Thomas Rompré - Tangible media - CART 360
Prototype

# Input

The idea of using biometrics as the input for the project came in quite early. The concept of externalizing feelings or emotions that would normally be camouflaged through mannerisms, habits, or sheer composure feeds directly into the idea of pulling data straight from the user’s body. Biometric sensors, however, come in a variety of forms and can produce all different kinds of data, so an exploration of such was necessary for the project.

My main takeaway from that exploration is that biometrics and the human body are wildly unpredictable compared to more common sensors. Difficulties aside, if you can make it work, it is absolutely worth it, not much can reproduce the information pulled from it and even less can boast to have that intimate of a connection with its user.

## Muscle Signal Sensors & Electromyography

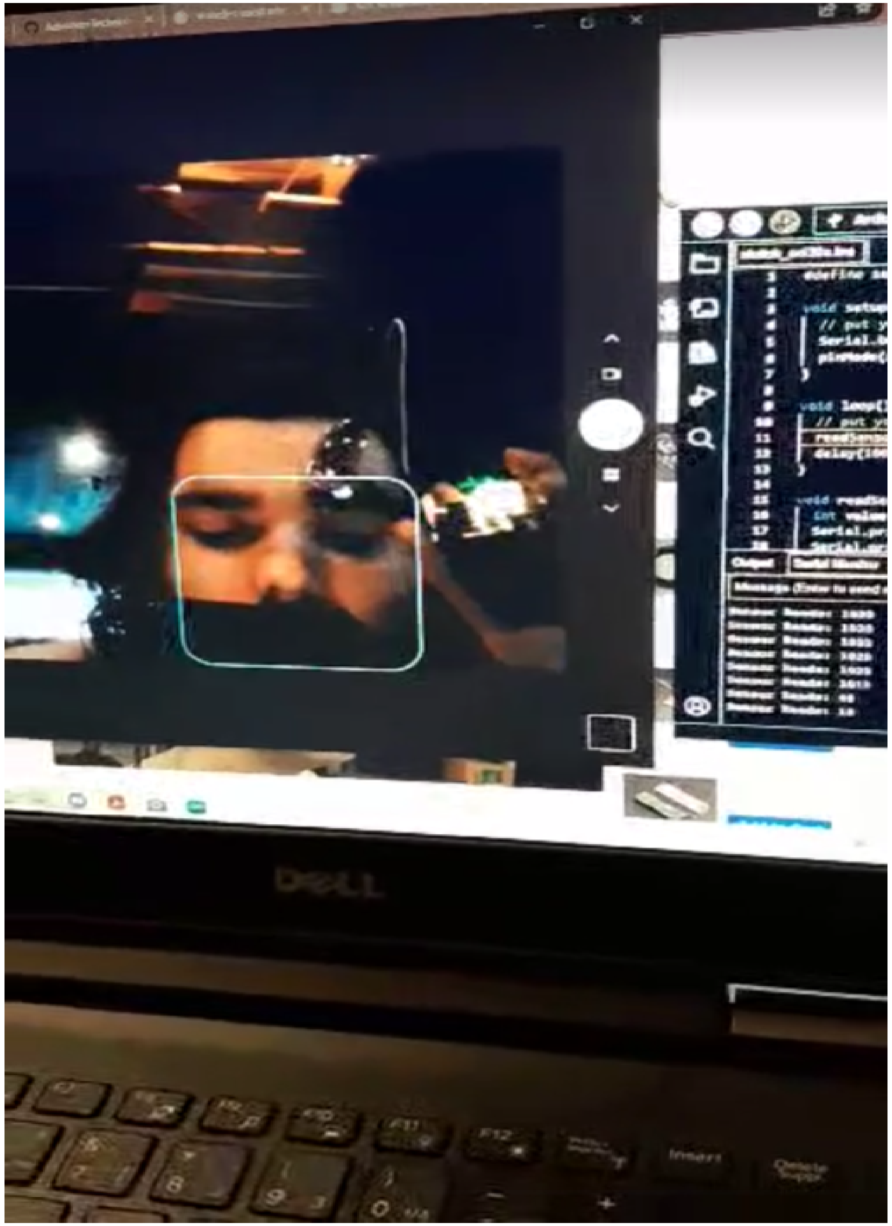
Our first idea of a biometric sensor were muscle signal sensors. They’re fairly well-known for their use in the medical field (and that one *old spice* ad) and their application seemed fairly straightforward: slap some electrodes on a muscle and it will read electrical signals that course throughout said muscle when it is flexed.

