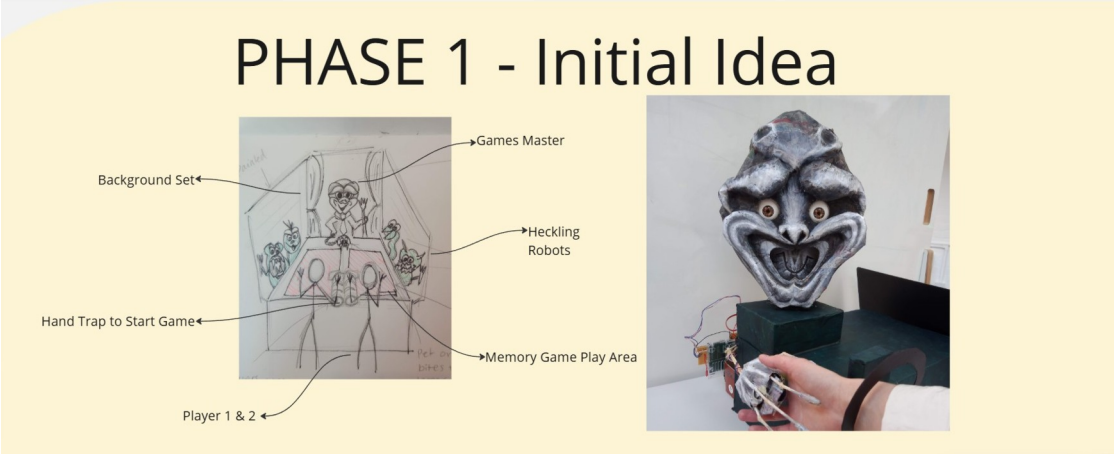
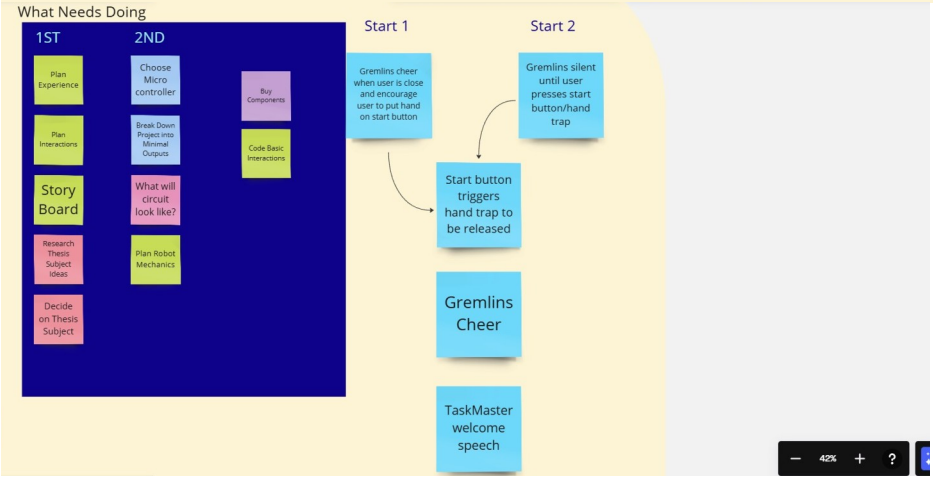
Process Book – Randy the Rabbit
By KiriAnn Rodenburg

Project Presentation Video: https://youtu.be/zIAQAEWWF1Y

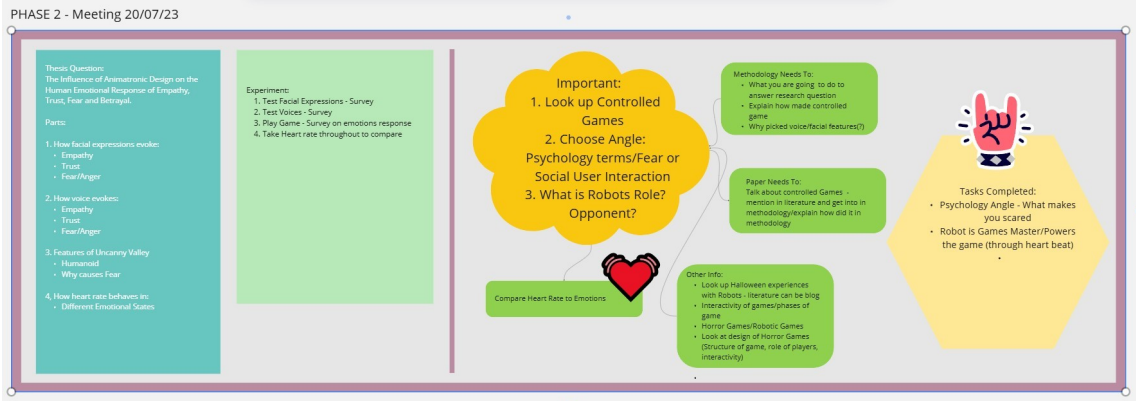
Phase 1 – Initial Idea

Inspiration – Goodbur + Others





Phase 2 – Thesis Direction



Initial Design and Reduction

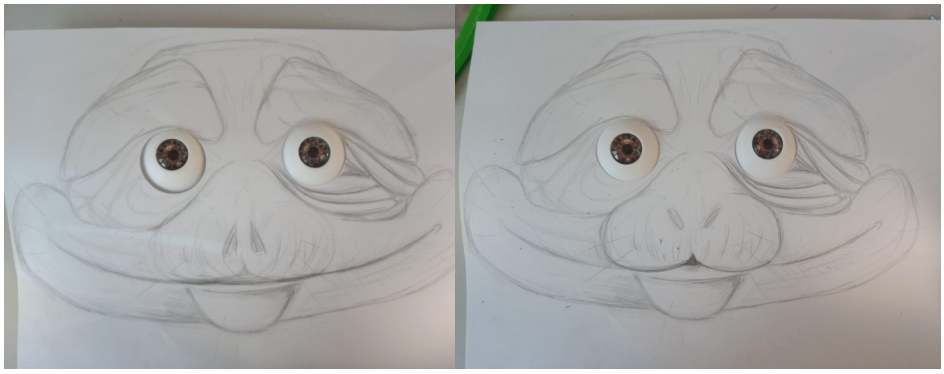
Initial Design

Phase 3 – Sketch Models & Inspiration

Sketches and Clay

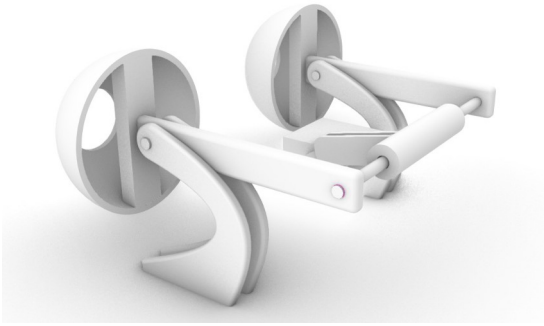
Technologist Inspo:	Mechatronics
Simone Giertz Will Cogley Michael Reeves Adam Savage's Tested	(70) Making a Robust Machined Eye Mechanism with 3D Printing and Arduino - YouTube

