, and research shows the effectiveness of self explanation and TAPPS. It is also very well possible to make a robot as Poppy social. Besides that, there has been few research about rubber duck debugging and whether it can be improved. Poppy as advanced rubber ducky would use prompted as well as corrective self-explanation. By utilizing the eyes and body movements inspired by the robot Nao it is possible to create convincing portrayal of emotions which can help the communication process between man and robot.

## 2.2 Ideation

The first stage was to get the plan of what to do with Poppy. The brainstorm was setup to find an answer to the following question: “What meaningful purpose can be fulfilled by Poppy using its nonverbal social potential and how can this be implemented in an effective manner?”
After quite some brainstorming and looking at what was out there the ideas were put into a mind map (see image 1).

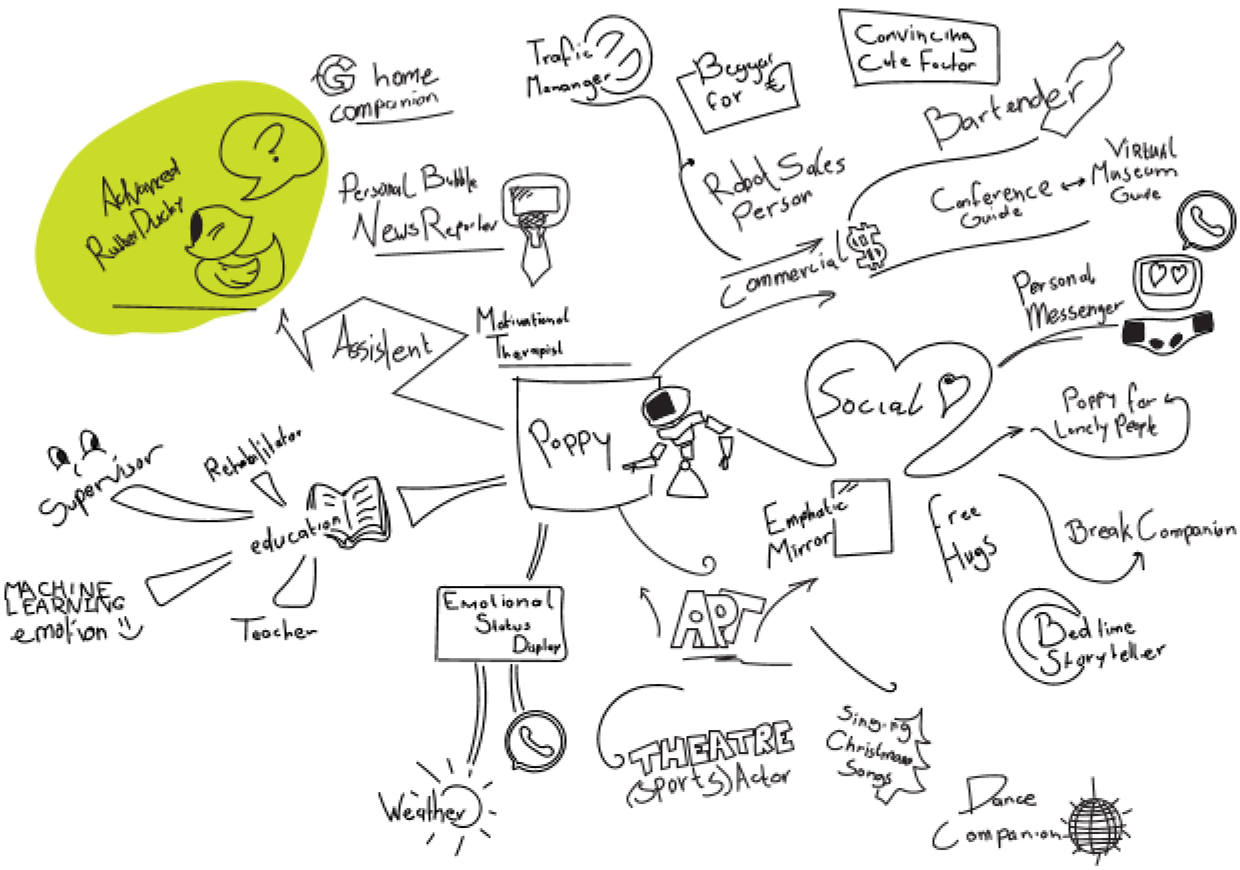


Image 1: *Mind map of possible purposes of Poppy*

The next phase was to find out which ideas were novel and meaningful and could be tested within the scope of this project. The concept of advanced rubber ducky was chosen for it didn’t need a too high skill level in programming, could provide actual benefit to people and was relatively easy to test. Also, there is not a large amount of research in this field and thus could fill a knowledge gap.

### *2.2.1 Advanced Rubber Ducky*

The idea of the rubber ducky comes from the term “rubber ducky debugging” which is used in the programming community. Rubber ducky debugging is debugging by explaining your code to a rubber ducky, or some other lifeless object, so that you understand your code and the

interactions between them better and find where is goes wrong.
The idea of the advanced rubber ducky is that these programmers talk to a humanoid robot instead of to a lifeless object.
For coming up with a way to test the concept of advanced rubber ducky different scenario where setup and evaluated.

#### **2.2.1.1 Scenario 1**

Heather works for Firedroid, a mobile app development company. Times have been rough for Firedroid since the last game they brought out wasn't as good received as they had thought. Heather had been stuck on this one bug where main character wouldn't jump whenever the menu was closed. After an hour of staring at her code she leans back in her chair.
Poppy sees her and turns his towards her and starts to wave. Heather laughs, gets up and lifts Poppy to place him on her desk. She starts explaining him what the code does. Poppy listens carefully and looks confused at her when she explains what the pause boolean does. She takes another crack at explaining it and noticed that when the pause boolean is set to false the controls never get re-enabled. It all becomes clear to her and she wonders why she didn't see that sooner.

#### **2.2.1.2 Scenario 2**

Carlos is a first year Electrical Engineering student. He is working out a diagnostic test and comes across a problem he couldn't solve immediately. He had always learned to solve electrical schematics using the rules about parallel and series. But he got confused with this one problem. He is afraid that he needs to use Kirchhoff's current and voltage law which he doesn't yet master. He grabs poppy and sets him on the desk. He explains poppy what he knows about the voltage and current laws then grabs his book and explains everything he missed in his explanation. Poppy acts to be listening. After doing this Carlos returns to the problem and solves it within ten minutes.

#### **2.2.1.3 Scenario 3**

Simone wants to tell her parents about her sexual orientation but she has been to shy for some time. She grabs Poppy from the book shelf and takes him to her room. She begins to tell him about how she really likes this girl in her class. Poppy scratches the back of his head and looks confused. "Right" thinks Simone. "This is not going to work like this." She dials poppy in to react mad. And she tries again. With seeing the angry eyes of Poppy, she tries to relax him in the same way she would do for her parents. She then dials in that Poppy reacts sad and tries again, then also for disappointment and finally for acceptance. She now feels well prepared to talk to her parents. She goes downstairs and begins to talk to her parents.

#### 2.2.1.4 Conclusion

Between the different scenarios the first scenario shows the most potential for testing. That is because there was excess to a target group with a known skill level in programming that would make it possible to make a challenging test while not being too difficult. The third scenario could be used for a wide target group, however it would involve confronting people on a personal level which makes it more difficult to set up an ethical test.

### *2.2.2 Requirements*

In this part a list of requirements will be set up to be able to perform the experiment. For Poppy to be used as an advanced rubber ducky, it will need to be able to react to the person explaining things to in a meaningful manner. This can be achieved by controlling the servo motors and screens in the head. This could be done by making Poppy respond automatically, however this is probably too difficult to realize within the time frame. A more reasonable approach would be to make Poppy controllable and have the researcher puppeteer the movement and eyes from a distance.
For the research to be valid:

1) Poppy must able to react to a person by being remote controlled.
2) Poppy must able to react understandable by the test participant.

To be able to be controlled remotely

1) There must be an interface the researcher can interact with.
2) The method of controlling must give the researcher the ability to let Poppy express intentions/emotions understandably within a reasonable time frame.

The scenario that will be tested is the scenario where Poppy is used as a debugging tool. For this Poppy will need to react like a person who is listening to someone explaining his or her code. In other words, Poppy needs to be able to display standard conversational cues and some emotional cues that fit within this context.

1) Poppy should be able to nod (say yes)
2) Poppy should to be able to shake it head (say no)
3) Poppy should be able to look confused
4) Poppy should be able to look like it's thinking
5) Poppy could be able to act sad
6) Poppy could be able to look happy

## 3 IMPLEMENTATION

### 3.1 Hardware setup

In this chapter all the design choices and implementation will be discussed. In Appendix X you can find the materials used and Appendix A and B give schematics for the electronics.

#### *3.1.1 Poppy*

There are two versions of Poppy: the Poppy humanoid and the Poppy torso[4]. The differences between these two versions is that the humanoid version has legs and the torso version doesn't. For the purpose of this research legs are not needed and only would make the build more complicated. That is why the torso version will be used. A lot of the hardware is from the stock torso version of Poppy[28] however some of that hardware has been changed to better fit the needs of this research.

#### <u>3.1.1.1 3D Printed Components and base</u>

All the 3D printed components are stock except for the screen support(see image 2) and the hands(see image 3).

3.1.1.1.1 Screen support

Image 2: *Image 2a and b: a screen support front, b screen support back*

A different screen support was chosen partly because the original one didn't support the LED matrices used and also because then laser-cut acrylic can be used which is quicker to make then the intended resin based 3d print.The screen support is made for two adafruit 8x8 Bi-Color LED Matrices. For the diffusion of the screen a piece of frosted plexiglass is used in conjunction with a piece of regular printer paper with light pencil markings on one side to better match the color of the LED matrices.

#### 8.1.1.1.2 Hands

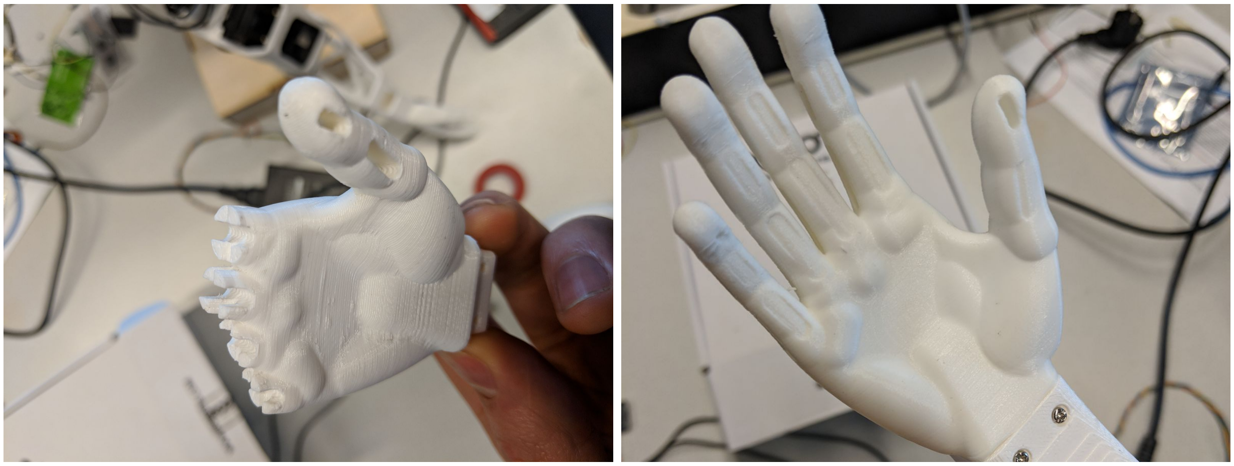

Image 3: *Image 3a and b: a, hand with broken fingers. b, new design with stronger fingers*

The original hands of Poppy have a lot of holes in them. This has caused the fingers to break of over time. Most of the holes are closed off in the version used for this research.

#### 3.1.1.1.2 Base

Poppy is put on a wooden laser-cut base(see image 4). This is because it makes sure that Poppy doesn't fall over with sudden and big movements and it creates a good place for hiding the electronics. Besides that it gives Poppy more room to move its arms. The stock solution for the Poppy torso is to use a suction cup, but this cannot house electronics and gives less flexibility on the surfaces you can put Poppy on.