Turns out it’s a bit more complicated than this.

The placement of the electrodes are *highly* specific, one of them requiring to be placed on a bone attached to the muscle in order to have a reference point to filter out noise.  Without taking in consideration that any amount of hair, dirt or grease that finds its way between the electrode and the skin can throw it off and nullify the signal, it becomes a painstaking process of trial and error until you find the sweet spots that your sensor will accept to read.

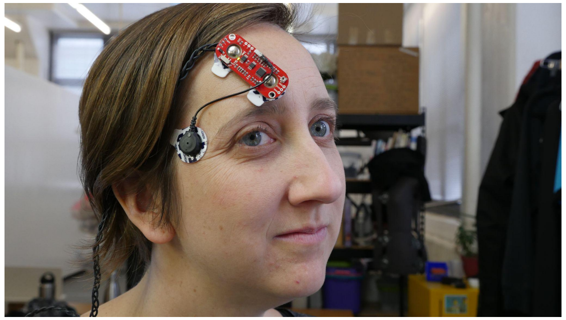
This is only the first hoop to leap through though, the initial device we purchased from amazon required the user to daisy-chain two 9V batteries for its own power supply. External power input from sources other than the arduino are a common requirement for Muscle Signal Sensors. This is compiled with the need for frequent maintenance, considering electrodes get used up quite quickly and aren’t meant to be reusable, and the complexity of setting it up in the context of a wearable mask discouraged us from using it for a while.

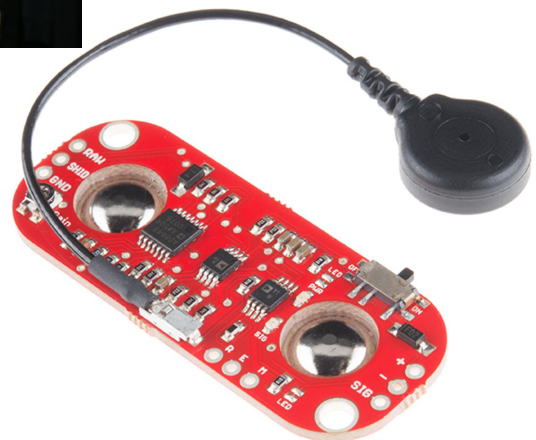
Eventually, I got my hands on a MyoWare Muscle Sensor kit, which included a sensor with embedded electrode connectors and could be powered with a 5V current from the arduino. This simplified the setup enough for me to reconsider the idea of using it. It also helped that in my research, I found a similar project online using the same device, where it was placed on the forehead to respond to the user raising his eyebrows. Mimicking their placement and movement, I managed to replicate it after *several* attempts and get feedback from it that could be potentially usable for an output.




Even if it can technically work, the conditions required for it are too delicate for it to be remotely usable as a wearable sensor. Not to mention, it would have to fit in with the rest of the hardware for the output as well.

A very important discovery i made while testing out this sensor though is the need to have the input come from somewhere around the head, as our device is meant to be a headwear, it would be much more appealing visually, less encumbering, easier to set up and more stable if the input was packed into the device, rather than dangling from somewhere else on the body altogether. Which would also somewhat betray the idea of externalization, since the sensors would be in plain view.





