Touch Me Not - Synesthesia Experience

Team Documentation

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1. Introduction

The Touch Me Not project aims to provide an opportunity for most people who don't have synaesthesia, an ability that only a very few people have. Although controversial, the mainstream view is that empathy is acquired through neural overwiring (Ward, J., 2013), and that synaesthesia is impossible to acquire (Cohen Kadosh, R., & Walsh, V. ,2008). Synaesthesia affects about 4.4% of the world's population (Simner, J. etc., 2006). Through this project, we hope to make more people aware of this ability by enabling them to experience synaesthesia.
Secondly, the synaesthesia experience can boost people's creativity(Ward, J., 2013; Pearce, J. M. . 2007). We hope this new experience for most people will inspire them to be creative and discover more of the joys of ordinary life.
The power of synaesthesia to enhance creativity allows it to be a design space that facilitates creation. Therefore, we wanted to design a productivity tool to better inspire the creators by using synaesthesia, such as a music synthesizer.

The project focuses on the auditory-tactile synaesthesia experience. For this purpose, we designed a partitioned panel with different materials covering the surface of different areas, and when the user touches the different materials, different melodies will be played depending on the materials. Users can create their own chords by touching multiple areas at the same time, giving them the experience of creating music through their own tactile feedback.

Figure1. Installation shape

As an experiencing device, how to make most people quickly understand the device and experience it is our first consideration in the process of prototype conception. With this in mind, we abandoned many imaginative and complex designs and instead drew inspiration from people's daily lives. As a music device controlled by the user, we can easily associate it with the DJ soundboard, a panel for DJ to manipulate the audio from multiple sources ("Buying a DJ Mixer", 2022). And the panel, as a common object in people's daily life, such as car panels, air conditioning panels, etc., can connect to the metaphor of a console and has a very strong connection to the interaction pattern of our prototype. The console metaphor helps new users to quickly understand the purpose of our device and provides them with an initial concept to learn to use our device.

2. Justification

2.1 Function Choice

The topic of the project is synesthesia between hearing and touching.

By research on synesthesia, the phenomenon which can be experienced by only 4.4% of the people (Simner, J. etc., 2006), we realized that it is not quite possible to make a device triggering synesthesia, the phenomenon itself, on the majority of people.
We also had some interviews with people who have experienced synesthesia. We found that their experiences are very personal and might not be understandable for common people. In one interview, our interviewee who has experienced synesthesia claimed that when listening to the strings, he would feel something round. Based on this result, we feel that it might not be a good idea to directly copy the synesthesia experiences from this small group of people to the general public.
We looked at other synesthesia related devices most of which connect images and music. The idea is basically painters binding to instruments—the painter will automatically paint when the instruments are played. (e.g. https://youtu.be/20faPwXUbb4) Inspired by those devices, we would like to make an artisan device to connect the sound and the feeling.

The application allows concurrent play by at most 3 people, but there is no reason to reject single user playing. Our goal is to provide the synesthesia-like experience to general people. As we have investigated, synesthesia is quite personal and it is different based on the perception, imagery, and memory of the individual. (Ward, 2013) Also, people feel differently when they hear the same piece of music or touch on the same piece of material. It is absurd to force our user to make a team to use the device.

As we had already decided to make a musical device, musicians involved are a must. Our team members who took charge of the music design have received musical education for more than ten years. We also made interviews and gained advice on both music and technical developments from multiple musicians. The music design was spoken highly when it was shown to the experts.

The final prototype has 6 textures for users to feel and each of them are connected to a clip of music. There is background music looping all the time if the device is turned on, but solely background music sounds nothing more than boring. The music clips linking to the materials can be seen as voice parts, and users can create their own music by adding, removing, and changing those voice parts.

Users can control the device by touching the materials inside of the blind box. They can control which voice part will be played by touching the corresponding materials or not. The volume and the parameters of the filter added on the clip of music can be controlled by touching with different strength. This control allows multi-level play. With normal strength of interaction, the device could create good sound, while skilled users could make better music with proper timing and strength of touch.