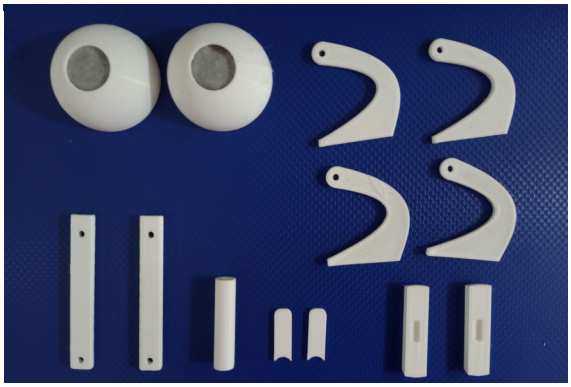
Clay sketch modelling

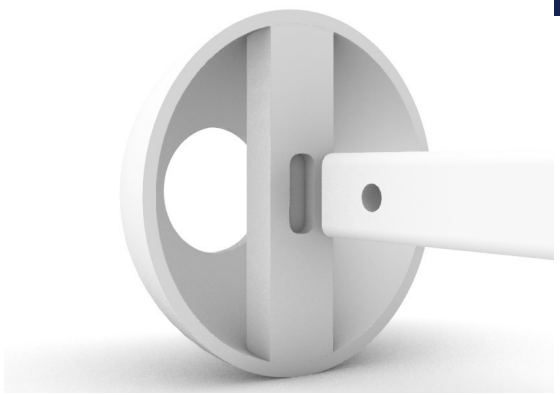


Drawn Iterations with eyes

Phase 4 – 1 Axis Eyes



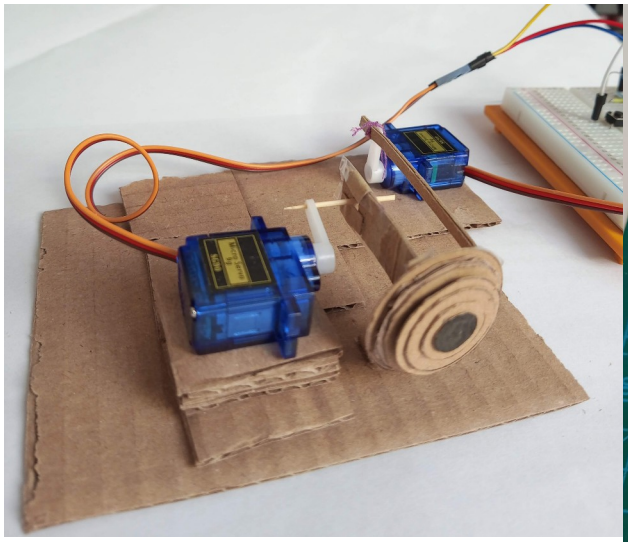
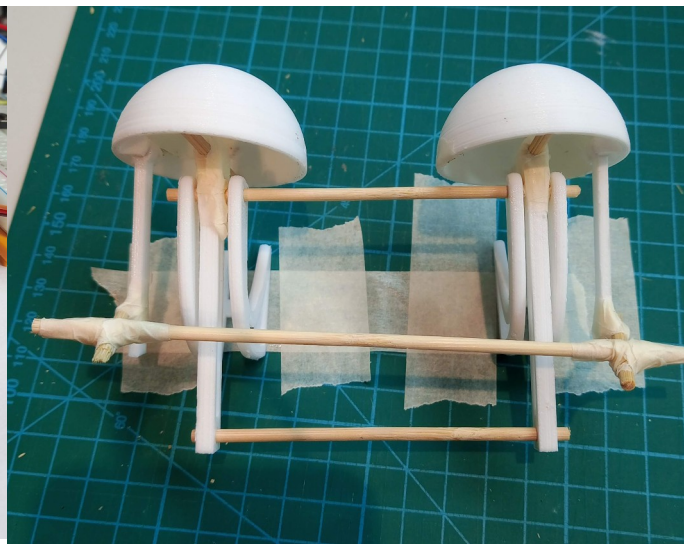




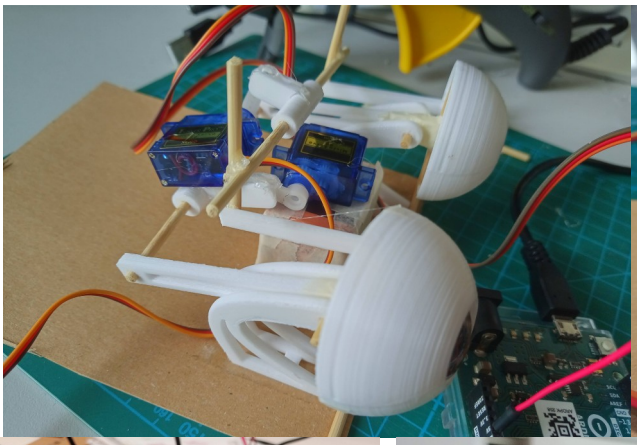
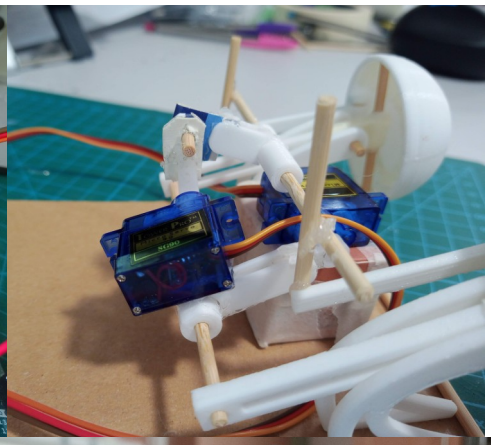
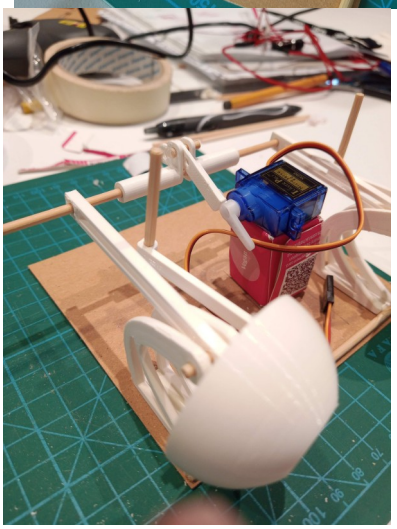
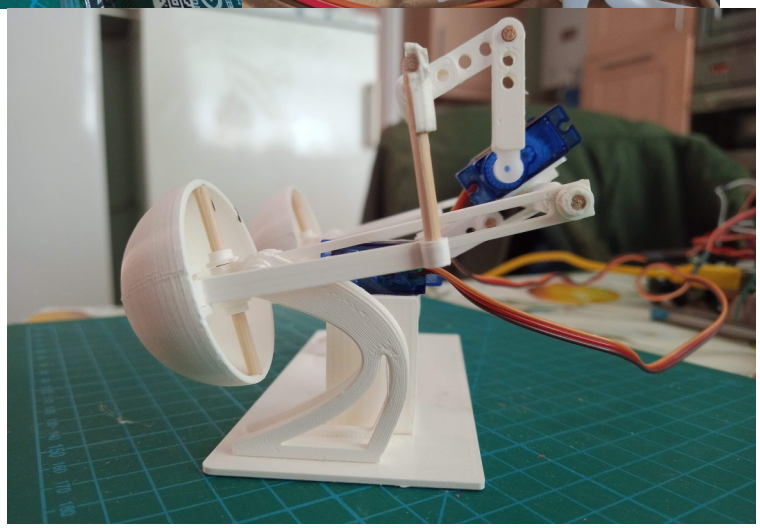
I took my existing eye mechanism design a from the robot I made in Creative Makings class (black and white robot on first page) and will develop it into a 2 axis eye so I can give the robot full eye range.