# Pulse Sensors

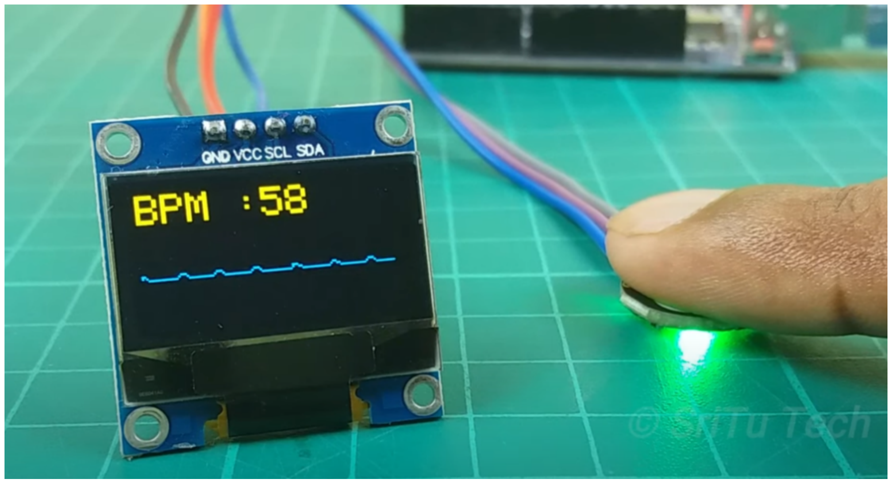
Unclear where we got the idea to use the user's heart pulse as an input. The idea of it was very appealing though, not only could it provide vacillating, rhythmic data with which something very visually pleasing and/or complex could be derived into, it was data that could implicitly react to the user's conditions. Heart pulse increases and decreases for various reasons: physical exercise, anxiety, fear, etc. Some of these are intentionally or not, internalized as to not let others be aware or be distracted by it. Exposing it using this device seemed like a natural direction to go for the project.

To that end, I discovered the SparkFun Pulse Sensor, which not only was small and light, but suggested application was to the earlobe, and it is commonly sold with an ear clip in order to attach it.

On a technical level, the pulse sensor works by shedding green light onto a thin piece of the user's skin, usually a fingertip or an earlobe, and a receptor adjacent to the light source captures the light refracted from white blood cells onto it, and uses this to send a signal representing blood flow. Due to how heart rate affects this, this forms a sort of waveform number when shown on an arduino.

In addition, it seems to react to noise and erroneous data fairly well, only beginning to send feedback after a few seconds after the correct application is done. This is further cemented by the pulseSensor Playground library for the arduino IDE, which comes with more functionalities to filter out noise and create callbacks to synchronize code to pulses as well as calculate BPM amongst other things.

I ended up choosing this as the main input for the project. This choice comes mostly from it being the most reliable form of biometric sensor I could find, but also because of the ease of setup, the accessibility of the libraries and its significance to the project's meaning. It was also crucial for this project that the sensors had to be light and compact enough to fit in the headwear, as well as pull biometric data from somewhere around the head in order to fit that criteria.



