

FH Joanneum & Universität für Musik und
darstellende Kunst Graz

Master Thesis in Sound Design



Sensim Artis

Music Technology From the Non-
Cis White-Male Perspective

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10. January 2022

Obligatory Signed Declaration

I hereby declare that the present Master's thesis was composed by myself and that the work contained herein is my own and that I have only used the specified resources. I also confirm that I have prepared this thesis in compliance with the FH JOANNEUM Standards for Good Scientific Practice and Prevention of Research Misconduct. I declare in particular that I have cited all formulations and concepts taken verbatim or in substance from printed or unprinted material or from the Internet according to the rules of good scientific practice and that I have indicated them by footnotes or other exact references to the original source.

The present thesis has not been submitted to another university for the award of an academic degree in this form.

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Graz, 10.01.2022

Place, Date

A handwritten signature in black ink, appearing to be 'Ernst', written above a horizontal line.

Signature

Acknowledgements

I am thankful and feel lucky to have had an extensive support network involved in the knowledge acquisition required to make this project come to life. Firstly, I want to thank my academic supervisor Birgit Bachler, who has been there with me throughout every step of the process and has made time to have (maybe even too) frequent meetings I requested. This helped me shape my idea and improve the structure of my academic research. Then, I would like to thank the whole team at Gründungsgarage. This accelerator program helped expedite the process of learning the business side of technical projects, as my goal was to turn my academic work into a start-up. Aside from Gründungsgarage, I also have to show some love to the team at Science Park Graz, who has been with me through the final stage of my thesis and will hopefully be extending their helping hand in the project in its future phases of development past academia. After that, I would like to thank all the interview participants, who gave me a raw and realistic look behind the scenes in the industry and helped me realise what to focus on in the rest of my research to address my research question. I would also like to thank Daniel Benedeti Piñeiro, who has decided to join as the CTO for my start-up project and has acted as a tutor for the technical execution of the project. With Daniel's help, I quickly learned the process and adopted a lean approach to technical skill acquisition that focused only on what was essential for this project. I am also thankful that Daniel is staying on board with this project for the foreseeable future in its further development as a start-up and, hopefully, a commercial project in the future. Participants in my polls and product demos also deserve credit for being an essential part of the iteration process. Lastly, I extend my gratitude to the most important people in my life - my parents and best friends, as their emotional support was cardinal in my success as a creator and helped me avoid burnout. Nobody is entirely self-made - it takes a village to raise a child and a community to bring forth intellectual and technological advancements.

Abstract

This thesis explores how to create a music controller centering on the experience of non-cis white male music producers and technology makers. According to many articles, publications and interviews explored in this thesis, non-cis white males still face prejudice and cannot reach the level of success their cis-white male counterparts usually can. Interviews explored in the thesis showed that the lack of expertise was, in fact, not the problem. I attempted to come up with steps to address the inequality present in the industry. This was done by creating actionable steps to highlight non-cis white male members of the community. Research performed mostly focuses on the technological achievements of non-cis white male individuals. A big part of the thesis acts as a guide for anyone who wants to build interactive controllers and create a music technology start-up. Prototype testing was performed in three phases, with user testing at every step of the way. Results revealed that emotion-to-sound translation through health-tracking sensors has a lot of potential for commercial use. Additionally, testers genuinely expressed interest in the building and programming process. This thesis emphasises the importance of reduced inequalities and the dissolution of prejudice toward non-cis white male tech enthusiasts. With a safer learning environment and mutual acceptance, there would be many more individuals actively participating in developing technology.

Kurzfassung

In dieser Arbeit wird untersucht, wie ein Musik-Controller entwickelt werden kann, der sich auf die Erfahrungen von nicht-weißen nicht-männlichen Musikproduzenten und Technologieentwicklern konzentriert. Die in dieser Arbeit untersuchte Literatur hat gezeigt, dass Menschen, die sich nicht als weiße Männer identifizieren, immer noch mit Vorurteilen konfrontiert sind und nicht das Erfolgsniveau erreichen können, das ihre weißen männlichen Gegenstücke normalerweise erreichen. Die im Rahmen dieser Arbeit durchgeführten Interviews bestätigten, dass der Mangel an Fachkenntnissen nicht das Problem ist, sondern dass relevante Teile der Musiktechnologie in Vergangenheit und Gegenwart als Inspiration für mein eigenes Produkt dienen. Die Ergebnisse zeigten, dass die Übersetzung von Emotionen in Töne durch Sensoren zur Gesundheitsüberwachung ein großes Potenzial für die kommerzielle Nutzung hat. Außerdem äußerten die Tester Interesse an der Entwicklung und Programmierung. Diese Arbeit unterstreicht die Bedeutung des Abbaus von Ungleichheiten und des Abbaus von Vorurteilen gegenüber nicht-weißen, männlichen Technikbegeisterten. Mit einem sichereren Lernumfeld und gegenseitiger Akzeptanz würden sich viel mehr Menschen aktiv an der Entwicklung von Technologien beteiligen. Im Ergebnis dokumentiert diese Arbeit meine Reise als Entwicklerin in der österreichischen/europäischen Start-up-Szene und soll als Leitfaden für alle dienen, die selbst interaktive Controller bauen und ein Musiktechnologie-Start-up gründen wollen.