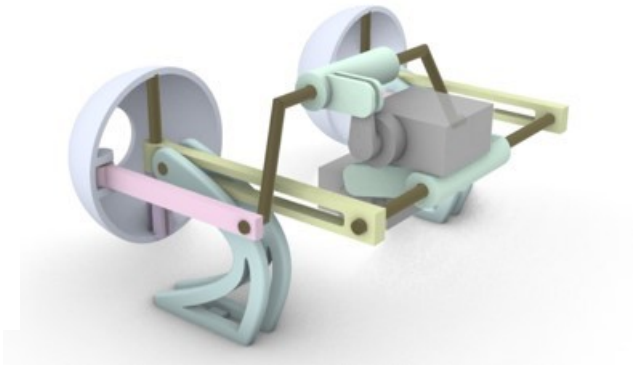
Phase 5 – 2 Axis Eyes

I started out by making the 2 axis eyes from card and two servos.

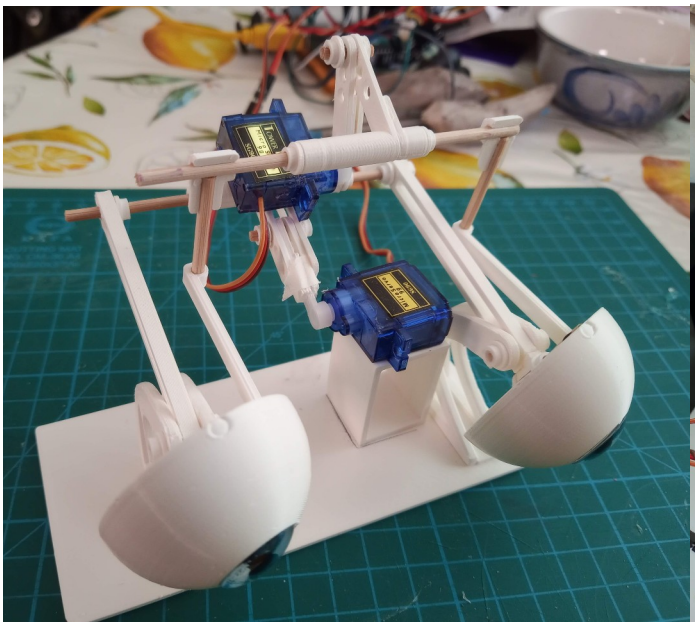
Next I used Rhino CAD to design and 3D print a new eye mechanism held together by 3mm dowel.

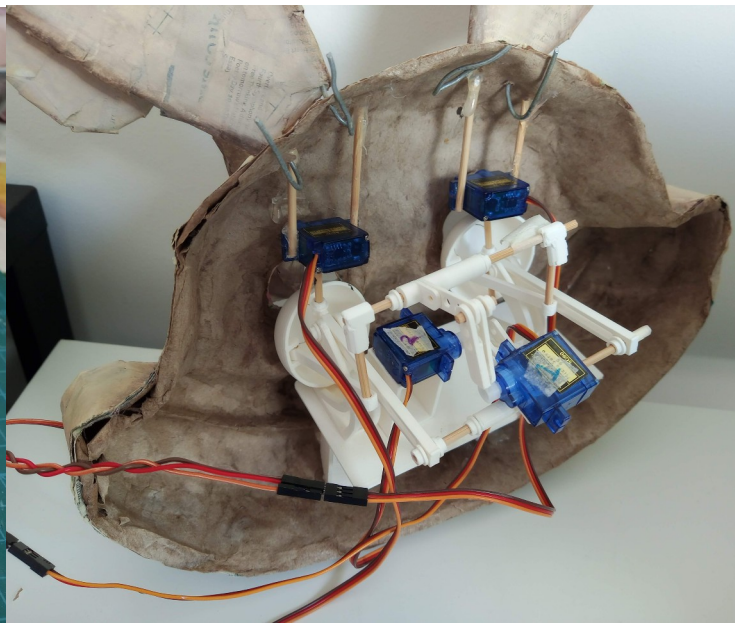







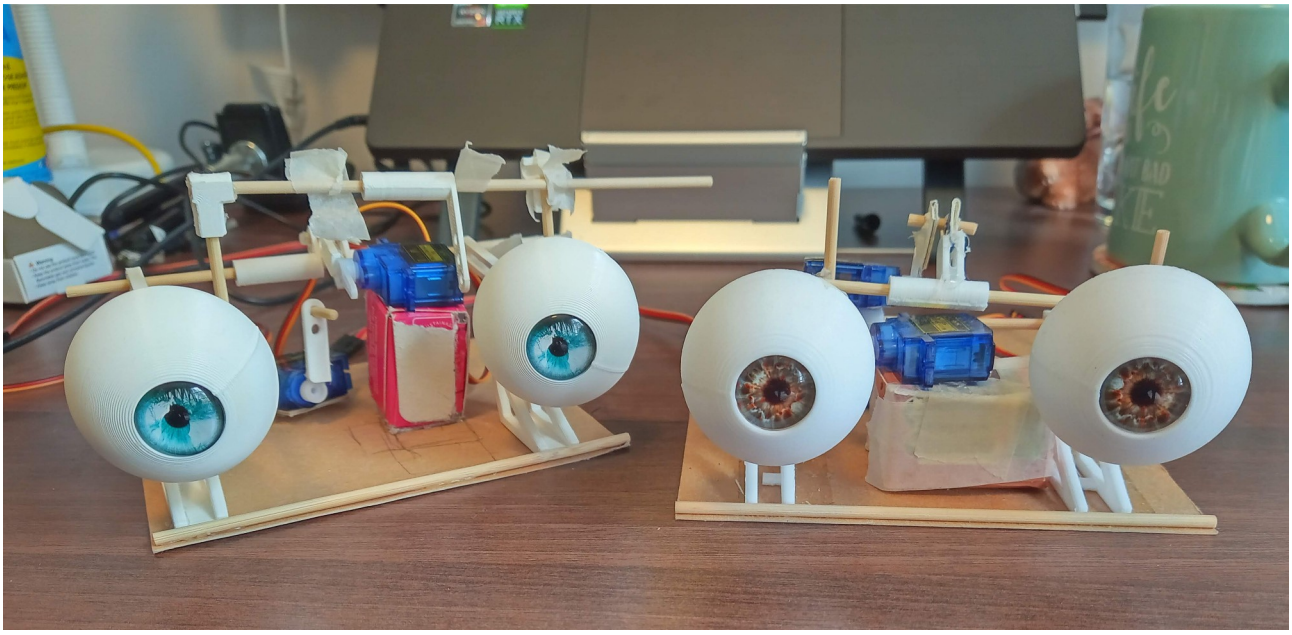
Four iterations of the eye mechanism

Rhino CAD of mechanism





Final Eye Mechanism placed in robot head.



Eye colour selection.

1) Robot Making:
The original idea for the Robot head was for it to be 3D printed and a material ‘skin’ to be layered over the top to make it look creepy. However when I experimented with Blender to sculpt the Rabbit head I realised my CAD skills were not sufficient enough to create the face that I wanted in the time frame given. So instead I decided to sculpt it from clay as it will be quicker.

1st Clay Iteration
This is the first Rabbit head I made using air dry clay to see if I could suculpt the face I wanted. I was happy with the rough proportions of the face and more confident in sculpting the material than using Blender. I am now ready to move onto sculpting the final head.