## EEG Brainwave Sensors

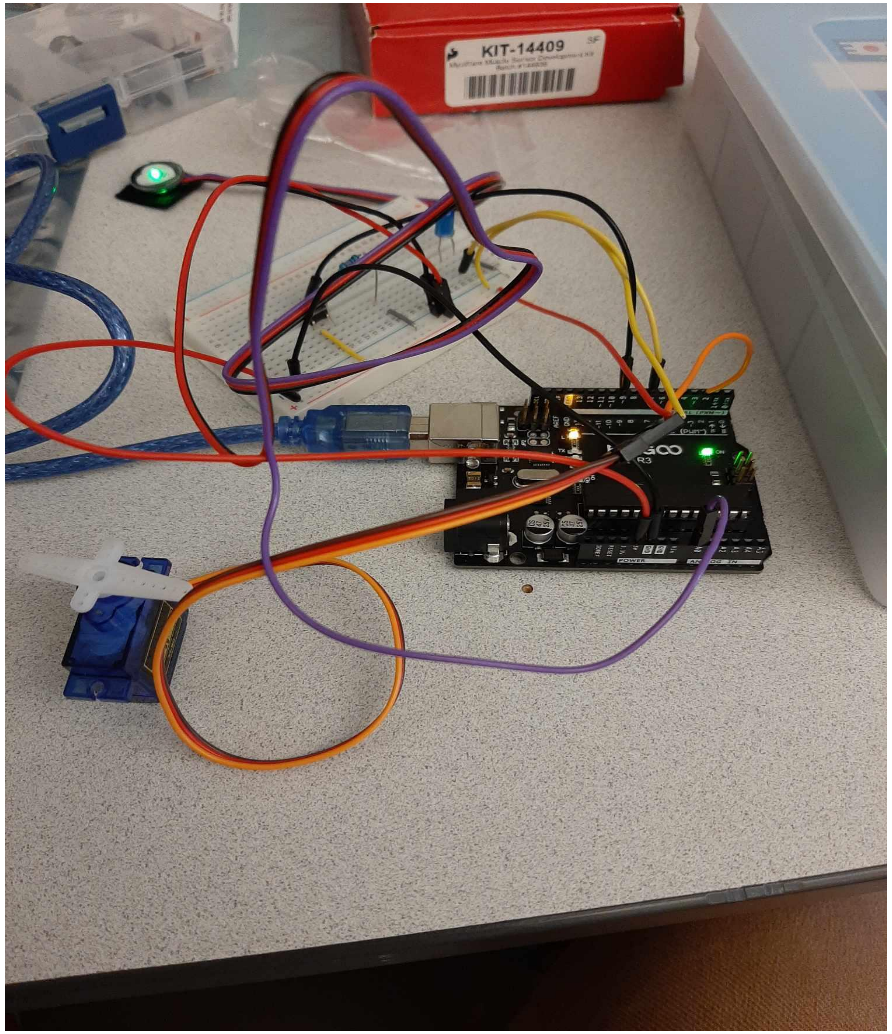
*Very* briefly considered, as the idea of taking biometric input from the head naturally brought the idea of reading some kind of brain activity. Any amount of brief research on the subject reveals that the sensors are both too bulky and expensive for the scope of this project. This isn't even considering setting up the sensor and reading data from it, or considering the power supply it would require to make it function.

While I half-knew we were not going to use this sensor in the final project I still believe that my research onto the subject was important to how I approached subsequent exploration on the subject of biometric sensors and how they could be appended to our device. And thus, bears mention here.

## The Prototype

Our goal for the prototype was mostly to finalize a proof of concept for the input and output, since our initial ideas of it were ambiguous and we were open about the idea that this was going to be an exercise in exploring what the possibilities and limitations of it were going to be. Considering this, we didn't set out to make the prototype wearable, rather we wanted it to demonstrate that the innards of the final project were functional, and not a lofty promise we couldn't keep up on. It was also important to prove to ourselves as well that the input and output were possible to replicate so that we could proceed with developing the final product.

Discussed here is the *Input* part of the prototype, a demonstration of the heart pulse sensor in action with a visual feedback to demonstrate how it can make use of the data it provides, and how reliable it is (or in some cases, how unstable or how unpredictable it can be).



While not very complex, here is a short explanation of how the circuit functions. For the sake of this example, we consider that the user has correctly put on the earclip and pulse sensor to his earlobe:

- The heart pulse sensor takes its voltage and is grounded directly from the arduino, and its signal feeds into analog pin 0.
- The pulseSensor library uses the feedback from analog pin 0 to run blinkOnPulse(), a function that writes HIGH on a digital pin every time a pulse begins. In that case, the digital pin that blinks is 7.
- Attached to pin 7 is a blue led, which due to the circumstances listed above, will blink in sync with the user's heartbeat.
- To further demonstrate the presence of a pulse, attached to pin 2 is a small rotor, which can swing from left to right on a 180 degree axis every time pin 7 reads HIGH, which consequently is whenever a pulse begins. This is due to a possible limitation that blinkOnPulse() can have issues working on multiple pins at once.
- On 9 is a button that prevents current from reaching unless it is pressed. If current reaches pin 9, the code will call pulseSensor.pause() or pulseSensor.resume() respectively to either halt or resume the process of reading the pulse and writing to pin 7 every time a pulse begins. The purpose for this is to avoid erroneous activation of the output due to noise or other circumstances. Despite the sensor's decent reliability (for a biometric sensor) and the pulseSensor library's ability to filter out noise data, this can still happen pretty frequently, and thus it becomes necessary to have a switch to activate/deactivate the output.

Ideally on the final project, the device would be powered by either its own rechargeable power module or 9v battery. However for the sake of this demonstration, we opted to simply hooking it up to a laptop, in case we needed to do quick adjustments to the code for any reason.

While the prototype functions, its overall lack of form does make it quite difficult for an outside audience to grasp any kind of meaning or ultimate intention behind it. This is partly due to this project being very ambiguous up to this point, constantly evolving and shifting due to our exploration and research into what was possible within the scope and theme of the project.

Noémie Carrier - Tangible media - CART 360
Prototype

# When everybody is watching

The project revolves around presenting different shapes by using a mask to hide the person wearing it, allowing them to anonymously explore their connection with a fluid sense of self. As it is now, it is intended to play with the fact that people will often display different mannerisms, habits and pieces of clothing to blend in or stand out in different social contexts, constructing different performed identities that shift quickly.

Unfortunately, the message shared to the user was still ambiguous, and the first iteration mostly consisted of exploring possibilities while hoping that our discoveries would clarify things about the meaning. The process of iteration definitely helped to learn about the constraints of the different possibilities.

After the prototype, we were able to identify clearly what was lacking to provide adjustments to the final project. Every step in the developpement allowed us to reflect on the purpose of the project, and the ways to better refine it. The risk with an iterative process is that if you constantly question what you are doing, you won't accomplish anything.

## Output

Experimentation and ideation has allowed me to discover a lot about the different methods I could use to get to my goal. To generate a mask that changes shape, I separated the movement I wanted to create in two. First, a drastic change of shape that would affect the structure of the mask, and second, a surface movement like flapping or pulsing.

### Structural movement

A big movement generally involves a stronger mechanism. To do so, I researched motors: their limitations and strengths. I understood that in general:

- Stepper motors are continuous, are more precise in the amount of steps and will require more energy.
- Servo motors are simple to wire up, will have more torque, and will require less energy, but they have a limit to what they can turn.

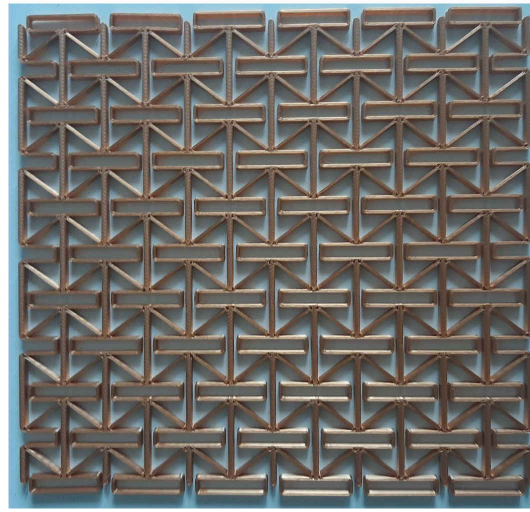
To make the piece wearable, we have to limit the amount and size of the components on the mask. Following that and my personal interest for compliant mechanisms, I discovered a material pattern designed by nature architects[1]. The pattern