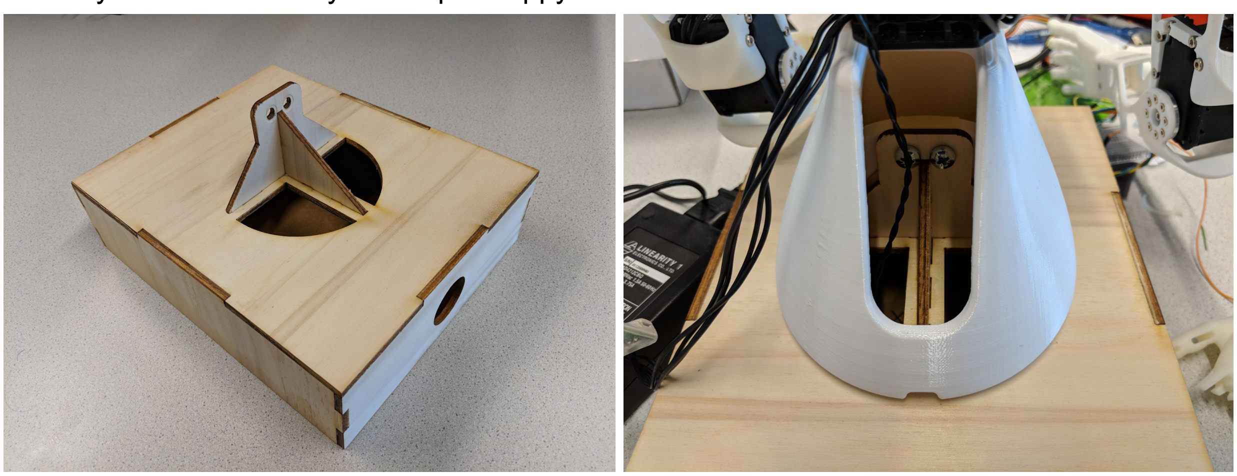

Image 4: *Image 4a and b: a, laser-cut base. b, mounting mechanism*

### **3.1.1.2 Electronics**

For this research, different electronics were used than in the Stock version of Poppy, except for the servos. Instead of the stock ODROID-XU4 and an LCD screen, two arduinos were used with breakout boards for driving the servos and the adafruit 8x8 Bi-Color LED Matrices. That is

because Arduino is very popular open source hardware with a lot of community and library support. Also it is embedded electronics and thus there is no operating system that takes up extra processing power and could cause instability issues.
One of the Arduinos and all the servos received power from a 12Vdc power power supply with a maximum output of 45W. The other Arduino received power from a USB connection. Some extra IC's where used to have everything working together (see image 5).

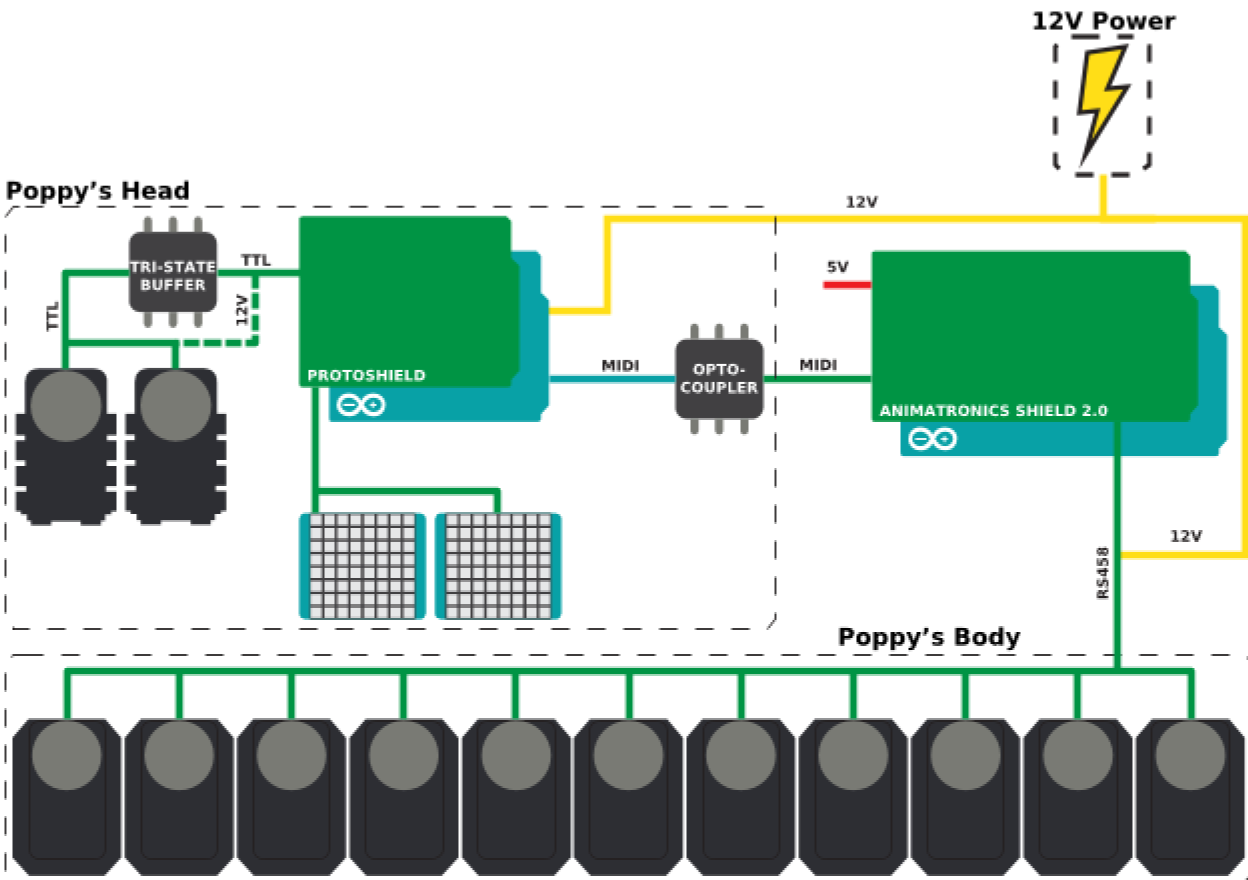


Image 5: *Schematic display of all electronics*

### 3.1.1.2.1 Head electronics

In the head of Poppy an Arduino Uno was used. This Arduino drives two servos in the neck of Poppy as well as the LED Matrices that are used as Poppy's eyes.
On the Arduino there is a ProtoShield v2 with all the supporting circuitry.

*Arduino Uno*

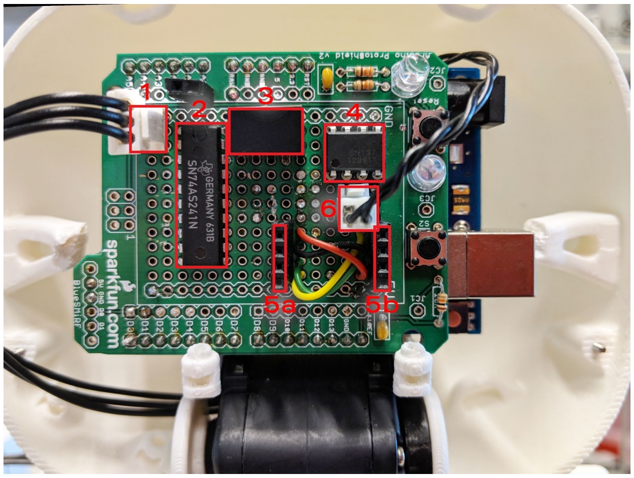

Image 6: *Arduino UNO in the head of Poppy*

List of hardware on the Arduino UNO (see image 6):

1) This is the TTL connector for the two Dynamixel AX-12 servos in the neck. This is also the point where the 12Vdc power input is.
2) This is the SN74AS241N, a tri-state buffer, this is used to improve the out- and input impedance of the TTL connection between the servos and the arduino.
3) This is the TSR 1-2450, this is used to efficiently step down the 12Vdc to an arduino friendly 5Vdc.
4) This is the 6n137, an optocoupler, this is used to receive MIDI signals from the other Arduino with a galvanic separation.
5) These are the headers for the two LED matrices.
6) This is the connector for a MIDI connection from the other arduino.

*Adafruit 8x8 Bi-Color LED Matrix*

These LED Matrices were used to to display emotive robot eyes on the head. These LED Matrices were chosen because library and community support and that they give enough flexibility to display eyes in a sufficient manner while still being easy to program.

#### 3.1.1.2.2 Base electronics

In the base of Poppy an Arduino Mega ADK is used in conjunction with an animatronics shield 2.0. This Arduino was chosen because it has an extra female USB connector which can be used for a midi controller. This Arduino is used to drive all the servos in the body, it interprets the instructions from the MIDI controller give the head arduino instructions which servos to move and what to display on the LED matrices.

*Arduino Mega ADK*

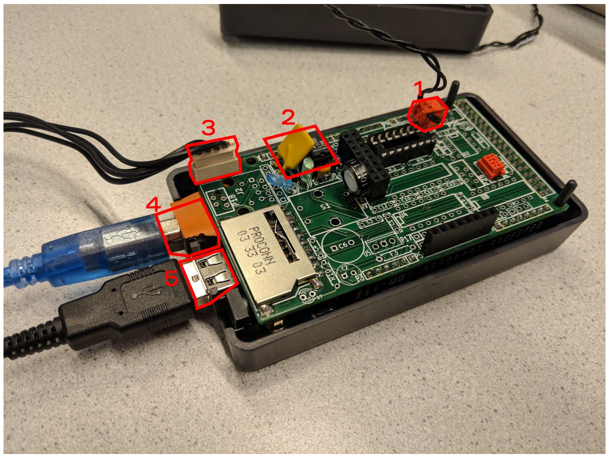


Image 7: *Arduino Mega ADK with Animatronics Shield*

List of hardware on the Arduino Mega ADK with animatronics shield(see image 7).

1) This is the Midi out connector. Here the wires that go to the head Arduino are coming from.
2) This is the circuitry that translates the serial signal from the Arduino to the RS485 protocol with the help of a LTC485 integrated circuit.
3) This is the connector to the servos.
4) This is the USB connection for reprogramming and to power the Arduino.
5) This is the USB connection to connect with the midi controller.

*Korg nanoKontrol 2*

This controller(see image 8) is used because it has enough actuators, it uses the widely implemented midi protocol, the layout of all the actuators is clear and is not too expensive(see image 10 for controller mapping).

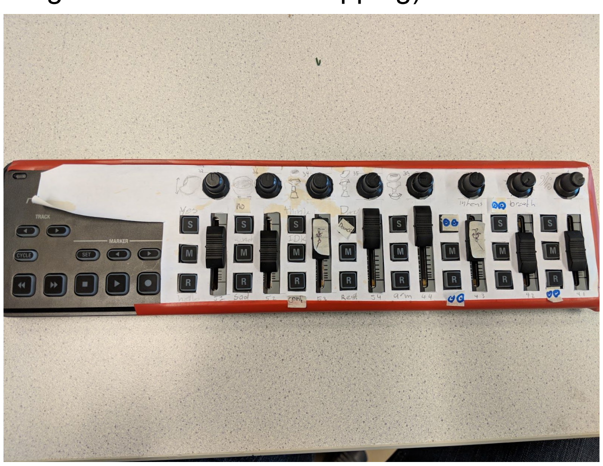

Image 8: *Korg nanoKONTROL 2 midi controller*

*Dynamixel MX-28 & Dynamixel AX-12*

The dynamixel servos are useful for robotics and mechatronics because they are a fully integrated solution. All the control mechanics and electronics are integrated and all the instructions that it needs are send to the onboard controller by TTL (for the AX-12) or RS485 (for the MX-28). They can also be daisy-chained. The main differences between the two models are that the MX-28 has more power, a larger operating angle and a higher resolution.

## 3.2 Software setup

### *3.2.1 Dynamixel Firmware setup*

Before controlling all the Dynamixel servos first index numbers need to be assigned. I assigned the index numbers according to the motor naming convention[29] using the dynamixel wizard in the RoboPlus software[30] and a USB2Dynamixel(see image 9). Also, in this software the maximum position values of the dynamixels is filled in for each motor. These values were determined by putting the different joints in maximal positions and reading out the value using the dynamixel wizard. The process was similar for determining the neutral position for each joint.

Image 9: *USB2Dynamixel for programming the onboard hardware of the dynamixels*

### *3.2.2 Poppy software*

There are 2 arduinos in this version of Poppy and thus also two arduino programs were created.

#### <u>3.2.2.1 Poppy_base_script</u>

This script:

- Interprits midi input from the midi-controller using the MIDI library[31] and the USBH_MIDI library[32]. This data is then used to determine program actions.
- Stores the position values of certain animations.
- Calculates servo positions from stored values for different intensities of animations.
- Sends position data for the servos in the neck and which eye animation that needs to be displayed to the Arduino in the head with the midi protocol.
- Offsets the chest and arm position values to make Poppy appear to be breathing.
- Sends position data to the dynamixel MX-28's using the DynamixelReader library[33].

The base script is based on code of Edwin Dertien that has been used in other projects with the Animatronics Shield. In the main loop of the program there is a 100 Hz clock for addressing the Dynamixels for not overloading the RS485 connection. This timer is also used for sending Midi signals to the Arduino in the head for the same reason and it is used to time the animations. At setup all the serial/midi connections are initialized. As soon as there is a connection with the midi controller all the servo's are set to the default position and the P-gain on the internal memory of the servos is lowered. This done to have the movements look more smooth and natural (since the P-gain has the most influence on the acceleration near the setpoint).

The midi controller sends out a midi message every time a button is pushed or a slider is changed. This message contains a value unique for every slider, button and knob and the an value to determine what the slider, buttons or knob is set to. These values are used to determine the action of the program. For instance, the sliders are used to change the position values of the joints in the arms. If the slider is in the middle position the joint is in the default position and all positions of the slider higher than that are mapped between the default and maximum value. For lower values vice versa. This is to make it easy to return to the default position of the joint. Image 10 is a diagram that displays what every button controls.