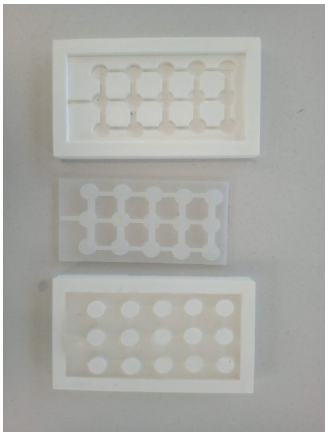
Final Sculpture
Phase 1: Sketching out proportions in clay.

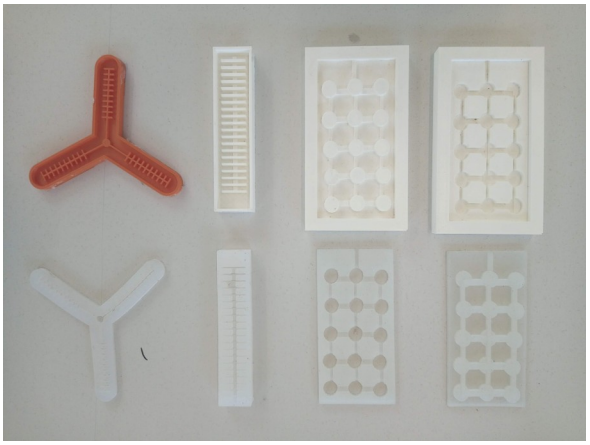
Phase 2: Adding eyelids, eyebrows and refining face shape and texture.

Silicone Skin Idea

After the face has been 3d printed I wanted to cast a moveable skin from it and use it as the Animatronics rabbit's face. After talking to the technicians they suggested I cast silicone. Below are a range of silicone moulds and cast silicone they have already made at uni.

I realised that to cast the face I would need a large mould and need to 3d print a second slightly smaller version of the face to place inside the mould. So when the silicone is poured into the primary mould the second face will press into the silicone to distribute the silicone across the face creating an even skin thickness.

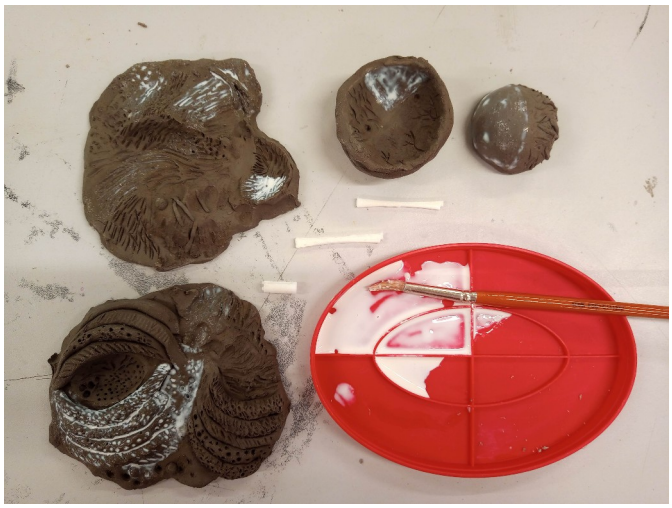




However, once the skin has been cast it won't support its own weight and will need to be placed over the original 3d printed face. This is not the effect I wanted so I decided not to use silicone.

Latex Skin/Eyelids

I still wanted to create some kind of skin for the robot so I experimented with liquid latex and created a range of clay textures to use it on.



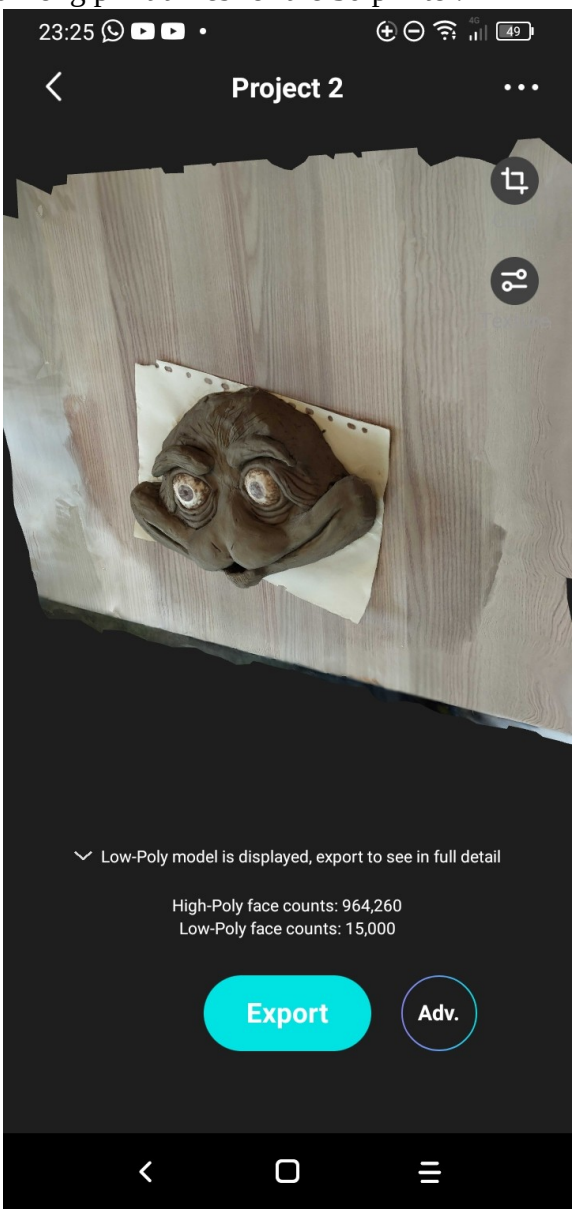
I painted layers of the liquid latex onto the clay and 3D printed parts to see how the latex took to the material. I was surprised how well it stuck to the 3D printing parts.

These clay experiments were meant to replicate the eyelid of the robots I wanted to see if I could create a skin like eyelid and so experiments are a mixture of Low and high relief sculpture to create veins and textures for the eyelid. The latex did not pick up the texture in the way I would have liked and required many many many layers of latex to further experiment with thickness and texture to so I decided to Remove eyelids from the design.

These clay experiments were to see how the latex sits inside and on top of high relief and low relief textures to see if I could make pitted skin or hair like skin for the robot, however the Clay still had some moisture in it when I applied the latex and it slightly bonded into the clay holes and ripped when I tried to pull it off. Again it would take a lot of time to experiment with the material to make the kind of skin I wanted to make so I decided to leave it and move on.

3D Scanning

Once the clay face dried I scanned it in 3D with the Kiri Engine: 3D Scanner App https://www.kiriengine.com/ however after scanning I realised when the scan is translated into a 3d print file it would require a lot of editing as the eyes are not meant to be present in the scan but cannot be removed from the clay. The clay eyelids have formed a tight seal around the eyeball meaning even if I can remove the eyes from the scan, when it is 3d printed, the eyelids will be too tight around the eyes to let them rotate freely. Also, the eyebrows and mouth are not meant to be attached to the robot and will need to be removed from the CAD file and patched up. It will take a lot of time to make these changes to the 3d model and with long print times for the 3d printer.