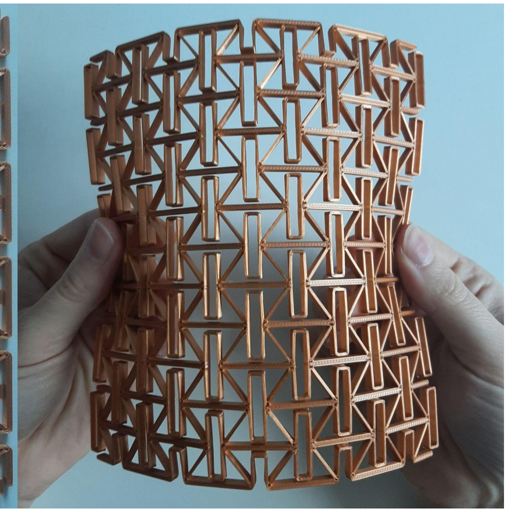
[1] *World's First Mechanical Metamaterials That Transform into Preprogrammed Curved Surfaces. YouTube*. Nature Architects Inc., 2020. https://www.youtube.com/watch?v=JeOrhh6shS8.

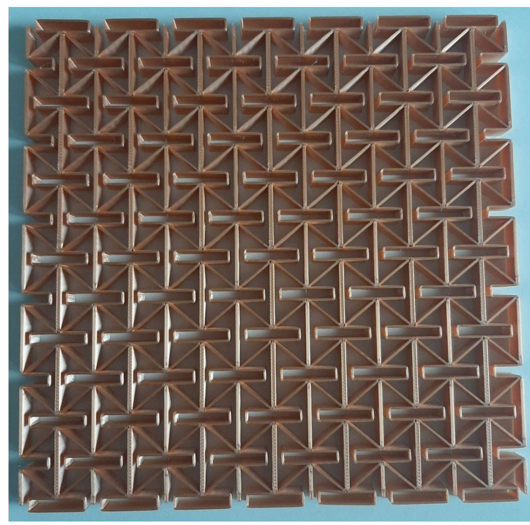
would allow, even printed in different original shapes, to have only two points of attachment to expand into a rounded form that we pre programmed. I quickly reproduced the pattern in Adobe Illustrator, exported it in tinkercad to generate an .stl file, and 3D printed it with the help of the CTC lab at concordia. The goal was to test the process, along with having a sample of the material in hand to know what kind of resistance we are working with.

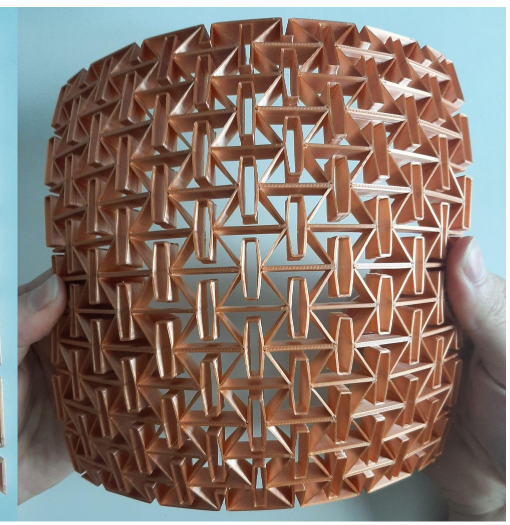
The thin print (3mm) requires little strength to bend, but will not take the intended rounded shape with only two points of contact. The thicker material (8mm) requires considerable strength to bend, more than what a tiny motor would be able to handle. It does bend to a rounded shape with just two points of control.

None of those experiments are appealing solutions at the moment, even when they were to be printed with a basic rounded shape to mimic a human face.