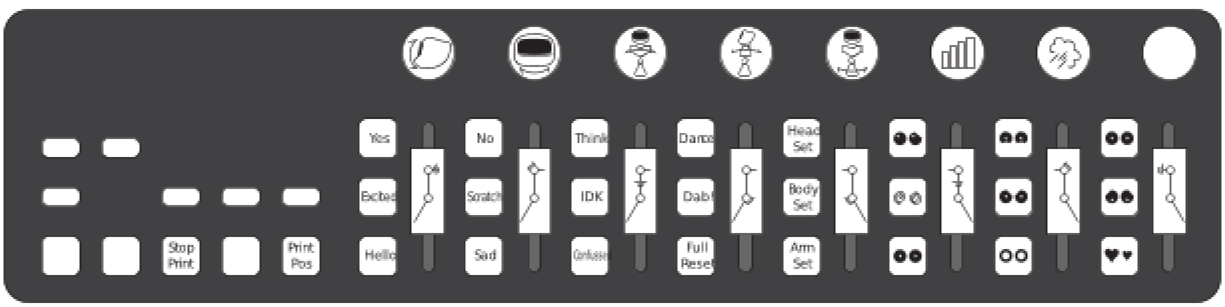


Image 10: *Layout of all the functions on the midi controller*

This script also stores different positions in a certain sequence to display body language to the user. The animation data is stored as an array of arrays, of positions of all the joints, and a timestamp variable. For playback of the animations a parametric approach was chosen. This was achieved by first designing an animation and then later increasing or decreasing the difference between sequential joint positions with a certain value. By controlling this value the animation seems more or less intense.
To make sure that the animation looks like a continuous movement without too many data points, linear interpolation between the stored values was used.

$$1)\ previous\ position\ + current\ time * \frac{next\ position - previous\ position}{next\ timestamp - previous\ timestamp} = current\ position$$

Current time stands for a variable that counts up using the 100 Hz clock mentioned earlier from 0,the beginning of an animation, to a value that stand for the end of the animation. Each position has a timestamp for when that position should be assumed according to the current time variable. With every animation there is also a value that stands for the eye animation send to head Arduino.

#### 3.2.2.2 Poppy_head_script

This script:
- Interprits midi input from the Arduino in the base using the MIDI library[31]. This data is then used to determine program actions.
- Stores bitmap data and sequences for different eye animations.
- Sends the right bitmap information to the Led-matrices for playback of eye animations using the Adafruit_GFX[34] and Adafruit_LEDBackpack libraries[35].
- Sends position data to the dynamixel AX-12's using the DynamixelSerial[36] library.

The head arduino listens midi signals from the base arduino. Midi has different channels and the different channels are used for controlling different functions in the head. Channel 1 and 15 are used to set the angle set point for the two servos in the neck and channel 3 is used to determine which eye animation should be displayed.

Eye animations are timed using the millis() function. Every eye animation is a loop of a couple seconds with 2 - 14 different frames.

The Dynamixels are directly controlled with the midi input from the Arduino in the base. With the midi value 64 corresponding to the default position of the servos and 0 and 127 corresponding to the maximum positions of the servos.

## 3.3 Animation design

For designing the animations a couple of steps where taken. First there was a small brainstorm phase to what kind of responses where needed for this application. Secondly there was a search for references by google images, drawings or performing the response myself to see what the response actually looks like. Thirdly designing each frame/intermediate position. Then playing the animation back and working out the timing and finally tweaking the positions, frames or timing.

**Eyes**

For the eyes a eye design tool was made in Processing. This design tool exported an image that was made in the tool to an array of bytes that is understandable for the Arduino. There was tried to keep some conformity between the eyes. The suggested eyebrows are good to show most of the emotions.

### 3.4 Experimental Design

For the experiment some sub research questions were written.
RQ1: Do test participants find it helpful to explain their problem to an animated Poppy, a non-animated Poppy or nothing?
RQ2: Do the test participants feel comfortable talking to Poppy?
RQ3: Are the test participants able to connect in a social way with Poppy?
The quality of puppeteering will also be measured to validate the research questions.

After signing an informed consent form (Appendix C), one participant at the time will make two assignments of seven minutes each. For each assignment, the Participant is going to solve it in a different way. One time the participant is asked to explain what they are doing to an animated Poppy and the other time it is asked to explain what they are doing to a stationary Poppy. A researcher for controlling Poppy and a camera will be present in the room as well.

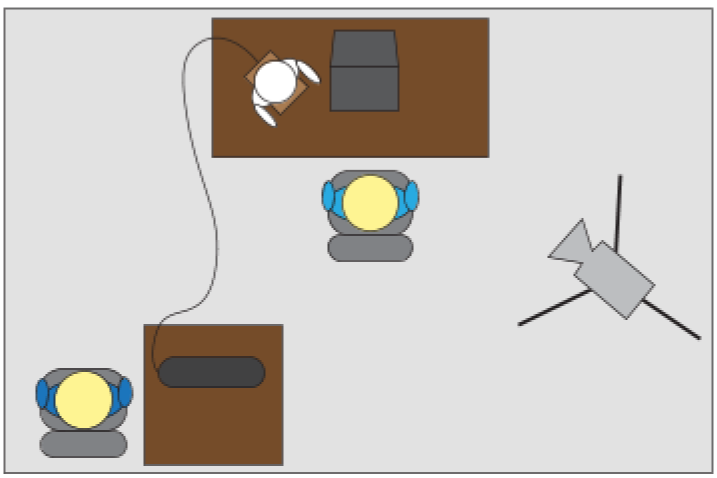

Image 11: *Experiment set-up*

A test protocol is written and can be found in appendix D.
The order of assignments and whether or not Poppy is animated will be shuffled between participants according to the table below. This will be done to suppress/distribute the influence of difficulty, order and fitness to the solving method of the assignments. Every solving method has the same number of the three assignments and every possible order of solving methods is present 4 times.

| | | |
|---|---|---|
| **p#** | Participant | |
| **a#** | Assignment | |
| **Order** | first | second |

| | **With animated Poppy** | **With stationary Poppy** |
|---|---|---|
| *p1* | a1 | a2 |
| *p2* | a1 | a2 |
| *p3* | a2 | a1 |
| *p4* | a2 | a1 |
| *p5* | a1 | a2 |
| *p6* | a1 | a2 |
| *p7* | a2 | a1 |
| *p8* | a2 | a1 |
| *p9* | a1 | a2 |
| *p10* | a1 | a2 |
| *p11* | a2 | a1 |
| *p12* | a2 | a1 |
| *p13* | a1 | a2 |
| *p14* | a1 | a2 |
| *p15* | a2 | a1 |
| *p16* | a2 | a1 |

### *3.4.1 Assignments*

In literature there is not much to find about rubber ducky debugging or similar methods to base the assignments on. However when searching for rubber ducky debugging, anecdotal evidence often leads to the use in programming. For both assignments the challenge is to understand how the different elements on screen are drawn. During the design of the assignments they were tested with colleagues and the aim was to not have the difficulty in the syntax. The assignments can be found in appendix E and are designed in and for the IDE processing.

### *3.4.2 Participants*

The participants are students from the program creative technology. This user group was chosen because the level of programming skills is known. The test was setup for within participant analysis.

### *3.4.3 Questionnaire*

For designing the questionnaire some research was done to the different things that need to be tested. So questions were set up that test the scales: puppertering quality, perceived social connection, perceived effectiveness and perceived comfort. For every scale different subscales are chosen and every subscale is tested with at least 3 different questions (see table below). Some subscales are taken from other research. C2, S3 and U2 are taken from Heerink[37] and Q3 and S2 are taken from Harms and Biocca[38]. All the questions where is the form of statements and the possible answers that could be given where 1, 2, 3, 4 and 5 with 1 being marked as fully disagree and 5 as fully agree. Besides that, there were also some demographics questions. Full questionnaire can be found in Appendix F.

| Perceived comfort | | Amount of questions |
|---|---|---|
| C1 | Talking to poppy comfort | 6 |
| C2 | Anxiety | 4 |
| Puppertering quality | | |
| Q1 | likeness of Poppy | 3 |
| Q2 | emotive convincingness | 4 |
| Q3 | perceived message understanding | 6 |
| Perceived social connection | | |
| S1 | Perceived connection | 3 |
| S2 | Perceived Affective Understanding | 6 |
| S3 | Perceived sociability | 4 |

| Perceived usefulness | | |
|---|---|---|
| U1 | Perceived effectiveness | 7 |
| U2 | Perceived usefulness | 3 |

### *3.4.4 Observations*

The video footage will be used to look for:

- Time to complete task in seconds(finish time).
- Time the participant is telling Poppy what he or she is doing in seconds (narrating).
- Time the participant is explaining to Poppy what the code means in seconds (explaining).
- Time making communicative sounds in seconds (communicative sounds).
- Time talking to Poppy about not assignment related things (talking).
- Whether there are any anomalies.

For the data analysis time for narrating and explaining are combined and called solving behavior, since it was not always clear what the difference between narrating and explaining was.
The communicative sounds and talking are also put together for the data analysis and called other behaviour together with everything that the participant says that is not understood.

## 4 RESULTS

Test Data can be found in Appendix G.

### 4.1 Evaluation Method

First off all the Cronbach's Alpha[39] of all the subscales are determined to validate the questionnaire. The Cronbach's Alpha is a method to measure whether different questions measure the same subscale. Everything above 0,7 is considered adequate and above 0,8 signals a good correlation between the questions. The answers can then be averaged into a new variable of the subscale. All the subscales of the same scale were then tested with a correlation analysis and if they significantly correlate the subscale variables are averaged into a scale variable. These scale variables can then be used to test different hypothesis.
Different suspected hypothesis are connected with the sub research questions and then tested with SPSS using sample t-tests and correlation analysis.

The quality of puppeteering to validate the measurements.

- H0: Just as many people are able to finish the first assignment as the second assignment
- H1: It takes just as long to finish the first assignment as the second assignment
- H2: People found the quality of puppeteering convincing

RQ1: Do test participants find it helpful to explain their problem to an animated Poppy or a non-animated Poppy?

- H3: When Poppy is animated assignments are finished more quickly
- H4: When Poppy is animated assignments are finished more frequent
- H5: People find it helpful to use Poppy
- H6: If people perceive Poppy as useful they finish assignments more frequent.
- H7: If people talk more to Poppy they finish the assignment more frequent

RQ2: Do the test participants feel comfortable talking to Poppy?

- H8: When people feel a social connection with Poppy they feel more comfortable talking to Poppy
- H9: If people say that they feel comfortable talking to poppy they talk more to Poppy
- H10: People feel comfortable talking to Poppy

RQ3: Are the test participants able to connect in a social way with Poppy?

- H11: People connect socially with Poppy
- H12: When Poppy is animated people talk more with Poppy

### 4.2 Data Analysis

Cronbach's Alpha test gives:

| C1 | C2 | Q1 | Q2 | Q3 | S1 | S2 | S3 | U1 | U2 |
|---|---|---|---|---|---|---|---|---|---|
| 0,857 | 0,29 | 0,653 | 0,78 | 0,781 | 0,665 | 0,824 | 0,799 | 0,823 | 0,723 |
| | Without C2.3 | Without Q1.2 | | | Without S1.2 | | | | |
| | 0,638 | 0,743 | | | 0,596 | | | | |

Values between ,7 and ,8 are considered adequate, higher than ,8 is considered good and lower than ,7 will be rejected.
So reject C2, S1 and Q2.1

With this in mind a mean was calculated between the different questions and a correlation test was done between the different subscales to see whether they gave an answer about the scale

| | Q1 | Q2 | Q3 | S2 | S3 | U1 | U2 | C1 |
|---|---|---|---|---|---|---|---|---|
| Q1 | - | > .01 | > .01 | | | | | |
| Q2 | > .01 | - | > .01 | | | | | |
| Q3 | > .01 | > .01 | - | | | | | |
| S2 | | | | - | > .01 | | | |
| S3 | | | | > .01 | - | | | |
| U1 | | | | | | - | > .01 | |
| U2 | | | | | | > .01 | - | |
| C1 | | | | | | | | - |

Every correlation was significant so the mean of the different subscales were taken and this gave an insight about the different scales:

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Q: Puppeteering quality | 18 | 2,39 | 4,64 | 3,63 | 0,53 |
| S: Perceived social connection | 18 | 2,21 | 4,42 | 3,46 | 0,65 |
| U: Perceived usefulness | 18 | 1,71 | 4,00 | 3,04 | 0,71 |
| C: Perceived comfort | 18 | 1,00 | 4,17 | 3,18 | 0,90 |

Then the different hypotheses were tested with independent sample t tests and correlation tests.
**H0:** Assignment 1 was finished 7 times out of 18 attempts and assignment 2 was finished 7 times out of 17 attempts.
**H1:** The mean length of finishing the assignments is not significantly different between assignment one (394.8 ± 57.2 s, n=18) and two (389.2 ± 51.3 s, n = 17) (two sample t-test, p = .76).
**H2:** The mean quality of puppeteering scale is significantly bigger than 3 (3.63 ± 0.53, n=18) (two sample t-test, p < .01).
**H3:** The mean total length of finishing the assignments is not significantly different between when Poppy was animated (334.3 ± 91.3 s, n=7) and not animated (359.4 ± 29.3 s, n = 5) (two sample t-test, p = .57).
**H4:** The mean chance of finishing an assignment is not significantly different between assignments made 'while Poppy is animated' (0.389 ± 0.50, n = 18) and 'not' (0.294 ± 0.470, n = 17) (two sample t-test, p = .57).
**H5:** The mean perceived usefulness scale is not significantly different from 3 (3.04 ± 0.71, n=18) (two sample t-test, p = .82).
**H6:** No significant correlation between perceived usefulness and the amount of finished assignments was found, r = .428, p = .08, n = 18.
**H7:** No significant correlation between talking time to Poppy and finishing the assignment was found, r = .004, p = .99, n = 18 for assignment 1 and r = .103, p = .693, n = 17 for assignment 2.
**H8:** No significant correlation between the perceived social connection scale and the perceived comfort scale was found r = .446, p = .064, n = 18.
**H9:** A significant correlation between the perceived comfort scale and talking time to Poppy was found, r = .655, p = .003, n = 18 for assignment 1 and r = .631, p = .007, n = 17 for assignment 2.
**H10:** The mean perceived comfort scale is not significantly different from 3 (3.18 ± 0.90, n=18) (two sample t-test, p = .40).
**H11:** The mean perceived social connection scale is significantly bigger than 3 (3.46 ± 0.65, n=18) (two sample t-test, p = .01).
**H12:** The mean time of 'talking to Poppy per time it took to do the assignment' is not significantly different between assignments made 'while Poppy is animated' (0.277 ± 0.180, n = 18) and 'not' (0.231 ± 0.154, n = 17) (two sample t-test, p = .42).