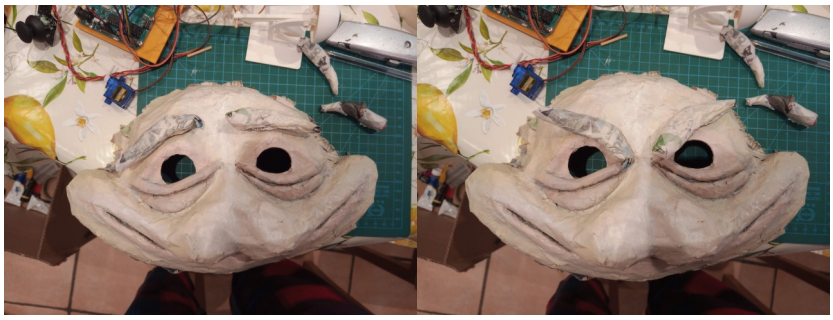


I don’t have time for the inevitable troubleshooting and reprinting this will bring. So due to time restraints I decided to move away from the 3D scanner and 3D print and will changed to paper-mache instead.

Papier-mâche:

After struggling greatly with how to make the face of the robot and with various methods I started not working or not being time efficient I decided to make the face from papier-mâche instead and use the existing clay face as the mould for it.

These photos show the first stages of making the papier-mâche robot head. From initial paper casting of the clay head (top left), building up the nose and eye bags, to the first few layers of acrylic paint.



Eyebrow expression experiment for placement.

First two layers of paint - trust the process!

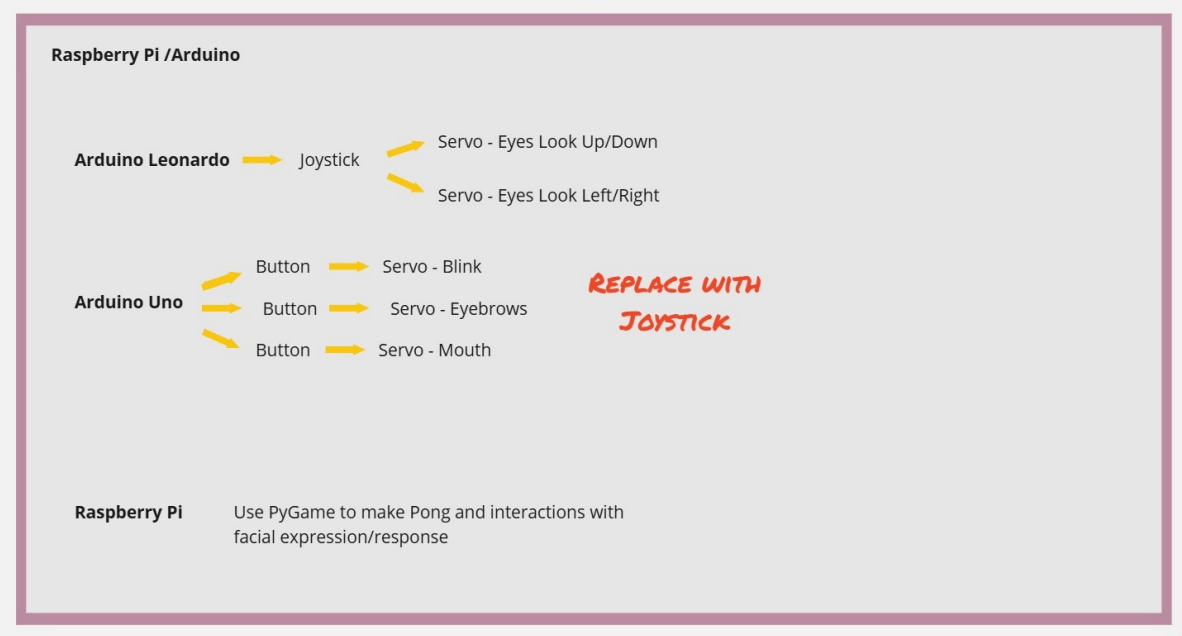
Creating the ears with wire, masking tape and papier-mâche, and assembling the eyebrows.

Code Development

DESIGN CHANGE - Pong
After realising I had no time to create a physical Arduio based arcade game I decided to go for Pong instead and use the raspberry pi 4 to connect the game of Pong on the computer to the animatronics.

In this scenario Randy the Rabbit will be the opponent (AI opponent) in the Pong game. He will to respond to the game and encourage/insult the player based on their performance. Being encouraging in the start and if they start to win he gets angry and if they are loosing he mocks them.

This will involve the arduino responding to data from the raspberry pi/pong game. The Pong code will need to flag when the human or robot score to allow the robot to respond in real time. It will also need to keep track of who is winning overall to allow Randy to react accordingly through the pong game - celebrating and cheerful when he Is winning or get angry if he is loosing.



PYTHON CODE BREAKDOWN:

- Source standard pong game code.
- Add difficulty - increase speed of ball over time.
- Source 'AI' code to control one paddle/player in place of Randy.
- Add flags to code when a score is won and store in robot or player variable.
- Add function to keep track of overall score and flag who it winning each round.

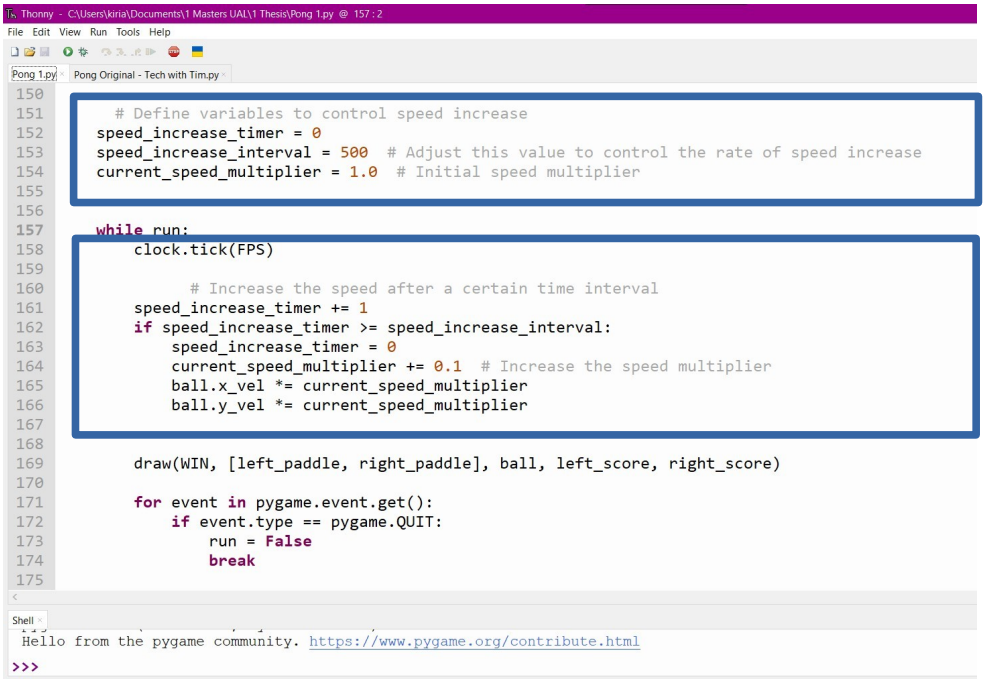
ARDUINO BREAKDOWN:

- The arduino will need to be able to receive live data from raspberry pi
- The score/winning/loosing data from pong/raspberry pi will need to trigger arduino facial expressions and speech in Randy the Rabbit.
- Code specific expressions and phrases to be activated in winning/loosing/scoring scenarios during game of pong

To create Pong I followed this Tech With Tim python tutorial.:
https://www.youtube.com/watch?v=vVGTZlnnX3U&t=107s and his code can be found here.
https://github.com/techwithtim/Pong-Python/blob/main/solution.py

I recreated the code on the python program Thonny and began making changes to the code to increase the speed of the pong ball as time passes to increase the difficulty of the game.