2.2 Appearance Justification

We defined the product shape at the start of the design as a midi controller-like model, with two main components: a square box where the material is placed, and a large container where the sensors are placed at the bottom (Figure 2). This appearance is the most intuitive way to demonstrate the correspondence relationship between various tactile sensations and the music being played. The container was made of transparent acrylic so that the audience could see the internal structure of the device clearly.

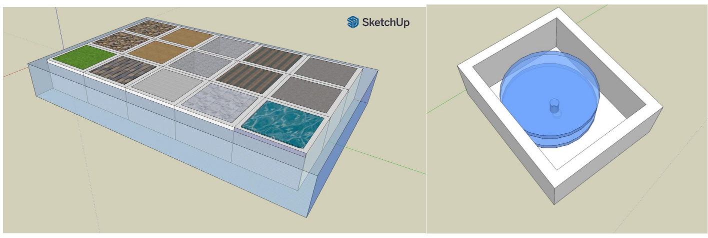


Figure2. Midi controller shape

During the evaluation of build, we gradually discovered that the above shape of the installation would amplify the visual impact on the user's perception; for example, when they saw the sand placed on the device, they would most likely ignore the roughness (the tactile sensation) brought by the sand and associate the music played with the specific substance. As a result, in the second design, we created the installation in the shape of a blind box (Figure 3). The blind box form not only blurs the user's vision and increases the need for the user to use their own tactile sensation, but it also gives the user a sense of association and surprise when doing the interaction. The size of the installation was also changed to be smaller because we would like the individual users can operate all the sensor by themselves.

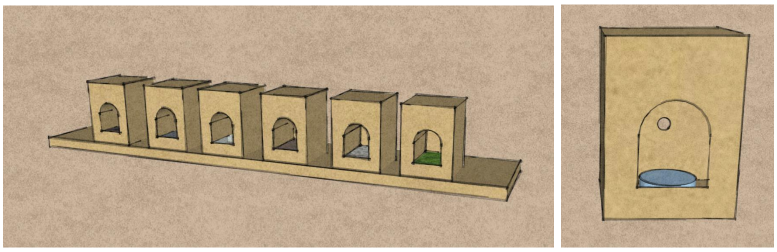


Figure3. Blind box

We chose a wooden board to build the device because it is the most efficient and low-cost material for us. To improve the device's appearance, we will glue the plush fabric (Figure 3), to the wooden container. The plush fabric itself provides a soft and beautiful tactile experience for the user, reminding them to pay attention to the device's tactile sensation during the interaction process.

Figure4. plush fabric

2.3 Music Justification

Prior to the design, we interviewed the synaesthesia group to gain a better understanding of synaesthesia (Figure 5). However, we found that the experience of synaesthesia people is often highly abstract and less acceptable to the general population. So instead of designing strictly according to the feedback of the synaesthesia group, we tried to design music from the perspective of the general people after obtaining their data.

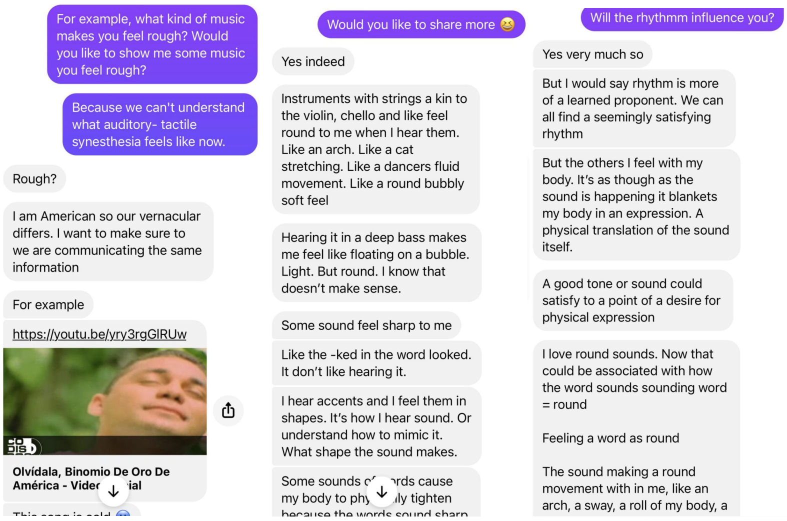


Figure5. A portion of the interview (with interviewer's consent and names were withheld)