To get some qualitative insight in the correlation between the Interaction with Poppy and the effectiveness of solving the assignments a scatter plot was created (see image 12).

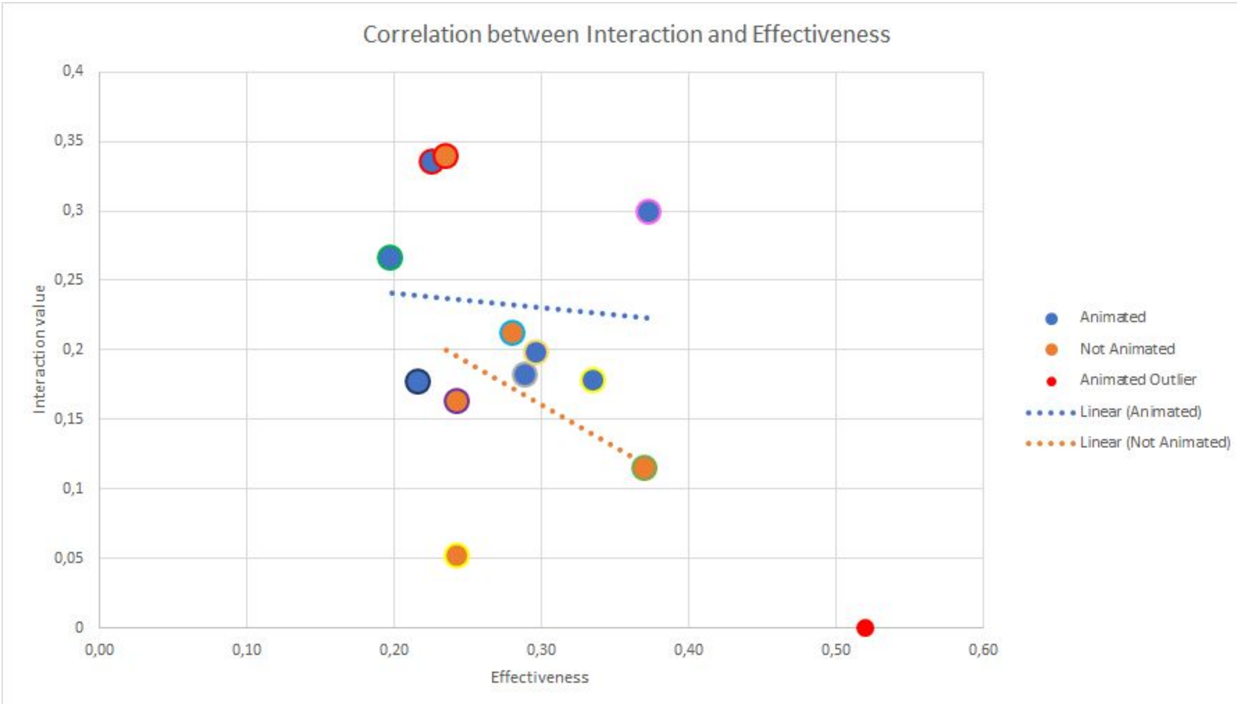


Image 12: Scatter plot between Interaction and effectiveness.

The effectiveness is determined by taking the time it took for the participants to finish the assignment and multiplying that with a factor that incorporates the perceived programming skill level between 1 and 5 and dividing that by one hundred.

$$\frac{100}{finishTime * C_1((skillLevel - 3) * C_2 + 1)} = Effectiveness$$

The division is meant to make the term invert, C1 determines the weight of the finishtime relative to the skill level and C2 determines the weight of the skill level relative to the finishtime. It was chosen that C1 = 1 and C2 = 0.2 in the graph below for C2 is less reliable.

The Interaction value is determined by the time spend talking to Poppy about the assignment (solving behaviour) and the time spend talking about other things or making communicative sounds to Poppy (other behaviour).

$$solvingBehaviour * C_3 + otherBehaviour * C_4 = Interaction\ value$$

C3 is set to 1 and C4 to 0.2 since it is suspected is that other behaviour is not as important for solving the assignment effectively as solving behaviour.

## 5 CONCLUSION

The research question is:
“Is it more helpful and/or pleasant for someone to explain a concept to a socially reactive entity compared to a non-reactive entity for said someone to get a better understanding of the concept?”
The Perceived usefulness scale scored lowest in the questionnaire with a mean of 3.0 and an SD of 0.7. This probably means that most people don’t perceive it as useful to talk to an robot in general. The statistical tests that test the actual usefulness are not significant possibly due to a sample size that wasn’t big enough or the difference in programming skills between the participants. And when looking for a correlation between effectiveness and and Interaction (see image 10) there does not seem to be one.
Whether it was more pleasant to talk to a animated robot or a stationary robot is not clear from the statistics since all nothing shows a significant difference between animated and not animated and the questionnaire only answered the questions for both animated and not.

Some people seem to have a greater affinity of talking to Poppy then others. Whether it works might be highly personal. There were also reports that participants were confused when Poppy didn’t react, which could have influenced the results. One participant said to have already used the rubber duck debugging concept before with a gnome statue. This participant reported finding it less difficult to speak to something that looked alive than to a gnome statue, whether Poppy was animated or not. There might also have been a bias since most of the participants knew me personally and a few also knew about the research. Finally, the time that participants spend on solving the assignment might also be of interest. It might be that the effect only shows after the participant is acquainted with the technique of talking to a robot to solve problems.

# 6 RECOMMENDATIONS

## 6.1 Design recommendations

A noticeable problem was that sometimes, the dynamixel AX-12’s in the neck would shut down after being on for a couple minutes. They also don’t respond to a message from the Arduino to change the compliance slope. It is recommended to use dynamixel MX-28’s for these servo’s instead. Another benefit that brings is that all the servo’s behave the same.
To make Poppy seem more engaged, having poppy look to the participant with face tracking is recommended.
The code currently doesn’t allow for smooth transitions between animations, which can lead to Poppy making sudden movements that might scare people.

## 6.2 Further Research

The experiment that was deducted barely held any significant results. To change this, a larger sample size and/or a longer experiment is recommended.
The rubber ducky debugging concept doesn’t have to be tested with a humanoid, if it seems to work trying it with a different cheaper to produce robot might be beneficial.
The experiment design would probably benefit from a bigger focus on the differences between the two states of animated and not animated. This could be achieved by having the participants fill in the questionnaire twice for instance.
Some control test are needed for comparing a ‘real’ rubber ducky with a robot since there is no research to be found on this concept.

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# 8 APPENDIX

## 8.1 Appendix A: Bill of Materials

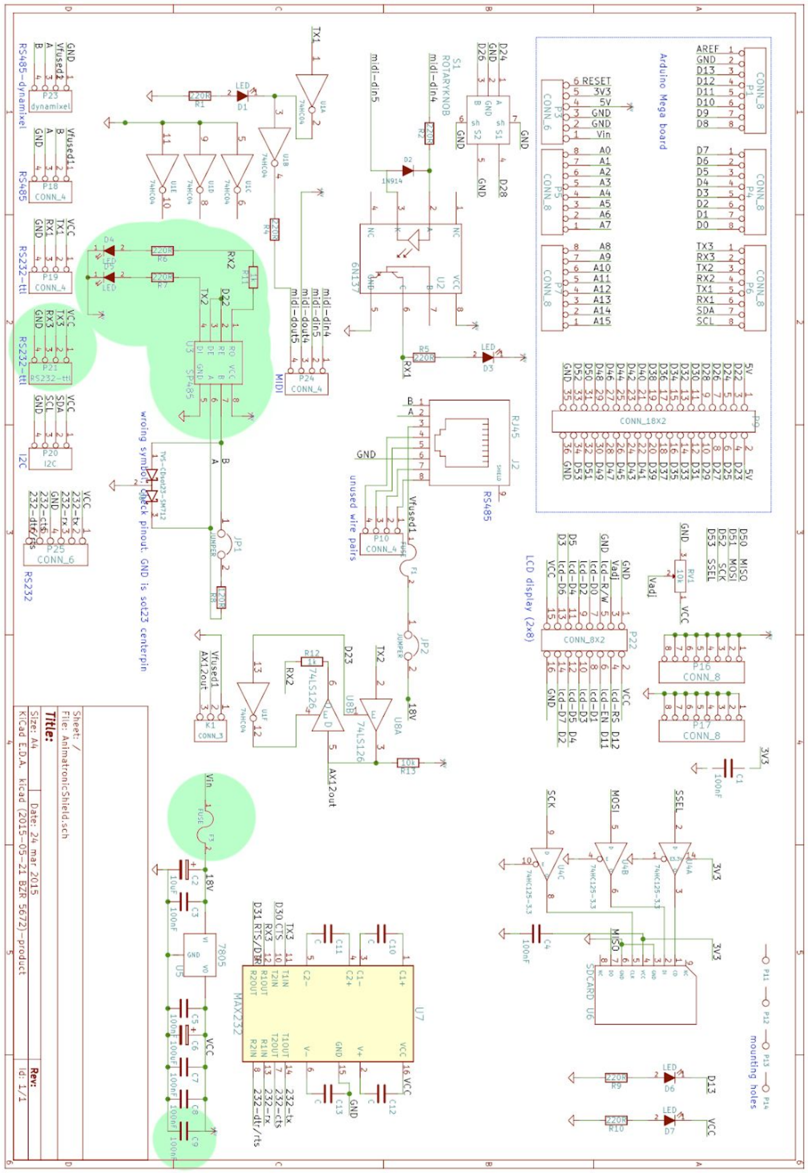
| **3D printed parts** | amount |
|---|---|
| **torso** | |
| support_for_table | 1 |
| spine | 1 |
| double_rotation_MX28_link | 2 |
| i101-Set_to_MX28_link | 1 |
| chest | 1 |
| **upper_limbs** | |
| shoulder_right | 1 |
| shoulder_left | 1 |
| arm_connector | 2 |
| upper_arm | 2 |
| forearm_left | 1 |
| forearm_right | 1 |
| hand_right (custom) | 1 |
| hand_left (custom) | 1 |
| **head** | |
| neck | 1 |
| head-back | 1 |
| head-face | 1 |
| 8x8 LED Matrix holder (custom) | 1 |
| | |
| **Electronics** | |
| **arduino mega ADK** | 1 |
| anamatronics shield 2.0 PCB | 1 |
| IC: SP485 | 1 |
| resistor 120 ohm | 1 |

| | |
|---|---|
| resistor 220 ohm | 2 |
| resistor 1k ohm | 1 |
| led | 2 |
| flexifuse | 1 |
| capacitor 100nF | 1 |
| micro-match connector | 1 |
| flexible wire 1m | 1 |
| molex 22-03-5045 connector | 1 |
| | |
| **Arduino Uno** | 1 |
| Arduino ProtoShield v2 | 1 |
| Adafruit 8x8 Bi-Color LED Matrix | 2 |
| IC: SN74AS241N | 1 |
| IC: TSR 1-2450 | 1 |
| IC: 6n137 | 1 |
| Female header pins | 8 |
| molex 22-03-5035 connector | 1 |
| 2 pin male molex connector | 1 |
| 2 pin female molex connector | 1 |
| resistor 1.2k ohm | 1 |
| resistor 120 ohm | 1 |
| misc wires | x |
| | |
| **Other** | |
| **Dynamixel** | |
| MX-28AT | 11 |
| AX-12A | 2 |
| Parts | |
| HN07-N101 set | 11 |
| HN07-i101 Set | 6 |
| **Visserie** | |
| Wrench Bolt M2*3 (200 pcs) | 1 |

| | |
|---|---|
| Wrench Bolt M2.5*4 (200 pcs) | 1 |
| Wrench Bolt M2.5*6 (200 pcs) | 1 |
| Wrench Bolt M2.5*8 (200 pcs) | 1 |
| BIOLOID Bolt Nut Set BNS-10 | 1 |
| Nut M2.5 (400 pcs) | 1 |
| N1 Nut M2 (400 pcs) | 1 |
| M5 nuts | 2 |
| M5x20mm screws | 2 |
| **Cables** | |
| SMPS2Dynamixel | 1 |
| Robot Cable-3P 60mm 10pcs | 1 |
| Robot Cable-3P 100mm 10pcs | 1 |
| Robot Cable-3P 140mm 10pcs | 1 |
| Robot Cable-3P 200mm 10pcs | 1 |
| **Other** | |
| frosted plexiglass screen | 1 |
| piece of office paper with light pencil marking | 1 |
| Lasercut box as base (custom) | 1 |
| Korg NanoKontrol 2.0 with cable | 1 |
| 12v 3.75A Power Supply | 1 |
| SMPS2Dynamixel Adapter | 1 |
| USB2AX | 1 |