This will create more mistakes by the player and allow Randy the Rabbit to react more often to the game.



Below are screen shots of the pong game being played and declaring which player won.

Unfortunately the Raspberry Pi4 I was provided my the university was not working and I spent a month trying to set it up. Once the problem had been solved it was apparent I no longer had time to

work on the pong game and make and code the Animatronic experience in time so I had to drop pong and the raspberry pi and only use arduino to make the animatronic.

DESIGN CHANGE - Rubik's Cube Detour

Now there is not enough time to code a game in python or make a physical arduino arcade game for the robot I have decided to take the retro toy of a Rubik's cube and use it as an instrument to play a game with. Now there will be no coding input from the game for the animatronic to react to it will now need to be controlled by using buttons and joysticks by myself during the experiment.

Rubik's Cube Game

The game using the rubik's cube will be a memory game where you have to memorise and rotate the cube based on an 8 move sequence.

User Testing

The first iteration of the game involved being told the sequence twice and then you have to recreate it with the rubik's cube with no repeat of the sequence. I found this very hard and found 8 moves were too many to memorise in one go. I found it easy to memorise 4 but any more became too confusing. Therefore in the experiment I will allow for repeats of the sequence to be allowed but each one will be documented to see how many are needed.

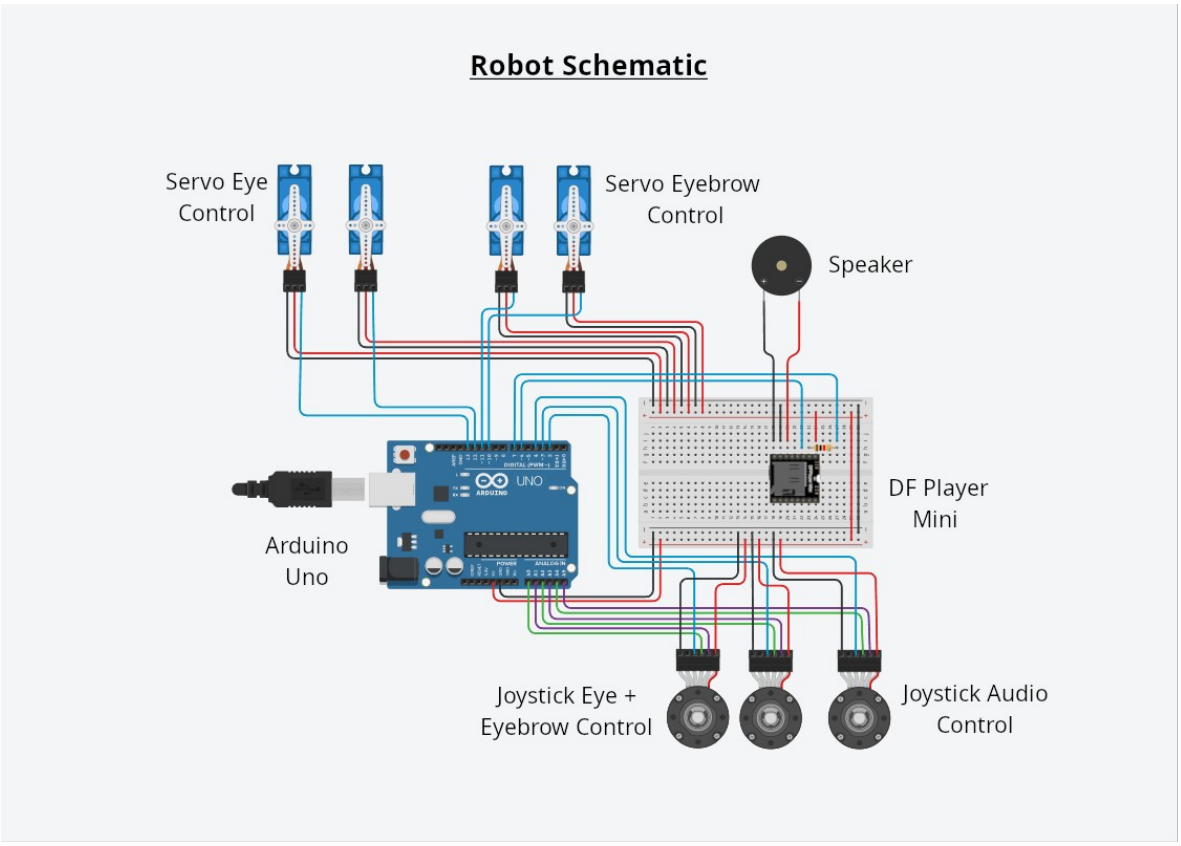
I then tested the game again with three rounds, replicating the same sequence. I found the third round unnecessary as I'd learnt the sequence by then and could complete it quickly. Two rounds seemed optimal for the experiment as it was still tricky to recall the sequence in the 2nd round but you had familiarity with it. Therefore I think it is appropriate to use the first round as a practice round to get familiar with the sequence and use the 2nd round as the test round and having the animatronic reacting to the players performance.

Link to testing videos:
MSc-Final-Project/Video Documentation at main · KR22041838/MSc-Final-Project (github.com)

Arduino

For the Arduino animatronic I needed the following components:

- x1 Arduino Uno
- x4 Servos
- x3 Joysticks Modules
- x1 Speaker
- x1 DF Player Module (MP3 Player)



Standard servo code
I based the servo code of of the standards Servo suite example in side the Arduino IDE by BARRAGAN <http://barraganstudio.com>,

Added Servos to the eye mechanism
I then added a second servo and looped the rotation back-and-forth to make The I mechanism look up down left and right.

Added Joystick
Next I added a joystick to Control the X and Y axis rotation of the eyes. I Adapted the code from ArduinoGetStarted.com's Tutorial page: https://arduinogetstarted.com/tutorials/arduino-joystick-servo-motor.

I now have two servos in that I mechanism responding to the left/up/down/right tilting of a joystick. Pressing the button on the joystick will reset the eye mechanism to a forward facing position.

Add more servos and joysticks
Next I added two more servos to control the eyebrows individually and another joystick to control them. I had to inverse the direction of one eyebrow to ensure that eyebrows move identically.

I have been having issues with the fourth servo which controls one of the eyebrows it seems to have a lot of feedback and makes the servo flutter or stop working.