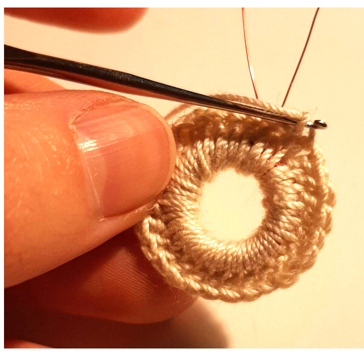
## Surface movement

To create small movement, the strength does not matter as much as being able to embed the element right under the surface. There are multiple actuators that have been explored in the world of wearables specifically, like shape memory alloys and inflatables like the Omnifiber[2]. Other alternatives to create a visual

[2] Kilic Afsar, Ozgun, Ali Shtarbanov, Hila Mor, Ken Nakagaki, Jack Forman, Karen Modrei, Seung Hee Jeong, Klas Hjort, Kristina Höök, and Hiroshi Ishii. “OmniFiber: Integrated Fluidic Fiber Actuators for Weaving Movement Based Interactions into the ‘Fabric of Everyday Life.’” *The 34th Annual ACM Symposium on User Interface Software and Technology*, 2021. doi:10.1145/3472749.3474802.

reaction like thermochromic and Polymer Dispersed Liquid Crystal (PLDC) film were considered too, but were relatively expensive.

I decided to go with a 30 AWG copper coil that could be programmed to create vibrations, sound, or a small movement with electromagnets like in the kobakant example “flapping wing”[3]. I created three samples, each made out of 2m of coil to be able to compare the design, usability and strength. I spun it around 3 different size drill bits: 12.mm, 7.4mm and 4.3mm. To better integrate it into a textile and to ensure that it would keep its shape, I crochet cotton thread around the element.

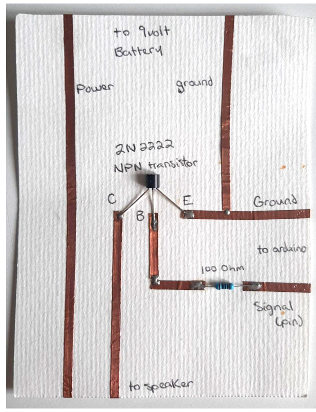


With a 9v battery, plugged directly to the circuit, the repelling force can repulse a light material of about 2 cm. It turned out to be pretty reliable when the structure does not allow a simple movement towards the side. As long as the material can keep a certain structure and is not stretchable, the result can be quite impressive. From there, we can generate a material that moves to the rhythm of a heartbeat or creates a ripple effect. It does require a lot of energy and should be used only for short intervals, because long durations can generate quite a lot of heat. After a second, there was no notable change of temperature, but it is still a risk.

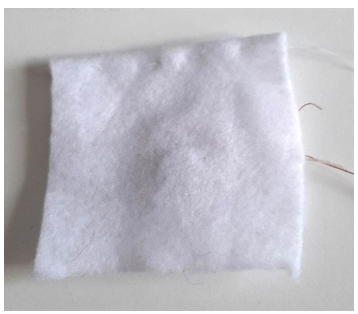
To be controlled with an arduino, the electromagnet requires an additional circuit to manage an external power supply. Transistors are the main component to this, and I had on hand

[3] https://www.plusea.at/. “FLAPPING WING SWATCH EXAMPLE.” *How to Get What You Want*. Kobakant, 2015. https://www.kobakant.at/DIY/?p=5900.

an old project from fabricademy[4] to quickly test it out. Wired to an external 5 volts, the circuit would generate enough energy to vibrate and generate sound, but not enough to create a big repulsion. Further research is required to make it work.




Overall, the high demand of energy (voltage and amps) will greatly affect the portability of our design: If it requires a lot of energy, the user will probably not be able to use it for a long time without recharging it. The ability of these little handmade components to blend in aesthetically into a soft material makes it an appealing option.



[4] Fabricademy, Textile Academy. “Fabricademy Week 8 Wearables.” *Vimeo*, October 8, 2023. https://vimeo.com/768645934/52f06f5f40.

## The project’s intention

Our project's initial meaning changed a lot during the past month, and will change again. It still lacks meaning and clarity, which can be provided by revisiting the message we intend to share to the user. By presenting the prototype, a lot of elements have been brought to our attention. Notably that there is still a link missing between the input and the output, and that we still need to refine our idea to make a coherent final project.