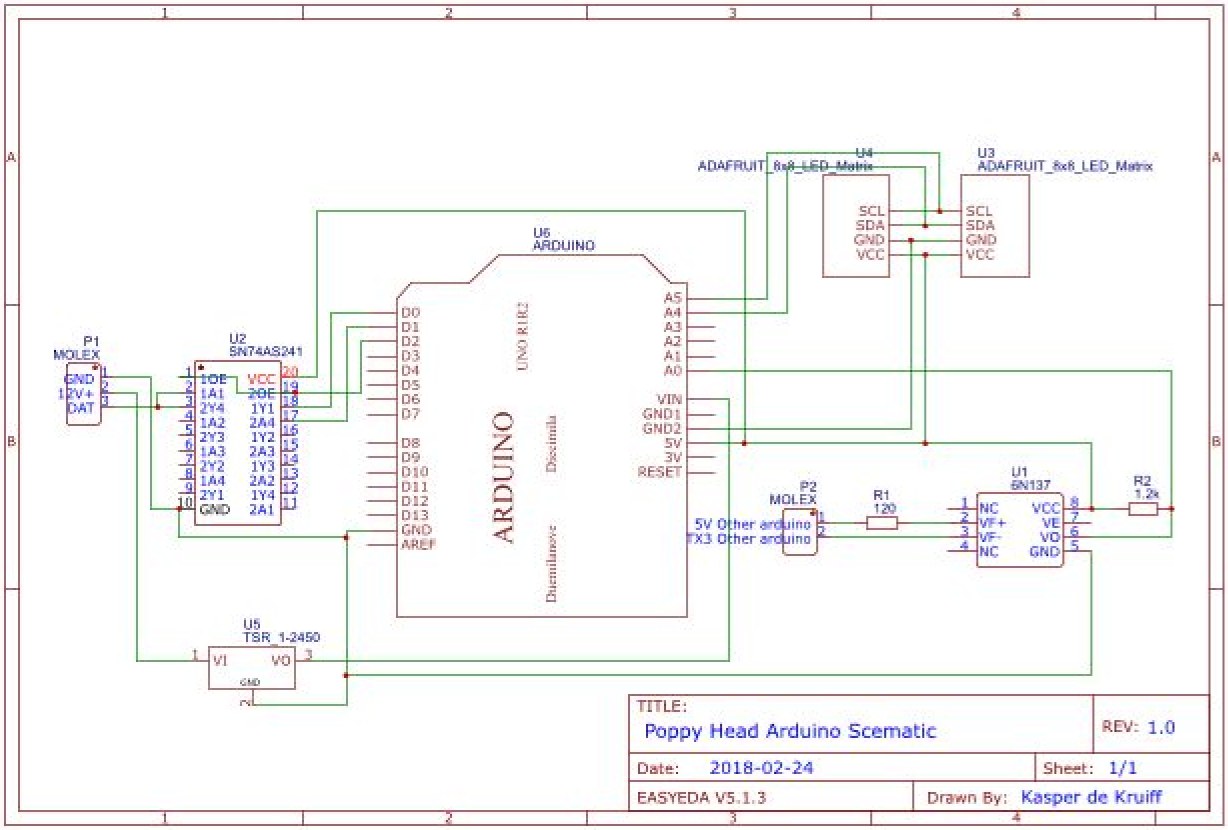
## 8.2 Appendix B: Electronics Schematic

Base(green is what needs to be populated):



http://wiki.edwindertien.nl/lib/exe/fetch.php?cache=&media=installations:animatronics:animatronicsshieldv2.png

Head:




### 8.3 Appendix C: Consent Form

## Consent Form: Robot guided self-explanation

Please read and sign this form.

**Outline:**

This informed consent form is for research in robot guided self-explanation. An example for guided self-explanation is rubber ducky debugging. This is when a programmer explains his or her code to a rubber duck to understand the code better themselves.
In this test, the participant is going to do two small programming assignments in Processing. During the assignments, it is encouraged for the participant to explain a robot what he/she is Doing.

**Rights:**

During this user test I agree to participate in doing two small programming challenges with the help of a humanoid robot named Poppy.
I understand and consent to the use of video recordings and the results of the questionnaire by the faculty RAM of the University of Twente for their social robotics research.
I understand that the information and recordings are for research purposes only and that my name and image will not be used for any other purpose.

I understand that if I want my video to be removed I can request that to Kasper de Kruiff.
I understand that participation is voluntary and if I want to seize my participation I can do that at any time without need for explanation.

If there are any concerns I can discuss them with Kasper de Kruiff.
Please sign below to indicate that you have read and understood the information on this form and that any questions you might have about the session have been answered.

Date:_________
Name: ____________________________________________________
Sign: ____________________________________________________

**Thank you!**
We appreciate your participation.

### 8.4 Appendix D: Test Protocol

1. Welcome the participant into the room.
2. Introduce the participant to Poppy.
3. Give them a short explanation what the test entails.
    a. What we are going to test here is robot guided self-explanation. An example for guided self-explanation is rubber ducky debugging. This is when a programmer explains his or her code to a rubber duck to understand the code better themselves. In this test, we're going to see how this phenomenon holds up with a robot. In a moment, you are going to do two small programming assignments in Processing. During the assignments, I want you to explain Poppy what you are doing.
    But first I would like you to fill in this consent form. By signing it you give me permission to use your data and you allow me to film you for the purpose of this research. The footage will only be used for this experiment and you can ask us to delete it any time. Also, you can leave anytime you want without need for explanation.
    b. In deze test gaan we robot ondersteunde zelfuitleg testen. Een voorbeeld hiervan is het rubberen eendje effect. Dit is wanneer een programmeur zijn of haar code uitlegt aan een rubber eendje om zelf de code beter te omvatten. In deze test gaan we kijken of een robot daar verschil in uitmaakt. Zometeen ga je twee kleine programmeer opgave doen in Processing. Tijdens het maken van deze opgaven vraag ik je om aan Poppy uit te leggen waar je mee bezig bent. Maar eerst heb ik graag dat je deze consent form invult. Door deze te ondertekenen geef je mij toestemming om de test data te gebruiken en je te filmen voor dit onderzoek. Het filmmateriaal zal alleen gebruikt worden voor dit onderzoek en je

kan altijd vragen om het te laten verwijderen. Daarnaast kan je altijd het experiment verlaten zonder dat je daar uitleg voor hoeft te geven.

4. Ask whether the participant has any questions and answer them.
5. Give the participant a consent form, give him or her time to read and sign it.
6. After the participant signed the form turn on the camera
7. Show the participant where he/she needs to sit and what Assignment he/she needs to do.
8. Sit at the control table to control or not control Poppy.
9. Wait until the participant is ready with their assignment or stop him/her after seven minutes.
10. Tell the participant we’re going to do the test again but this time Poppy will react/not react.
11. Sit at the control table to control or not control Poppy.
12. Wait until the participant is ready with their assignment or stop him/her after seven minutes.
13. Thank the participant for participating.
14. Turn off the camera.
15. Offer the participant a piece of cake.
16. Let him leave the room and get the next participant.

### 8.5 Appendix E: Programming Assignments

#### Assignment 1:

```
/*
 //      ▒▒                       ▒▒           ▒▒▒▒▒▒▒▒▒▒▒
 //     ▒▒▒                      ▒▒▒                ▒▒
 //    ▒▒ ▒   ▒▒▒ ▒▒  ▒  ▒     ▒▒ ▒  ▒ ▒▒▒ ▒      ▒▒▒  ▒▒▒    ▒▒▒    ▒▒
 //   ▒▒  ▒  ▒    ▒            ▒▒ ▒   ▒▒   ▒▒▒▒   ▒▒   ▒   ▒  ▒   ▒ ▒▒
 //  ▒▒▒▒▒▒ ▒▒  ▒     ▒  ▒   ▒▒▒▒▒▒  ▒   ▒      ▒▒▒  ▒▒   ▒ ▒▒   ▒ ▒▒
 // ▒▒    ▒    ▒ ▒    ▒▒ ▒▒ ▒▒    ▒ ▒▒    ▒      ▒▒   ▒  ▒  ▒   ▒  ▒▒
 //▒▒     ▒ ▒▒▒   ▒▒ ▒  ▒  ▒▒     ▒ ▒      ▒▒   ▒▒▒   ▒▒▒    ▒▒▒    ▒▒▒

 This is an AsciiArtTool:
 The program shows a grid in which you can change the color of the squares
by clicking on the screen.
 When you press 's' your grid get's converted to text with for every gray
square a ' '
 and for every green square a '▒'.
 This gets saved in a file called "Ascii.txt".

 Your assignment is to make it that when you press 'i' the screen get's
inverted,
```

```
 in other words, all the gray squares become green and all the green
squares grey.

 Press the run button once, so you know how the program works and if you're
done,
 ask the researcher to start the timer,
 scroll down
 and finish the assignment while explaining your thoughts to Poppy.

 //     ▒▒▒▒▒▒
 //   ▒▒▒     ▒▒
 //  ▒▒        ▒
 // ▒    ▒     ▒▒
 //▒▒     ▒    ▒
 // ▒      ▒▒▒▒
 // ▒▒
 //   ▒▒
 //    ▒▒
 //      ▒▒
 //        ▒▒▒
 //           ▒
 //            ▒
 //            ▒▒
 //            ▒
 //           ▒▒
 //          ▒▒
 //        ▒▒
 //        ▒▒
 //      ▒▒
 //     ▒▒
 // ▒▒  ▒▒    ▒▒
 //  ▒▒  ▒   ▒▒
 //   ▒▒ ▒▒ ▒▒
 //     ▒▒▒▒
 //
 */

//GridSize
int gridWidth = 16;
int gridHeight = 8;

//Grid information and output array
```

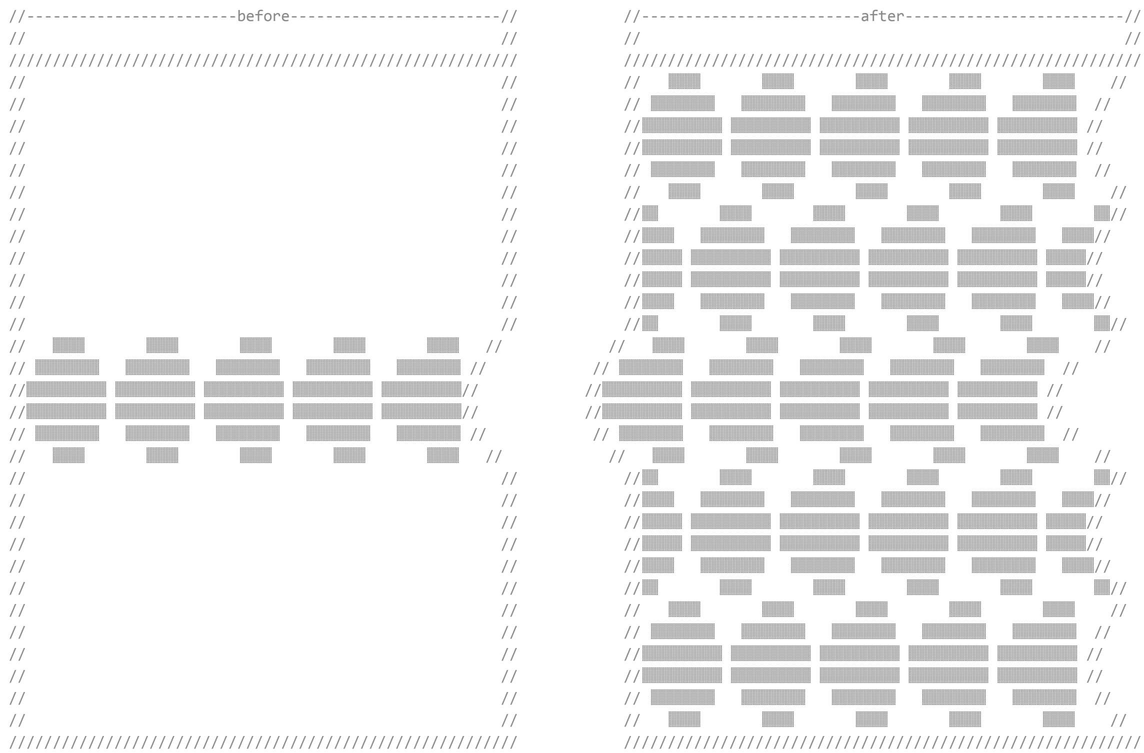
```
String squares[][] = new String[gridWidth][gridHeight];
String output[] = new String[gridHeight];

//Appearence
static byte borderWidth = 1;
static byte squareWidth = 32;
static byte squareHeight = 64;
static color activeColor = #00FF00;
static color inactiveColor = #888888;
static color borderColor = #000000;

void settings() { //Standard function in Processing, runs once before
startup
  size(squareWidth*gridWidth, squareHeight*gridHeight);
}

void setup() { //Standard function in Processing, runs once at startup
  for (int i = 0; i < gridWidth; i++) {
    for (int j = 0; j < gridHeight; j++) {
      squares[i][j] = " ";
    }
  }
}

void draw() { //Standard function in Processing, runs continuously
  //Draws the background
  background(borderColor);
  //Draws the grid
  for (int i = 0; i < gridWidth; i++) {
    for (int j = 0; j < gridHeight; j++) {
      if (squares[i][j] == " ") {
        pushStyle();
        fill(inactiveColor);
        rect(
          borderWidth+((width/gridWidth)*i),
          borderWidth+((height/gridHeight)*j),
          (width/gridWidth)-borderWidth,
          (height/gridHeight)-borderWidth
          );
        popStyle();
      }
      if (squares[i][j] == "█") {
```

```
        pushStyle();
        fill(activeColor);
        rect(
          borderWidth+((width/gridWidth)*i),
          borderWidth+((height/gridHeight)*j),
          (width/gridWidth)-borderWidth,
          (height/gridHeight)-borderWidth
          );
        popStyle();
      }
    }
  }
}

void keyReleased() { //standard function in Processing, runs whenever a
keyboard key is released
  if (key == 's' || key == 'S') {
    //saves your work
    for (int i = 0; i < gridHeight; i++) {
      String line[] = new String[gridWidth];
      for (int j = 0; j < gridWidth; j++) {
        line[j] = squares[j][i];
      }
      output[i] = join(line, "");
    }
    println("saved");
    saveStrings("Ascii.txt", output);
  }
}

void mouseReleased() { //standard function in Processing, runs whenever a
mousekey is released
  //Assignes the variables to the grid
  for (int i = 0; i < gridWidth; i++) {
    for (int j = 0; j < gridHeight; j++) {
      if (mouseX > i * (width/gridWidth) && mouseX < (width/gridWidth) + (i
* (width/gridWidth))) {
        if (mouseY > j * (height/gridHeight) && mouseY <
(height/gridHeight) + (j * (height/gridHeight))) {
          println(i+";"+j);
          if (squares[i][j] == " ") {
            squares[i][j] = "▦";
```

```
          } else {
            squares[i][j] = " ";
          }
        }
      }
    }
  }
}
```