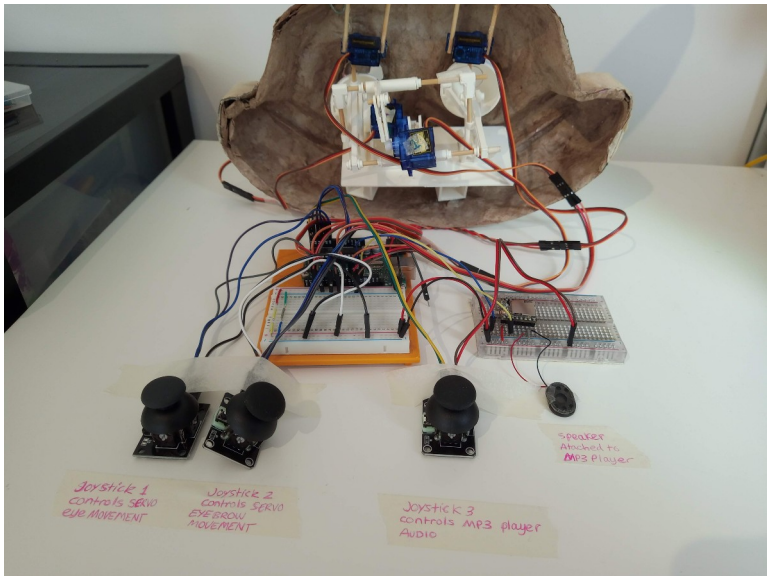
This created a lot of issues when trying to control the facial expressions of the robots as the eyebrow did not always work but sometimes it worked fine.
Code can be found here:
MSc-Final-Project/Randy The Rabbit Code at main · KR22041838/MSc-Final-Project (github.com)

Added MP3 and speaker

To add The voice of Randy to the Robot I Added a DF Player module With an SD card of the audio and a speaker. I adapted the code from [MP3 Player With Arduino Using DF Player Mini : 5 Steps – Instructables](), however The code would run on its own however I could not get it to work when integrated into the rest of the Robot code and ran out of time to fix it. However the animatronics still work inside the combined code.

Code can be found here:

[MSc-Final-Project/Randy The Rabbit Code/Expression_Audio_Combined_Code at main · KR22041838/MSc-Final-Project (github.com)]()



This is the final circuit connected inside the robot.

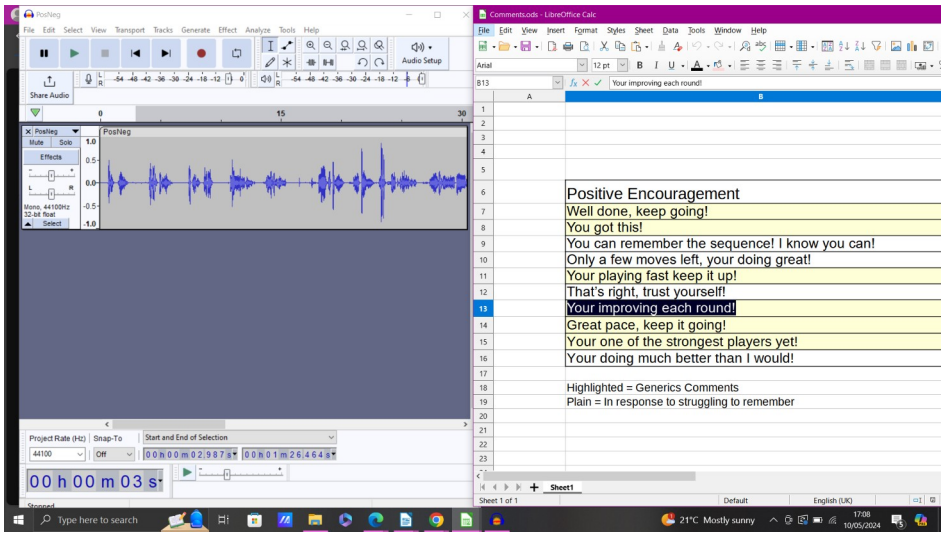
Testing Expression

Randy the Rabbit's Voice

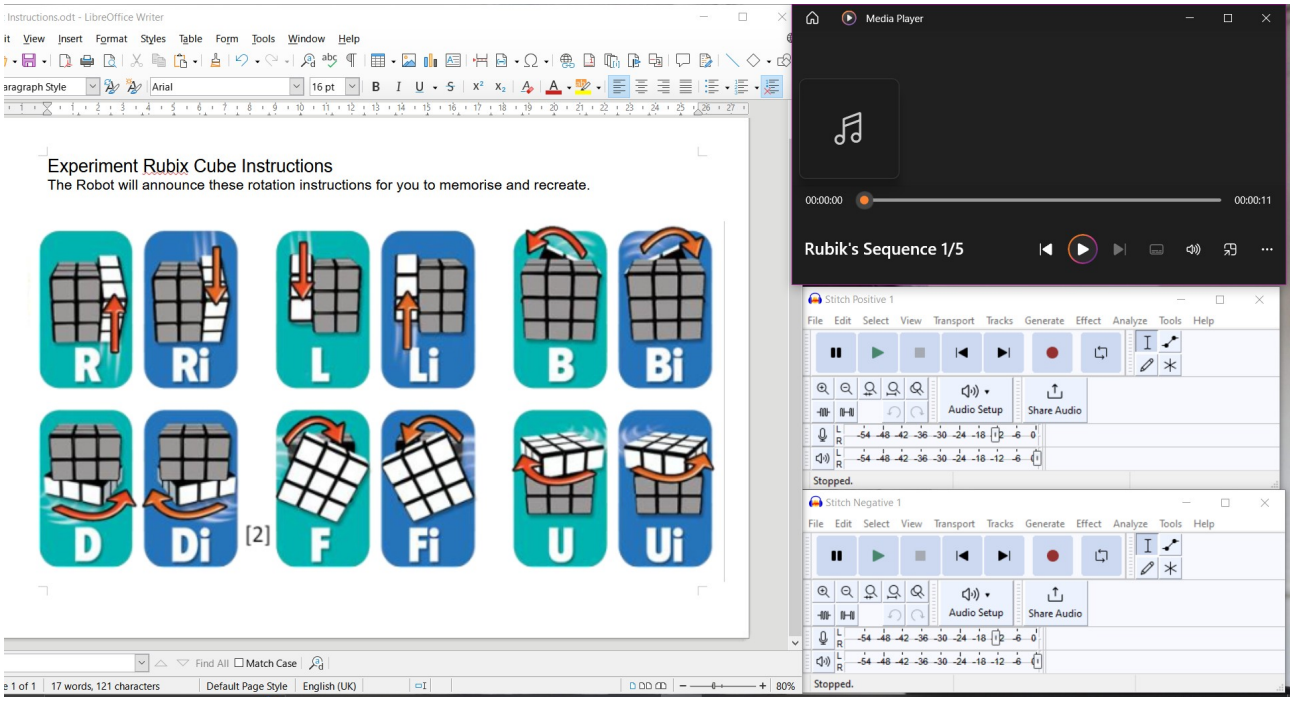
For the robot voice I recorded my brother reading the positive/negative encouragement and Rubik's cube sequences.

The voice recordings Can be found here:

[MSc-Final-Project/Audio Documentation/Robot Voice Audio at main · KR22041838/MSc-Final-Project (github.com)]()



Experiment:
During experiment I could not get Randy's voice/audio to trigger from the Arduino So I played it from the laptop instead. During the experiment the voice of Randy was my own speaking voice because I did not want the humorous characterisation of Randy's voice to distract away from the content of the positive and negative encouragement however during exhibition it will contain the character voice.
The voice recordings Can be found here:
[MSc-Final-Project/Audio Documentation/Standard Voice Rubik's Sequence and Encoragement Audio at main · KR22041838/MSc-Final-Project (github.com)]



This is what the Computer screen look like for the participant during the experiment with the instructions on the left and audio files on the right which triggered when appropriate.