At the beginning of the design, we did not involve any background music production, but simply planned to make each material into a sound effect of hitting the material, and edited them into a rhythmic combination. These sound effects mainly include: sharp(tooth stick), rough (sand, wooden, rock), Smooth(cloth, iron), sticky (slime, double-size adhesive), slippery(iron), granularity (sand, rice, foamed plastic) ,humid (dirt, slime, porcelanosa with water),elastic (slime, silicon) and jelly (slime). However, during our evaluation, we found that piecing together these effects purely as rhythmic percussion would make the overall music sound very noisy, chaotic, and slightly tedious. In the later design, we decided to make part of the material into a melody that can be associated with the material. Added some sound effects with longer playing lengths. For example, when people touch ice cubes or glass-like substances, they can associate some crisp music.
In addition, the music group has also designed background music (Figure 6). Users can touch different materials to add the rhythm pattern or accompaniment melody of percussion instruments on the basis of the background music, so that the level of the music can be increased, and feel more noticeable changes.

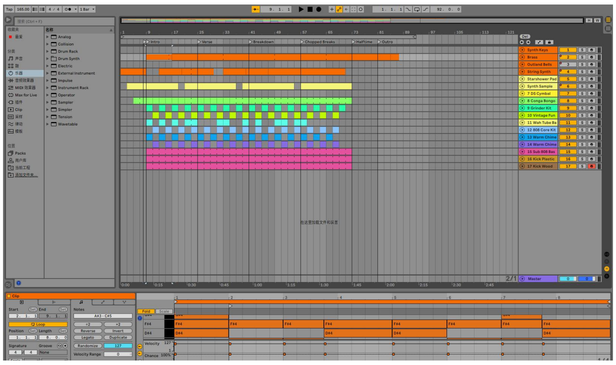


Figure6. music production
Another problem was that the clips of music did not actually connect to the materials. To solve the problems all at once, we grouped the existing parts and wrote more clips other than percussions, trying to correspond the feeling of specific materials to the music parts and bring more richness to the overall music. We wish those parts will bring a more sensible experience and we did user tests on

each part. Based on the user test result, we finally are able to make a more solid linkage of the music and the 6 materials.(Figure 7)

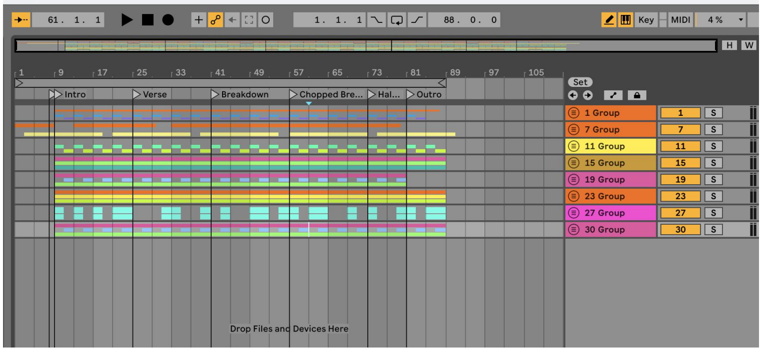


Figure7. music grouped by the materials

Also, as we would like to allow a higher level of play and make the device more interesting, we decided to give more control to our users. Because materials will feel different when touched with different strength, we decided the music should sound different as well. According to the feeling when touching materials with larger or smaller strength, we added more sound effects to the clips which have parameters changing with the strength of touch. For example, the music part associated with wood will be harsher when users press harder on it.

3. Tool and technologies

In this project, our team utilised Arduino, Ableton Live and Max as a set to build our project.

3.1 Arduino and Sensors

We compiled and compared the pressure ranges, the force area ranges, the degree of sensitivity, and the degree of accuracy of three different pressure sensors (Table 1), which were XC3738, FSR402, HX711, and ultimately selected HX711 as the sensor for our device.