**Assignment 2:**

```
//code is based on code from Processing:
https://processing.org/examples/radialgradient.html
/*
```




```
 This is a GradientBall visualisation:
 The program shows a patern, like shown in the top left, of colored spheres
.
 The spheres have a radial gradient and change color every second.

 Your assignment is to change the pattern to what you see in the top right.
 in other words, add two more rows that are offset by half a sphere.

 Press the run button once, so you know how the program works and if you're
done,
```

```
 start the timer,
 scroll down
 and finish the assignment.

 //     ▓▓▓▓▓▓
 //   ▓▓▓     ▓▓
 //  ▓▓        ▓
 // ▓    ▓     ▓▓
 //▓▓     ▓    ▓
 // ▓      ▓▓▓▓
 // ▓▓
 //   ▓▓
 //    ▓▓
 //      ▓▓
 //        ▓▓▓
 //           ▓
 //            ▓
 //            ▓▓
 //            ▓
 //           ▓▓
 //          ▓▓
 //        ▓▓
 //        ▓▓
 //      ▓▓
 //     ▓▓
 // ▓▓  ▓▓    ▓▓
 //  ▓▓  ▓   ▓▓
 //   ▓▓ ▓▓ ▓▓
 //     ▓▓▓▓
 //
 */

int dim;

void setup() {
  size(640, 360);
  dim = width/9;
  background(0);
  colorMode(HSB, 360, 100, 100);
  noStroke();
  ellipseMode(RADIUS);
  frameRate(1);
```

```
}

void draw() {
  background(0);
  for (int x = dim/2; x <= width; x+=dim) {
      drawGradient(x, height/2);
  }
}


void drawGradient(float x, float y) {
  int radius = dim/2;
  float h = random(0, 360);
  for (int r = radius; r > 0; --r) {
    fill(h, 90, 90);
    ellipse(x, y, r, r);
    h = (h + 1) % 360;
  }
}
```

### 8.6 Appendix F: Questionnaire

O: open question
C: closed question
R: rate whether agree with the statement (strongly disagree to strongly agree)

**Demographics**
O: Participant number
O: What is your age?
O: What is your gender?
O: What is your nationality?
C: Are you a Student at the University of Twente
R: Relative to an average CreaTer who finished their first year, I am a good programmer

**Quality of Puppeteering**
R: Poppy reacted to me in a credible way
R: Poppy reacted directly (without delay) to me
R: Poppy’s emotions where neither too small nor too big
R: I like the appearance of Poppy
R: I like Poppy as a robot

R: Poppy’s emotions where convincing
R: My feelings have changed positively about Poppy during this experiment

Perceived Affective Understanding – Harms & Boicca
R: I could tell how Poppy felt
R: Poppy could tell how I felt
R: Poppy’s emotions were not clear to me
R: My emotions were not clear to Poppy
R: I could describe Poppy feelings accurately
R: Poppy could describe my feelings accurately.

**Social Connectedness**
R: I had a connection with Poppy
R: Poppy had a connection with me
R: I am willing to talk to Poppy more often

Perceived Message understanding
R: My thoughts were clear to Poppy
R: Poppy’s thoughts were clear to me
R: It was easy to understand Poppy
R: Poppy found it easy to understand me
R: Understanding Poppy was difficult
R: Poppy had a difficulty understanding me

Perceived Sociability – Heerink
R: I consider Poppy a pleasant conversational partner
R: I find Poppy pleasant to interact with
R: I feel Poppy understands me.
R: I think Poppy is nice

**Comfort**
R: I felt comfortable talking to Poppy
R: I had no problems explaining the code to Poppy
R: I felt at ease when explaining the code to Poppy
R: It was easy talking to Poppy
R: It felt awkward talking to Poppy
R: I felt forced to talk to Poppy

Anxiety – Heerink
R: If I should use Poppy, I would be afraid to make mistakes with it
R: If I should use Poppy, I would be afraid to break something
R: I find Poppy scary
R: I find Poppy intimidating

**Usefulness**
R: I understood the code better after I explained it to (the animated) Poppy
R: I felt like Poppy was distracting
R: I felt like Poppy was a useful addition in understanding the code
R: I felt like talking to Poppy was helpful
R: I would've needed more time if Poppy wasn't there
R: I would consider explaining something to someone else more often to get a better understanding myself
R: I would consider explaining something to Poppy more often to get a better understanding myself

Perceived usefulness – Harms & Boicca
R: I think Poppy is useful to me
R: It would be convenient for me to have Poppy
R: I think Poppy can help me with many things.