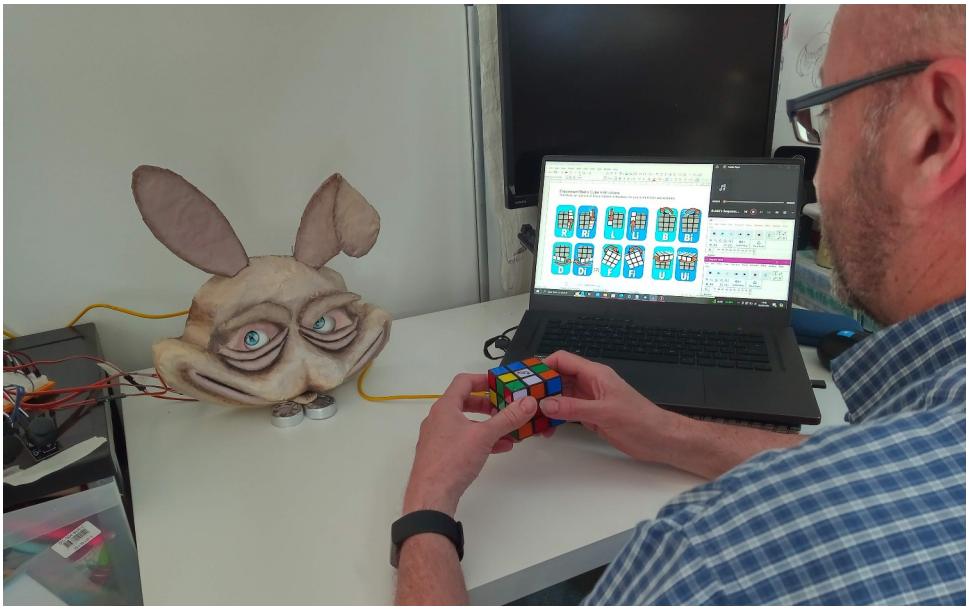
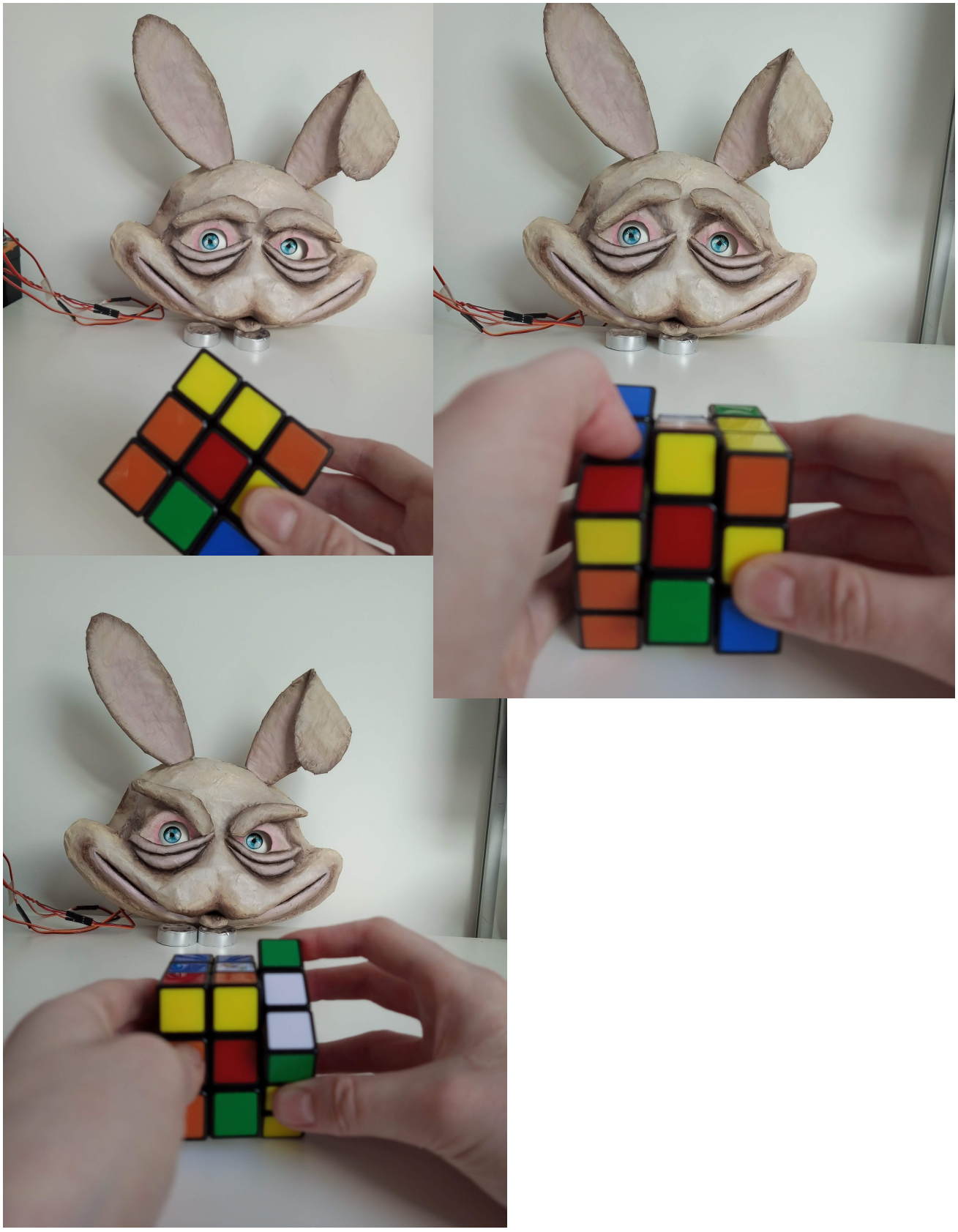


Photo of Participant During Experiment
Video of Experiment Can be found here…..



Participant POV Of robot expressions during experiment

Range of stills from video of robot expressions.
Video of can be found here:
[MSc-Final-Project/Video Documentation/Robot Facial Expression Videos at main · KR22041838/MSc-Final-Project (github.com)]

Final Robot:
I had a lot of issues with running out of time when trying to create the robot Randy the rabbit and it is a shame I was not able to incorporate an actual arcade arcade game like Pong into the installation. I researched into and tried many techniques through the project that I could not use in the end such as liquid latex, silicone moulding, clay sculpting, 3D scanning to 3D print Raspberry Pi.

I would have liked to make Randy react to the gaming performance of the player and make him more interactive through the use of Arduino and Rasberry Pi. However the robot is a good starting point For making an animatronic arcade game and I am happy with how the papier-mâche Rabbit has come out and the look of the animatronic eyes and eyebrows.

To improve the projects I would not only make Randy more reactive to the game being played but also give him eyelids and a body to allow his heads turn left and right. I started off looking into uncanny valley when designing Randy and studied uncanny Valley for my thesis before changing direction and focusing on positive and negative encouragement and its effect on a player's performance. It states that the eyes and I expression are the most contributing factor to Creating the uncomfortable sensation of being around a human like robot – As currently Randy is perceived as creepy but also quite amusing, I would like to make him more unnerving like the animatronics in five nights at Freddie's. I also would like to experiment with liquid latex skin again to create movable skin around the eyes to add to the realism to it, And possibly make a mouth that moves.

The thesis has given me good groundwork for making an arcade game using Randy the Rabbit as a gamesmaster I have learnt that negative encouragement or trash talk creates a very competitive environment and can affect your ability to remember retain and recall information such as a Rubik's cube sequence This can be used to my advantage when making the arcade game to make it difficult but engaging.

I have also learnt that positive encouragement creates a comfortable and supportive environment and this could be used to creates a false sense of security in my future an arcade game to engage the player with the game before the robot turns evil.