Table1. Comparison of different pressure sensor

	Detective pressure ranges	Force area ranges	Degree of sensitivity	Degree of accuracy	Other
XC3738	0-10kg	Circular area with a diameter of 5 mm	Not sensitive to large areas of extrusion	Most accurate results are obtained up to 0.5kg	It can expand the force area by certain means, but affect the sensitivity of the detection and the

					accuracy of the value.
FSR402	0.2-20N	Circular area with a diameter of 18.28 mm	Sensitive	Pressure and resistance are nonlinear and therefore cannot be used for accurate measurements	
HX711	0-5kg	Circular area with a diameter of 10cm	Sensitive	Accurate	The sensor has no specific force area limit, depending on the size of the tray used by the user.

In the choice of microcontroller, we used the Arduino family of basic microcontrollers that are quick to get started, and by comparing the functions of different models, we finally chose the Arduino Leonardo. Unlike the Arduino UNO basic microcontroller, the Leonardo has an integrated USB driver that allows the simulation of the keyboard, mouse and other functions, which may be applied to our subsequent music operation. The software used to write the sensor-related programs is the Arduino IDE that comes with the Arduino.

3.2 Ableton Live and Max

There are plenty of music sequencers for different levels of users on the market. Among them, Ableton Live, FL Studio, Apple Garageband, PreSonus Studio and Acid Pro are suitable for beginners and meet our needs since all team members don't have a music-creating experience. Eventually, Ableton Live (Ableton, Ableton Live 11 Suite 2021) was thought to be the best choice based on the recommendation of some musicians, its usability, beginner-friendly nature, and its scalability across platforms for a variety of extensions. Max for Live (Cycling'74, Max for Live 2009) is one of the extensions available. At the start of our project, we intended Max for Live to be the medium linking Arduino with Ableton Live. However, Ableton Live always crashed while connecting with Arduino.

After that, we decided to use the software Max (Cycling'74, Max8 2022) to process the input from Arduino and connect the data with various audio files made from Ableton Live. In this approach, background music and sound effects are generated in Ableton Live, exported as audio files (.wmv), and imported into Max. All sounds and effects will be displayed through Max.

4. User test

After we sorted out the texture of the material that we thought had a chance to fit into the device, our music group wrote a set of chords based on our feelings.

4.1 Test process

We first asked our testers to listen to each piece of music and asked them to describe the emotional experience, like sadness or happiness, that the music gave them.
We first asked them to describe the emotional experience because when we first conducted a small scope pre-test, we found that it was challenging for us normal persons to associate a piece of music with the sense of touch. The testers tended to mistake the auditory-textile connection for the sound that the material could make. So we improved our test process and first asked them to describe the emotional experience, trying to guide them toward more abstract concepts. Subsequent tests verified that our process improvements were effective, and the testers were more active in expressing their thoughts and were able to make connections to a broader range of material tactile sensations.
After the first round of testing, we give a list of the material that our creators corresponded to when they composed the music, and ask the tester to connect the material that they feel has a connection to music. We tried to narrow down the wide and varied range of answers by using this list linkage to redirect the testers' associations and feelings toward more practical material. At the same time, this suggestive hint allows us to better synthesise the feelings of different people and allows us to better identify generic solutions through the test.

4.2 Test result

We collected a total of 20 valid data from the online interviews and field interviews. Here are our processed data tables.

Table2. User test data

Origin track inspired by	Quote(1st round)	Most match (2nd round)	Synthesise	Final texture
Humidity	"calm and positive. Like I was in a rainforest and could feel the soft green leaves in my hands." "The feeling of touching the wooden Buddha beads is colder and settles the mind"	Ice(6/20), Iron(4/20)	Most(13/20) people felt the music feel like cold material	Frozen asparagus