## 8.7 Appendix G: Test Data

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| What is your participant number? (ask the researcher) | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| What is your age? | 20 | 20 | 21 | 19 | 19 | 41 | 26 | 19 | 20 | 21 | 19 | 20 | 20 | 19 | 21 | 20 | 20 | 21 |
| What is your gender? | F | M | F | M | F | M | M | M | M | M | F | M | M | F | F | F | F | M |
| What is your nationality? | NL | NL | NL | NL | NL, PT | NL | FR | ID | NL | NL | NL | NL | NL | NL | NL | NL | NL | NL |
| Are you a student at the University of Twente? | Yes | Yes | Yes | Yes | Yes | teacher | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Relative to an average CreaTer who finished their first year, are you a good programmer? | 2 | 3 | 2 | 4 | 3 | 1 | 3 | 3 | 3 | 2 | 3 | 4 | 1 | 3 | 4 | 4 | 2 | 2 |
| C: Comfort | 4.00 | 3.17 | 3.67 | 4.17 | 2.67 | 2.60 | 3.00 | 3.00 | 3.83 | 3.83 | 2.00 | 3.00 | 3.00 | 2.00 | 4.00 | 1.00 | 4.17 | 4.17 |
| C1: Talking to poppy comfort | 4.00 | 3.17 | 3.67 | 4.17 | 2.67 | 2.60 | 3.00 | 3.00 | 3.83 | 3.83 | 2.00 | 3.00 | 3.00 | 2.00 | 4.00 | 1.00 | 4.17 | 4.17 |
| C1.1: I felt at ease when explaining the code to Poppy | 4 | 3 | 4 | 4 | 3 | 2 | 3 | 3 | 4 | 4 | 2 | 4 | 3 | 2 | 4 | 1 | 4 | 4 |
| C1.2: I felt comfortable talking to Poppy | 4 | 4 | 4 | 4 | 3 | | 4 | 3 | 2 | 4 | 2 | 2 | 4 | 2 | 5 | 1 | 5 | 5 |
| C1.3: (inverse) I felt forced to talk to Poppy | 5 | 2 | 4 | 4 | 3 | 3 | 3 | 3 | 4 | 4 | 2 | 2 | 4 | 2 | 4 | 1 | 4 | 3 |
| C1.4: I had no problems explaining the code to Poppy | 3 | 5 | 2 | 5 | 2 | 2 | 2 | 3 | 4 | 3 | 3 | 4 | 1 | 2 | 3 | 1 | 4 | 4 |
| C1.5: (inverse) It felt awkward talking to Poppy | 4 | 2 | 4 | 4 | 2 | 3 | 2 | 2 | 5 | 4 | 1 | 2 | 2 | 2 | 4 | 1 | 4 | 4 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1.6: It was easy talking to Poppy | 4 | 3 | 4 | 4 | 3 | 3 | 4 | 4 | 4 | 4 | 2 | 4 | 4 | 2 | 4 | 1 | 4 | 5 |
| C2: Anxiety | | | | | | | | | | | | | | | | | | |
| C2.1: I find Poppy intimidating | 1 | 1 | 2 | 1 | 3 | 1 | 1 | 1 | 4 | 1 | 1 | 3 | 1 | 4 | 1 | 3 | 1 | 2 |
| C2.2: I find Poppy scary | 1 | 1 | 1 | 1 | 3 | 2 | 1 | 1 | 4 | 1 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 |
| C2.3: If I should use Poppy, I would be afraid to break something | 4 | 3 | 2 | 2 | 2 | 1 | 4 | 4 | 2 | 2 | 1 | 3 | 1 | 2 | 3 | 1 | 1 | 4 |
| C2.4: If I should use Poppy, I would be afraid to make mistakes with it | 1 | 1 | 2 | 1 | 1 | 3 | 3 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 |
| Q: Quality of puppeteering | 4.17 | 4.08 | 3.53 | 3.89 | 3.14 | 3.33 | 3.58 | 4.36 | 2.39 | 3.61 | 3.17 | 3.92 | 4.64 | 3.42 | 3.67 | 2.97 | 3.89 | 3.58 |
| Q1: likeness of Poppy | 4.50 | 4.50 | 4.00 | 4.00 | 3.50 | 4.00 | 4.00 | 4.50 | 2.00 | 3.50 | 3.50 | 4.00 | 5.00 | 4.00 | 4.00 | 3.00 | 4.50 | 3.50 |
| Q1.1: I like Poppy as a robot | 5 | 5 | 4 | 4 | 4 | 4 | 5 | 5 | 2 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 5 | 4 |
| Q1.2: I like the appearance of Poppy | 5 | 5 | 4 | 5 | 5 | 4 | 5 | 5 | 4 | 4 | 5 | 4 | 5 | 2 | 5 | 4 | 5 | 4 |
| Q1.3: My feelings have changed positively about Poppy during this experiment | 4 | 4 | 4 | 4 | 3 | 4 | 3 | 4 | 2 | 3 | 3 | 4 | 5 | 4 | 4 | 2 | 4 | 3 |
| Q2: emotive convincingness | 4.00 | 3.75 | 3.25 | 4.00 | 3.25 | 3.50 | 3.75 | 4.25 | 2.50 | 4.00 | 3.00 | 3.75 | 4.75 | 3.25 | 3.50 | 2.75 | 3.50 | 3.75 |
| Q2.1: Poppy reacted directly (without delay) to me | 4 | 4 | 3 | 4 | 3 | 4 | 4 | 5 | 3 | 5 | 3 | 4 | 5 | 3 | 3 | 3 | 4 | 4 |
| Q2.2: Poppy reacted to me in a credible way | 4 | 4 | 4 | 4 | 4 | 3 | 4 | 4 | 3 | 4 | 3 | 4 | 4 | 3 | 4 | 3 | 4 | 4 |
| Q2.3: Poppy's emotions where convincing | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 2 | 3 | 3 | 4 | 5 | 4 | 3 | 3 | 3 | 4 |
| Q2.4: Poppy's emotions where neither to small nor to big | 4 | 3 | 2 | 4 | 3 | 4 | 4 | 4 | 2 | 4 | 3 | 3 | 5 | 3 | 4 | 2 | 3 | 3 |
| Q3: Perceived Affective Understanding | 4.00 | 4.00 | 3.33 | 3.67 | 2.67 | 2.50 | 3.00 | 4.33 | 2.67 | 3.33 | 3.00 | 4.00 | 4.17 | 3.00 | 3.50 | 3.17 | 3.67 | 3.50 |
| Q3.1: It was easy to understand Poppy | 4 | 4 | 3 | 4 | 2 | 2 | 3 | 5 | 2 | 4 | 3 | 4 | 4 | 3 | 4 | 4 | 4 | 4 |
| Q3.2: My thoughts were clear to Poppy | 4 | 4 | 3 | 4 | 3 | 2 | 2 | 3 | 3 | 4 | 4 | 4 | 4 | 2 | 3 | 2 | 3 | 4 |
| Q3.3: Poppy found it easy to understand me | 3 | 4 | 3 | 3 | 3 | 2 | 4 | 4 | 3 | 3 | 3 | 4 | 4 | 3 | 4 | 2 | 4 | 3 |
| Q3.4: (inverse)Poppy had a difficulty understanding me | 4 | 4 | 4 | 3 | 4 | 3 | 3 | 5 | 4 | 3 | 3 | 4 | 4 | 3 | 2 | 4 | 4 | 3 |
| Q3.5: Poppy's thoughts were clear to me | 4 | 4 | 3 | 4 | 2 | 2 | 3 | 4 | 2 | 3 | 2 | 4 | 4 | 4 | 4 | 3 | 3 | 3 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q3.6: (inverse)Understanding Poppy was difficult | 5 | 4 | 4 | 4 | 2 | 4 | 3 | 5 | 2 | 3 | 3 | 4 | 5 | 3 | 4 | 4 | 4 | 4 |
| S: Social Connectedness | 4.42 | 4.17 | 3.71 | 3.79 | 2.63 | 2.79 | 3.29 | 3.88 | 2.21 | 3.38 | 2.71 | 3.88 | 4.33 | 3.00 | 4.25 | 2.87 | 3.42 | 3.67 |
| S1: Percieved connection | | | | | | | | | | | | | | | | | | |
| S1.1: I am willing to talk to Poppy more often | 5 | 4 | 4 | 4 | 2 | 2 | 3 | 4 | 3 | 4 | 2 | 4 | 4 | 2 | 4 | 3 | 5 | 4 |
| S1.2: I had a connection with Poppy | 3 | 3 | 4 | 4 | 2 | 3 | 2 | 4 | 4 | 2 | 3 | 3 | 4 | 2 | 4 | 2 | 3 | 3 |
| S1.3: Poppy had a connection with me | 4 | 4 | 3 | 3 | 3 | 2 | 2 | 4 | 2 | 3 | 2 | 3 | 4 | 3 | 4 | 2 | 2 | 2 |
| S2: percieved message understanding | 4.33 | 3.83 | 3.67 | 3.83 | 2.50 | 2.83 | 3.33 | 3.50 | 2.17 | 3.00 | 2.67 | 3.50 | 4.17 | 3.50 | 4.00 | 2.40 | 3.33 | 3.33 |
| S2.1: I could describe Poppy feelings accurately | 4 | 3 | 3 | 3 | 3 | 2 | 3 | 1 | 2 | 3 | 3 | 3 | 4 | 4 | 4 | 2 | 4 | 4 |
| S2.2: I could tell how Poppy felt | 5 | 4 | 4 | 4 | 2 | 3 | 3 | 4 | 2 | 4 | 3 | 4 | 4 | 4 | 4 | 4 | 3 | 4 |
| S2.3: (inverse)My emotions were not clear to Poppy | 4 | 4 | 4 | 4 | 3 | 3 | 3 | 4 | 3 | 3 | 3 | 3 | 5 | 3 | 4 | | 3 | 3 |
| S2.4: (inverse)Poppy's emotions were not clear to me | 5 | 4 | 4 | 5 | 2 | 3 | 4 | 4 | 3 | 3 | 2 | 4 | 5 | 4 | 4 | 2 | 4 | 3 |
| S2.5:Poppy could describe my feelings accurately | 4 | 4 | 4 | 3 | 2 | 3 | 4 | 4 | 2 | 2 | 2 | 3 | 3 | 2 | 4 | 2 | 3 | 2 |
| S2.6:Poppy could tell how I felt | 4 | 4 | 3 | 4 | 3 | 3 | 3 | 4 | 1 | 3 | 3 | 4 | 4 | 4 | 4 | 2 | 3 | 4 |
| S3: Perceived sociability | 4.50 | 4.50 | 3.75 | 3.75 | 2.75 | 2.75 | 3.25 | 4.25 | 2.25 | 3.75 | 2.75 | 4.25 | 4.50 | 2.50 | 4.50 | 3.33 | 3.50 | 4.00 |
| S3.1: I consider Poppy a pleasant conversational partner | 4 | 4 | 4 | 3 | 2 | 2 | 1 | 3 | 1 | 4 | 2 | 4 | 4 | 2 | 5 | 3 | 4 | 4 |
| S3.2: I feel Poppy understands me | 5 | 4 | 3 | 4 | 3 | 2 | 4 | 4 | 3 | 4 | 3 | 4 | 4 | 3 | 4 | 3 | 2 | 4 |
| S3.3: I find Poppy pleasant to interact with | 4 | 5 | 4 | 4 | 2 | 3 | 4 | 5 | 1 | 3 | 2 | 4 | 5 | 2 | 4 | 3 | 4 | 4 |
| S3.4: I think Poppy is nice | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 5 | 4 | 4 | 4 | 5 | 5 | 3 | 5 | 4 | 4 | 4 |
| U: Usefulness | 3.83 | 2.67 | 4.00 | 3.67 | 2.17 | 3.00 | 2.57 | 3.14 | 2.43 | 3.17 | 2.45 | 3.71 | 3.86 | 2.74 | 3.76 | 1.71 | 3.67 | 2.14 |
| U1: Perceived effectiveness | 4.00 | 3.00 | 4.00 | 4.00 | 2.00 | 3.00 | 2.14 | 3.29 | 2.86 | 3.00 | 2.57 | 3.43 | 3.71 | 3.14 | 3.86 | 1.43 | 4.00 | 2.29 |
| U1.1: I felt like Poppy was a useful addition in understanding the code | 3 | 4 | 4 | 3 | 2 | 4 | 2 | 3 | 2 | 1 | 2 | 4 | 3 | 3 | 4 | 1 | 4 | 2 |
| U1.2: (inverse)I felt like Poppy was distracting | 5 | 5 | 4 | 4 | 5 | 3 | 2 | 5 | 2 | 2 | 2 | 2 | 4 | 2 | 5 | 1 | 3 | 4 |
| U1.3: I felt like talking to Poppy | 4 | 2 | 4 | 4 | 2 | 3 | 3 | 4 | 4 | 4 | 2 | 4 | 4 | 3 | 4 | 1 | 4 | 2 |

| | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| was helpful | | | | | | | | | | | | | | | | | | |
| U1.4: I understood the code better after I explained it to (the animated) Poppy | 3 | 2 | 4 | 5 | 1 | 2 | 2 | 3 | 3 | 4 | 3 | 4 | 4 | 3 | 4 | 2 | 4 | 1 |
| U1.5: I would consider explaining something to Poppy more often to get a better understanding myself | 4 | 2 | 4 | 5 | 2 | 2 | 3 | 4 | 3 | 4 | 2 | 4 | 4 | 4 | 4 | 2 | 5 | 3 |
| U1.6: I would consider explaining something to someone else more often to get a better understanding myself | 4 | 4 | 4 | 4 | 1 | 4 | 2 | 2 | 4 | 4 | 5 | 4 | 4 | 4 | 4 | 2 | 4 | 3 |
| U1.7: I would've needed more time if Poppy wasn't there | 5 | 2 | 4 | 3 | 1 | 3 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 1 | 4 | 1 |
| U2: Perceived usefulness | 3.67 | 2.33 | 4.00 | 3.33 | 2.33 | 3.00 | 3.00 | 3.00 | 2.00 | 3.33 | 2.33 | 4.00 | 4.00 | 2.33 | 3.67 | 2.00 | 3.33 | 2.00 |
| U2.1: I think Poppy can help me with many things | 3 | 3 | 4 | 3 | 2 | 2 | 3 | 4 | 2 | 2 | 3 | 4 | 4 | 2 | 4 | 3 | 3 | 2 |
| U2.2: I think Poppy is useful to me | 4 | 2 | 4 | 4 | 3 | 4 | 4 | 3 | 2 | 4 | 2 | 4 | 4 | 3 | 4 | 1 | 3 | 2 |
| U2.3: It would be convenient for me to have Poppy | 4 | 2 | 4 | 3 | 2 | 3 | 2 | 2 | 2 | 4 | 2 | 4 | 4 | 2 | 3 | 2 | 4 | 2 |
| Video Data Assignment 1 | | | | | | | | | | | | | | | | | | |
| First or Second | F | F | S | S | F | F | S | S | F | F | S | S | F | F | S | S | F | S |
| Animated | no | yes | yes | no | no | yes | yes | no | no | yes | yes | no | no | yes | yes | no | yes | no |
| Finished the assignment | no | yes | no | yes | no | no | no | yes | no | no | no | yes | no | no | yes | no | yes | no |
| Length in s | 420 | 192 | 420 | 353 | 420 | 420 | 420 | 355 | 404 | 420 | 420 | 342 | 420 | 420 | 420 | 420 | 420 | 420 |
| Talk time in s | 81 | 0 | 227 | 146 | 35 | 52 | 175 | 119 | 175 | 65 | 21 | 70 | 11 | 31 | 156 | 0 | 100 | 203 |
| Video Data Assignment 2 | | | | | | | | | | | | | | | | | | |
| First or Second | S | S | F | F | S | n.a. | F | F | S | S | F | F | S | S | F | F | S | F |
| Animated | yes | no | no | yes | yes | n.a. | no | yes | yes | no | no | yes | yes | no | no | yes | no | yes |
| Finished the assignment | yes | no | no | yes | yes | n.a. | no | no | no | no | no | yes | no | yes | no | no | yes | no |
| Length in s | 372 | 420 | 420 | 368 | 345 | n.a. | 420 | 420 | 383 | 398 | 420 | 223 | 420 | 410 | 420 | 420 | 337 | 420 |
| talk time in s | 107 | 97 | 139 | 160 | 133 | n.a. | 165 | 147 | 184 | 60 | 35 | 81 | 76 | 29 | 148 | 0 | 50 | 225 |

## Annotated Data

| | Explaining | Narrating | Communicative Sounds | Unknown | Talking |
|---|---|---|---|---|---|
| '1-1' | 6,72 | 54,68 | 11,48 | 7,76 | 0,00 |
| '1-2' | 21,84 | 33,88 | 34,52 | 10,72 | 6,16 |
| '2-1' | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| '2-2' | 72,84 | 6,88 | 8,08 | 4,52 | 4,24 |
| '3-1' | 77,84 | 10,08 | 26,80 | 19,88 | 4,08 |
| '3-2' | 109,68 | 29,16 | 47,96 | 21,64 | 18,28 |
| '4-1' | 63,16 | 51,24 | 31,56 | 3,52 | 8,64 |
| '4-2' | 73,00 | 39,68 | 18,64 | 11,56 | 3,92 |
| '5-1' | 7,80 | 5,60 | 4,72 | 17,20 | 0,00 |
| '5-2' | 35,48 | 19,44 | 13,80 | 6,72 | 17,88 |
| '6-1' | 30,36 | 1,52 | 4,04 | 0,00 | 16,44 |
| '7-1' | 82,88 | 20,60 | 30,28 | 22,76 | 8,20 |
| '7-2' | 40,64 | 36,00 | 31,60 | 28,52 | 37,88 |
| '8-1' | 35,00 | 29,76 | 18,92 | 49,40 | 13,80 |
| '8-2' | 25,64 | 39,32 | 10,08 | 38,80 | 2,12 |
| '9-1' | 74,56 | 39,00 | 11,76 | 43,88 | 5,88 |
| '9-2' | 43,80 | 78,80 | 20,40 | 17,12 | 23,84 |
| '10-1' | 63,92 | 0,00 | 0,36 | 0,00 | 1,16 |
| '10-2' | 40,20 | 10,96 | 6,84 | 2,12 | 0,00 |
| '11-1' | 19,72 | 0,00 | 12,72 | 0,00 | 2,68 |
| '11-2' | 9,12 | 0,00 | 5,32 | 6,24 | 0,00 |

| | | | | | |
|---|---|---|---|---|---|
| '12-1' | 41,60 | 21,40 | 11,72 | 2,64 | 3,60 |
| '12-2' | 14,44 | 37,68 | 9,48 | 8,24 | 0,00 |
| '13-1' | 0,00 | 0,00 | 1,60 | 0,24 | 8,76 |
| '13-2' | 0,00 | 15,48 | 10,96 | 28,96 | 20,80 |
| '14-1' | 22,52 | 0,00 | 6,08 | 0,84 | 1,76 |
| '14-2' | 17,36 | 1,88 | 0,80 | 8,80 | 0,00 |
| '15-1' | 11,36 | 36,60 | 20,40 | 36,24 | 3,52 |
| '15-2' | 50,52 | 50,08 | 20,96 | 14,04 | 19,24 |
| '16-1' | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| '16-2' | 0,00 | 0,00 | 0,00 | 0,00 | 0,00 |
| '17-1' | 64,36 | 14,28 | 16,36 | 2,20 | 2,44 |
| '17-2' | 23,88 | 11,92 | 8,24 | 1,48 | 4,52 |
| '18-1' | 65,64 | 123,96 | 22,28 | 1,76 | 11,44 |
| '18-2' | 133,92 | 44,08 | 16,28 | 3,48 | 5,24 |

### 8.8 Appendix H: Reflection Report

# Introduction

## Project overview

This document is an ethical review about the “Poppy as advanced rubber ducky” project. It will discuss the ethical aspect of the project and what is morally good and bad about it. This Project started with Poppy. Poppy is a child sized humanoid and open source robot designed for educational artistic, engineering, humanities and life science research. The goal of this project is to investigate social interaction with Poppy. The way that this is going to be done in a meaningful manner is by exploring the rubber ducky effect. The term comes from the computer science scene. The story goes that there was a programmer stuck on his code and asked his supervisor about it. The supervisor gave him a rubber ducky and said to explain his code to it. By explaining the code to the rubber ducky, the programmer understood his own code better and was able to work out the bugs and thus the term ‘rubber ducky debugging’ was born. The plan with Poppy is to have it act like an advanced rubber ducky. In other words, it will be used to speak to and help you understand a certain problem better: a listening robot. However, it might also be useful support ordering thoughts, practice conversations and presentations, or just to get something off your chest. The difference between an actual rubber ducky and a humanoid robot is that, instead of doing nothing, the robot will try to motivate the explaining behavior by interacting with, and reacting to the person in question. This builds on the premise that someone would rather converse with something that acts alive and aware than something that does not. This report is going to consider hypothetical versions of the further developed Poppy as an advanced rubber ducky in different scenarios.

First the possible stakeholders are explored, then the moral consequences that might occur are discussed, thereafter conclusions will be derived from the discussion and finally there will be a small personal reflection on this report.

# Stakeholders

To identify the stakeholders there will be looked at what Poppy as advanced rubber ducky could and might be used for. Firstly, it might be used for: social interaction to order thoughts (programming help, study help or support during emotionally difficult times), social interaction for practice (practicing a job interview, practicing a presentation or a conversation with an acquaintance) and intrinsic social interaction (for people that need more social interaction in general of socially challenged people). Secondly, it can be used for research and possible stakeholders that interact directly with Poppy are: students who could use Poppy as a learning tool, programmers that could use Poppy as a debugging tool, Other stakeholders might be: IT businesses, universities and personal trainers, because they might have to provide a Poppy. Thirdly people in need of more social contact who could use Poppy as a substitution for other social contact, and people who need to rehearse with “a listener”. Fourthly, because Poppy has the size of a child and it is not illegal to have sexual interactions with a robot Poppy is of use to pedophiles for a sexual outlet and finally robot enthusiasts (artists, tinkerers, researchers, educators) who want to hack Poppy to do the things they want it to.

# Possible ethical consequences

The use of Poppy might lead to morally undesirable consequences. Where all people should benefit from its use, poor or disabled persons are excluded because new technology is expensive.  Another consequence can be, that by using Poppy as a substitute for interaction with human beings, social connections might become obsolete and people get socially excluded. Moreover, people can get dependent on the robot, by getting used to it or even falling in love with it. Lastly, as all technology, it can be used to bother other people in a socially unaccepted way.

# Exclusion

The first cause of exclusion is money. This robot is expensive for most people[1]. The people who might need a study helper the most are probably also the people who can't pay for one: (poor) students. On the other hand, if this concept of Poppy as an advanced rubber ducky seems promising enough there can be research on how to make this concept cheaper. Universities might be inclined to buy more robots for their students if it really proofs to help. This all however still does not directly translate to poorer countries where the schools do not have enough money to buy robots.
Also, Poppy's system depends on the use of eyesight to create effect, and 0.5%[2] of the world population is blind. In this case it becomes the question if a design is supposed to be used by everyone. A utilitarian approach[3] would be to only design and develop things that contribute to the general happiness. In other words, to create something that gives the most happiness to the most amount of people. In this case developing Poppy as an advanced rubber ducky would probably be morally sound, since most people are not blind and people who are not proficient in using the potential of Poppy probably are not interested in using it in the first place. So, the net total of happiness would go up. On the other hand, there is the deontological[4] approach, which is more duty bound and states that if something is bad, it will always be bad regardless of the consequences. In this case one could argue that since this concept of Poppy can be seen as discriminating, and since discriminating is morally unjust, the development of Poppy as an advanced rubber ducky is unjust. However, it is morally good to help people, and, within this concept, Poppy is built to do that, which makes it, using the same logic, morally good.

# Social Exclusion

A different form of exclusion that might occur is that Poppy might replace some social connections. For instance, a son might always have needed his father to help him with his homework and thus they created a good social bond with each other. If suddenly the father is not needed anymore because a robot replaced that need, it can have a serious impact on their relationship. And because robots can always be improved they might become close to the perfect study partner and makes this exclusion inevitable because the robot is therefore more preferred. If this happens, the son's idea about social interaction might change to the point that interacting with his father about homework is just tiresome because the robot is a 'perfect' partner to interact with. This renders humans less capable than they used to be in this aspect of life. However, this has already happened to some extent. A larger part of the population used to be more physically fit due to food not being readily available and getting said food was physically demanding. Besides that, allergies are becoming more present in current times because children get less exposure to dirt and filth[5]. Also, there seem to be more visual impairments due to modern lifestyles[6]. The pragmatic ethics movement [7]is one that that fits this phenomenon. The hypothesis is that it is bad to replace social interactions between humans with human robot interaction but in due time the hypothesis might be rejected for a hypothesis that states that interaction between humans is worse than human robot interaction. Besides that, robots might also provide social interaction for people that don't have access to it.

## Social Implications

The concept of Poppy as an advanced rubber ducky requires a person to speak to Poppy. Because of this, Poppy can be used to perform selfish acts that can be harmful for others. For example, if a student brings Poppy to a place where also other students study, because the student feels that studying is done best at that place, and the student starts to talk to Poppy the others can be distracted which could cause them to fail a class. If the concept of Poppy works as it should and this is not regulated the above is a reasonable possibility. But regulation is essentially taking away a little freedom. There is a good chance that the student of the example really takes the utmost care to not bother the others by talking softly and sitting far from the others which might result in all the students to pass their exams. Another possibility might be that it works very well for most students, when someone talks to a robot, but then that single person that like to work in silence needs to adjust to rest. This is in line with the utilitarian approach though. Because in this case, the advanced rubber ducky concept causes more happiness to more students than working in silence. But there might just be a sweet spot between regulating and freedom in this example where both silence and rubber duckies can coexist.

*Creating dependency*

If people use Poppy as an advanced rubber ducky extensively, some might get so used to it or find it so helpful that they are unable to go without it. People might not think clearly anymore without talking out loud to something or someone. This can have effect on their daily life if they need to keep secrets or follow informative presentations where people are expected to keep silent.

Another way of dependency is if people fall in love. This can happen because Poppy as an advanced rubber ducky is made to listen which might not be self-evident for everybody. It is very much possible that falling in love with robots is not accepted in this society and this might have an effect on how to deal with it. They might try to keep it a secret and feel embarrassed or this person might not be taken seriously because he is the weird one that has a robot as significant other. Another option is that they suppress their feelings and get depressed.

People who might have this problem can be pedophiles, because Poppy kind of looks like a child. This can be a good thing if Poppy is used as an outlet for them so that they do not have sexual or romantic tendencies towards children who are not ready for romance or sexuality . What also could happen is that they are not fully satisfied with a robot and get more frustrated which can lead to illegal activity.

# Conclusion

The Poppy as an advanced rubber ducky project is a research project to see whether advanced rubber duckies are a useful concept. Although the research outcomes are yet unclear, the concept is promising and it could help out a lot of people. In this paper the consequences of the “Poppy as an advanced rubber ducky” project is explored on moral issues. Found was, that exclusion, social exclusion, application in a socially unaccepted way and dependency could follow when the undertaken research would turn out to be fruitful and Poppy was taken into production.
Of these, some problems are concerned with the prize of technology and others with the use of Poppy as a rubber ducky. To prevent most of these consequences is to not use Poppy for the rubber duckie concept because Poppy is expensive and poppy is a small humanoid which people relate to easily. Although this was exactly the reason it is used to test this concept: since people can easily read social cues from a humanoid and that is very useful for the proof of the concept. Unless it appears that for the concept to really work the robot needs to be similar to Poppy, it is also possible to use something that can be lend or leased or is available at the place where it is used. This would solve the issue of people using Poppy at inappropriate times and places. However, in this small-scale research these problems could not a threat, while the robot has only been used in the experimental setup.

# Reflection

The writing of this report was interesting because I could explore the edges of the consequences of my research. And would this concept be used in a product, then it is a good thing that the extremes already have been considered. Everything that I came up with however is not that likely to happen, especially not in the scope of this research. For the experiment I chose to have people interact with poppy for approximately fifteen minutes and measure their experience and behavior. I felt that there were at least no moral complications with the research I’ve done so far. Except maybe that I have gathered some personal information about people for the user test, but that will be officially as anonymized as needed. Making this report and thinking about the ethical issues has not made me change any design decision. However, it has strengthened my opinion about trying the rubber ducky effect with different robots that are less expensive and not necessarily resemble a human.

# References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[4] I. Kant, *Grundlegung zur Metaphysik der Sitten*. 1785.

[5] E. von Mutius and D. Vercelli, “Farm living: effects on childhood asthma and allergy,” *Nat. Rev. Immunol.*, vol. 10, no. 12, pp. 861–868, Dec. 2010.

[6] J. A. Guggenheim and C. Williams, “Role of Educational Exposure in the Association Between Myopia and Birth Order,” *JAMA Ophthalmol.*, vol. 133, no. 12, p. 1408, Dec. 2015.

[7] H. LaFollette, “Pragmatic Ethics,” *Blackwell Guid. to Ethical Theory*, pp. 400–419, 2000.

### 8.9 Appendix I: Getting Started with Poppy

## Getting started with Poppy

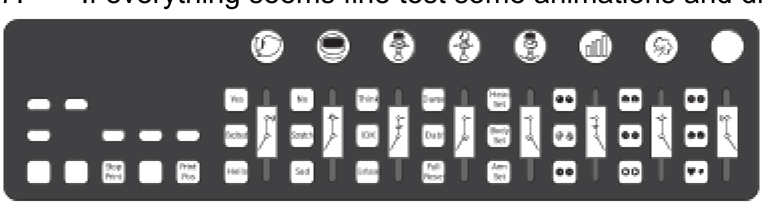
First time start-up:

1. Make sure all the sliders and knobs of the KORG nanoKONTROL2 are roughly in the middle position.
2. Make sure Poppy is as much as possible in the neutral position with the hole of the base pointing to the back.

3. Plug everything in

a. The Dynamixels in the Arduino’s (should already be).
b. The KORG nanoKONTROL2 in the Arduino Mega ADK.
c. A 12v power supply into the SMPS2Dynamixel Adapter.
d. A USB cable connected to a 5V supply (could be a laptop) and the Base Arduino.

4. Hold Poppy in the neutral Position while the startup sequence of the base Arduino is running. Poppy should snap into the neutral position.
5. Spam the square stop button on the midi controller a couple of times. Poppy’s limbs should look like they’re relaxing and it should start breathing.
6. Test all the limbs by adjusting the sliders carefully. If one of the limbs seem jittery restart the base Arduino by unplugging and replugging the USB cable and going back to the previous step.
7. If everything seems fine test some animations and different eyes using this diagram:



8. Be careful not to turn too much on the intensity knob (6th from the right) during animations.

Programming your first new animation:

1. Turn on Poppy as described above but make sure the Base Arduino is connected to a computer and a terminal to read out serial communication from the Arduino is running.

2. Put Poppy into its first position for the animation using the sliders and knobs on the midi controller.
3. Press to “Print Pos” button and look at the serial monitor. The position values should get printed.
4. Press the “Stop print” button and copy the array of joint positions.
5. If the PoppyBaseScript is opened in Arduino there should be a ‘poses.h’ tab. Click on that and make a new 2-dimensional array:

```
const static int yourAnimationNameStates[][14] = { };
```

6. Paste your copied array of joint position into the Array:

```
7.  const static int yourAnimationNameStates[][14] = {
{1090,1024,1804,3222,624,2269,3037,3135,2048,2156,2048,64,127}
};
```

8. Put a time stamp at the end of the array. This indicates how long it takes to get to that position in ticks of approximatly 200 ms.

```
9.  const static int yourAnimationNameStates[][14] = {
{1090,1024,1804,3222,624,2269,3037,3135,2048,2156,2048,64,127,5}
};
```

10. Then add all the different positions in the same manner. Make sure to have the timestamp greater for every new position.
11. Make a boolean called:

```
bool AnimationYourAnimationName = false;
```

and put it above and outside of the `void loop()`.
12. Then put

```
if (AnimationYourAnimationName) {
      playAnimation(
yourAnimationNameStates,
lengthOfYourAnimationNameArray,
eyeAnimationValue,
&AnimationYourAnimationName
);
}
```

Inside the `void loop()`. (`lengthOfYourAnimationNameArray` stands for the amount of different positions present in the animation you’re making and `eyeAnimationValue` is a value between 0 and 127 that stands for a particular eye animation)
13. Make sure the code is able to turn the `AnimationYourAnimationName` to true and upload it to the Arduino and test it out.
14. Now just tweak the animation until it is just right for your purpose.