Plastic	“ Startled and annoying feeling. I could feel construction work starting in the apartment next to me. The material feels like steel.” “Restless and anxious, giving me the feeling of a crisp but heavy iron.”	Plastic(6/20)	Most people(12/20) felt it like metal material in the first round	Metal slice
Expandable Polystyrene	“The third one is a bit like the traffic lights of Australian pedestrians. Touching sounds like wood.” “I feel like it gives me a feeling of drumsticks, no I don't mean the sound of drumsticks hitting, he feels like many drumsticks, or pens stacked together.”	Wood(8/20)	The answers given by most testers for this music varied greatly. Many people think this music has a strong sense of texture, like some very angular material	Bamboo stick
Ice	“Peaceful, quiet and happy, felt like I was watching the rain falling in a quiet place. Material is water.” “The rhythm is sharp but comfortable, and it gives me the feeling of blue glass, smooth. Yes, it has to be blue.”	Ice(14/20)	Most of the answers given were close to some transparent and cold textured material. In linkage, ice was also the linkage that got most people.	Ice may be a better choice. but considering the limitations of freezing conditions in the exhibition, we finally chose marble ball
Wood	“Dry, fluffy, sandy feel” “Uplifting inspirational, or the opening overture, touching the feeling of the stage curtain.”	wood(11/20)	Most of the answers given were close to some transparent and cold textured material. In linkage, wood was also the linkage that got most people.	Wood
Sand	“Awakened. Sounds like an alarm clock. Feeling of my phone in my hand to make it stop. Material hard and smooth.” “The sixth one feels like a glass bottle. ”	Sharp(2/20)	This sound performed poorly in both rounds of testing and could not be distilled into a consensus, so it was discarded	

Sharp	“Anticipation … like waiting for your friend to pick you up to go out somewhere nice. Feeling of the fabric of my dress like silk.” “Flat, wooden, like an old-fashioned pendulum hammer.”	Expandable Polystyrene(13/20)	The answers given by the testers in the first round of testing all varied widely, but all pointed to a smooth yet textured material. And with a large percentage of Polygon in the linkage, our team also believes Polygon qualifies as smooth yet textured.	Expandable Polystyrene

4.3 Iteration

After we selected the materials that may connect to the pieces of music, we conducted a second round of sound tests using the materials. We let testers’ hands touch each material, but they would not see the shape of the material in this process, they could only feel it with their hands, and then we would play the sound aside.In this way, the influence of other senses on the tester can be avoided as much as possible, and the test error can be reduced. After that we would give the scale for them to evaluate each sound. Here are the scale.

How well do you think the sound matches your tactile experience?

0:Completely unconnected.
1:Have a vague feeling of something but can't say exactly if it is connected.
2:May be related, but hard to tell.
3:Similar to the feeling but may be slightly different, for example, wet and humid.
4:Can be related, but perhaps not to a sufficient degree, for example, not as rough as one might expect.
5:Completely connected.

We obtained a total of 16 valid data in the second iteration. The minimum maximum and average scores for each material are shown in the table.

Table3. Score of material

Material	Lowest score	Highest score	Average score
Frozen asparagus	1	5	3.25

Metal slice	3	5	3.9375
Bamboo stick	2	4	3.3125
Marble ball	3	5	4.25
Wood	2	4	3.1875
Expandable Polystyrene	2	4	3.125

All the materials scored above 3 on average in the test, proving that there is a connection between them and the corresponding music, and that this connection exists with varying degrees due to subjective factors. However, we believe that the device as a subjective experience can give most people a synaesthesia-like experience.

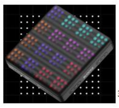
5. Positioning our prototype

The definition of an electronic music synthesizer is a machine that electronically generates and modifies sounds, frequently with the use of a digital computer (The Editors of Encyclopaedia Britannica, 1999). The sounds and music of our prototype are generated and modified by Ableton Live, which is purely electronic. Through Max, the volume is manipulated and specific effects are added based on user input via touching corresponding sensors. Finally, all operations will create a distinct piece of music through a computer. In this sense, our work fits the definition of an electronic music synthesiser.

The research conducted by Technavio (2022) disclosed that the market growth of the music synthesizers market between year 2022 and 2026 is expected to be $65.16 million whilst its year-over-year growth will be 1.9%. The key players in this market include Yamaha, Arturia, Roland, Casio Computer and Teenage Engineering AB among others. In this fragmented market, products are diverse with the target audience ranging from experts to beginners. Most key players focus on sophisticated synthesizers for musicians for live performance and music creation. In contrast, some, like Teenage Engineering AB, have started to explore the market for beginners. Notably, a trend started in 2007 of companies launching synthesizers for the beginner level, including Sphero, Maywa Denki, Roli and AlphaSphere. The sophistication level of their products is also disparate.

By mimicking audio-textile synaesthesia, our prototype aims to spark creativity in music creation. Our target audience is young adults with no to the middle level of musical experience. Below is a table listing all our competitors and products that have similar target audiences and purposes to ours.

Table4. Competitive landscape

	Product	Company	Music Experience Required	MIDI compatible	Purpose	Potential Price	Description
	**Touch Me Not**		**X**	**X**	**Music creation Inspiration creation**	**50 AUD**	**A collection of 6 boxes, filled with substances of different textures, attached on a board provides users with the simulation of audio-textile synaesthesia. Each substance in the box generates a corresponding sound. As the user presses harder, corresponding effects will be added. Initially, a set of effects and background music is programmed. For further inspiration, users are allowed to change the background music to generate different music genres as they wish.**
 1	Pocket Operator (PO-24 office)	Teenage Engineering AB	O	X	Music creation Inspiration creation	95 AUD	A pocket-sized and portable music device provides studio quality sound and the flexibility to make music anytime, anywhere.
 2	Orba	Artiphon	X	O	Music creation Inspiration creation	160 AUD	A handheld synth, looper, and MIDI controller allows anyone to make music on the go. It is also equipped with a built-in speaker and can use the provided app to customise instruments. Various gestures have been defined to correlate to different sound effects.
 3	Lightpad Block	Roli	O	O	Music creation Inspiration creation	320 AUD	A tech-vibe drum pad allows users to bend and shape drums and build tracks with their fingers. As the user's finger moves, the LEDs on the pad flash with different colours.
 4	Specdrums	Sphero	X	X	Music creation Inspiration creation	103 AUD	Coupled with its app, this ring creates sounds, loops, and beats by tapping any surface or the provided PlayPad. Rhythms and melodies can also be generated by tapping different colours. Corresponding sounds of specific colours can be set on its mobile app and user creations can be shared through social media.
 5	Otamatone	Maywa Denki	O	X	Live Performance Music Composition	35 AUD	This tadpole-like synthesizer plays notes as the user presses on the stem and vibrato can be added when the mouth is squeezed. This product is well-known and has gone viral on various media platforms.
 6	du-touch S	dualo	O	O	Live Performance Music Composition	770 AUD	A geometric keyboard arranges harmonious notes together and the backlit keyboard lets users play tones by touch. It acts like a kind of music controller. Custom samples are also available for easy creation and improvisation.
 7	Audiocubes	Percussa	O	O	Live Performance Music Composition Sound Design	370 AUD with Interface	This collection of wireless intelligent light-emitting objects detect the distance and direction of other cubes and user gestures generate corresponding harmonies.
 8	AlphaSphere me	AlphaSphere	O	O	Live Performance Music Composition	265 AUD	This edition is simpler than other models and allows users to create music. The equipped 32 tactile pads can be mapped to any conceivable sound.

Compared to other competitors in this market, our prototype seems to lack flexibility in performance and scalability, especially in the choice of sounds and MIDI compatibility. However, the main characteristic of our prototype is simulating audio-textile synaesthesia and no competitors have developed their products towards this goal. This can be our opportunity to stand out in the market.

6. Team project management & Collaboration

At the beginning of the project, we developed a rigorous progress plan for the project and managed the plan mainly by applying the scrum methodology. The scrum method helped us to be more agile and allowed us to maximize the design, build, user testing and iteration of the product in a shorter time (within one semester). At the same time, we enumerated and evaluated the risks that might be encountered during the project and provided feasible backup solutions for each possible risk.

Since the team members came from different backgrounds and had no prior knowledge of the microcontroller technology and music technology required for the installation, we divided the team members into a technical group and a music group in the early stage of the project to learn about the technology and the music design respectively. This division of labour was flexible, and tasks would be redistributed according to the specific needs of our project.

During the build process, we encountered some of the difficulties listed in the risk matrix and made reasonable adjustments based on the options provided in the risk mitigation:

1. Some members of the group struggled with music production due to a lack of necessary music knowledge. After consulting with the other team members, we decided to adjust the staff and redistribute the tasks. Members who lack relevant knowledge will be reassigned to user testing and device appearance construction, while one of the technical team members who had a basic understanding of music will help the music team with background music and sound design.

2. Some of the materials used to build the device, such as sensors and DuPont wire, experienced transportation delays, resulting in a longer build time. After consulting with the tutor and group members, we decided to apply for the school's lab and borrowed some of the lab's equipment to finish the installation.

After reasonable and necessary adjustments, we ended up with the following division of labour.

1. Technical team members: Yingzi Zhuang and Chia-Hsu Jung

The technical team members are responsible for learning and practising all the technologies needed for the project, including microcontrollers, sensors, music control functions and relevant coding.

2. Music team members: Yunchong Chen and Zhaoying Han

Music team members are responsible for the design and implementation of music or sound effects required for the project, including the background music, and sound effects corresponding to different touch sensations.

In this process, we mainly use Ableton live software to make music. Throughout the production process, how to connect the various materials to the music we make is a very serious challenge. So in the process of making music and sound effects, we did some user testing and solicited suggestions from other people to create melodies and sound effects that can be linked to the material through the Ableton live software.

3. Testing team members: Ziang Song, and Wanqi Yang

The testing team members are responsible for user testing and selecting the sound effects that meet the requirements of the device according to the analysis of the user test, and building the shape of the installation.

The project was successfully built slightly later than the expected plan due to technical difficulties and difficult access to resources. During the project implementation, the team members were able to solve the above difficulties due to smooth communication and close cooperation when they encountered problems, therefore, we can finally deliver the project before the deadlines.

7. Ethics, security and data privacy

The Touch Me Not project was conceived with the possibility of copyright issues arising from the use of material and resources in mind. Throughout the project's progress, all of the musical material, including the design of material tactile connected sound, background music, and rhythms, was created independently by the team members using licensed authoring software. The sound sources used were all sourced from open-source websites or from the sound library that comes with the editor.
In addition, all members of the team completed a lab safety course and assessment before making the device to ensure that no safety hazards were posed during the manufacturing process.
In terms of ethics and data privacy, the team takes all types of ethics very seriously. At every meeting, decisions were made with the consent of each team member. During the many rounds of user testing, the testers informed the test subject, the format of the test, the specific content, and the treatment of their data. The tests are conducted only with the consent of the participants.
In summary, the ethical, security, and data privacy issues are our prior considerations in the development of the project and guide our every choice.

8. Summarise

From the beginning to the end of the Touch Me Not project, the goal was to bring the experience of synaesthesia to ordinary people. We interviewed synaesthesia to learn about their auditory-textile synaesthesia experiences. Based on what they shared, we gained a greater understanding of synaesthesia. Our music group then applied these experiences to their compositions. These experiences helped them to better create melodies that would drive the senses. Based on the melodies, our test group conducted two rounds of user testing to verify the high correlation between the melodies and the general tactile sensation. At the same time, the hardware team members gave a touch control solution based on Arduino and pressure sensors. They used Max to complete the connection between hardware and software. Throughout the design process, we followed agile development principles, with the rapid iteration of the solution within each working group. We also maintained reasonable communication between the groups to coordinate rapid optimization and iteration throughout the project. In the end, we completed our project with the set goals and timeline.

9. Future direction

As a prototype, there is room for further iteration of our product.
First, in sticking with the synaesthetic music synthesizer, we need to do more user testing to ensure that we can give users a more accurate synaesthesia experience. In the tests we have conducted, the testers' cultural backgrounds have converged around the East Asian culture, although we have had testers from Western cultures, the sample size (n) is small (n=3). In future tests, we should strengthen the testing of differences in music-tactile associations across cultural backgrounds to obtain a more universal result.
Secondly, as a music synthesizer-like creative tool, the current user's creative freedom is still low. In future iterations, we can explore better hardware and software solutions to give users more creative freedom, and in the final goal, we should only control the timbre performance, and the pitch and melody should be left to the user's control.

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