Table of Contents

1	Introduction	9
	1.1. Chapter Summaries	13
2	Topic Choice	17
	2.2. Statement of Research Problem	18
	2.3. Hypothesis	19
	2.4. Methodology	19
3	Research and Background	25
	3.1. History of Interactive Music Projects	26
	3.2. Music Production Software for Interactive Projects	28
	3.2.1. MUSIC by Max Matthews	28
	3.2.2. Max/MSP	29
	3.2.3. Ableton Live	30
4	Inequality in the Music Industry	33
	4.1. Binary Genders	34
	4.2. Non-Binary Genders	36
	4.3. TikTok's Sub-Community - GayTok	38
	4.4. Behind the Scenes Experiences	39
	4.5. Mental Health in the Community	41
5	Female/LGBT Music Tech Innovators	43
	5.1. Female/LGBT Pioneers of the Industry Through History	44
	5.2. Female/LGBT Pioneers in Today's Music Tech	47
	5.3. Interviews	51
	5.4. Problems in the music industry and how to stay safe	53
6	The Thesis From a Start-Up Perspective	55
	6.1. Sensim Artis in Start-Up Programs	56
	6.2 Business Model	58
	6.3. User Personas/Target Audience	58
	6.4. Business Plan	60
	6.5. Funding for Female/LGBT-led Projects	61
	6.6. Female-led Music Tech Start-ups	62
	6.7. Learnings	64

7	Product Development process	67
	7.1. Prototype 0 (MVP)	68
	7.2. Prototype 1	86
	7.3. Prototype 2	98
	7.4. Final Product Video	104
8	Where To Go From Here?	107
	8.1. The 3 Roads of Music Tech Products	108
	8.2. Future Plans	108
	8.2.1. Fourth prototype and sales-ready model	109
	8.2.2. Gamified Learning	109
	8.2.3. Multi-practical use (Health monitoring + music production)	110
	8.2.4. More funding plans	110
	8.2.5. Teamwork	111
	8.2.6. Addressing gender-related problems in the industry	111
	8.2.7. Addressing Statistical Inadequacies	111
9	Research Recommendations	113
	9.1. Start-Ups in Music	114
	9.2. Female-Led Initiatives	115
	9.3. Resources for Programming (MAX, Arduino, C#)	116
	9.4. Resources for Electronics & Soldering	116
	9.5. The Future in a Nutshell	117
10	Conclusion	119
11	Bibliography	121
12	Appendices	130

1 Introduction



Ever since technological advancements enabled the composition of the first pieces of electronic music in the 50s, musicians and audio engineers experimented with new ways of creating and controlling music. In 1977, the first DAW (digital audio workstation) was created, and it was called Soundstream. This software was a digital recorder, but it set off the development of software that would become a staple for electronic music recording and production. In 1983 came an invention that would expedite the evolution of computer music - MIDI (*Musical Instrument Digital Interface*). Kakehashi and Smith uncovered it, enabling the development of instruments that could now be used as controllers for music software. Shortly after, Pro-16, the predecessor for Cubase, was created. In 1986, the Atari ST MIDI Interface enabled the possibility of using graphical user interfaces and built-in MIDI interfaces. Sound Tools was released in 1987, introducing Digital Audio Tapes as its source and storage medium. In 1991, the first version of Cubase Audio was released, integrating both audio and MIDI into its Arrangement view. That same year, Pro Tools came out with its release offering four tracks inside music projects. In 1997, VST (Virtual Studio Technology) was incorporated into Cubase, bringing a real-time studio environment (EQs, effects, automation).¹ 2001 is when Ableton arrived on the market, giving artists robust sampling capabilities and the option to create advanced music controls and instruments through MAX4Live.² MAX4Live originated from MaxMSP, created by the developer of the brunt of popular music software and programming languages - Max Matthews. Starting in 1957, he developed the MUSIC N series, all the way up to MUSIC V. It provided the basis for synthesis software like Csound, Cmix, SuperCollider, and MaxMSP, which are currently extremely important in audio engineering and sound design.³

The following work explores the potential of emotion-to-sound translation with a sensor-based interface. The classification of sensors can be broad, even in the context of music production. These can be knobs, faders, motion, tactile, bend or even health-tracking sensors. The latter ones will be described further in Chapter 3.5, where I mention how Laetitia Sonami uses them. There is a distinction in how these sensors work, which can be classified into active and passive interaction sensors. Health-tracking sensors could be classified as passive because they do not require the user to take any conscious action. They can be actively manipulated, but it is not necessary to get an output. My motivation for creating this project stems from multiple factors. Firstly, my passion for music led me to dig deeper and learn not only how to make sound with computers but also how to create devices that could generate sound. The latter was something entirely new for me, and I wanted to challenge myself to get out of my comfort zone. This thesis project was performed centering the experiences of non-cis white male members of the music industry. Many non-cis white male individuals were either overlooked or had their achievements diminished through the history of music and music tech development. Through my research into the alternative, feminine/ LGBT, and POC

¹ Stubbing, Sam. "History and Development of the Digital Audio Workstation (DAW)." Music Tech Student, 2013.

² Cep. "Evolution of Ableton: History of Ableton Live (Versions Comparison from Ableton 1.0 to Ableton 11)." *Screech House*, 8 July 2021, <https://screechhouse.com/evolution-of-ableton-history-of-ableton-live-versions-comparison-from-ableton-1-0-to-ableton-11/>.

³ Sheffield, Mike. "Max/MSP for Average Music Junkies." *Hopes&Fears*, 20 Nov. 2015, <http://www.hopesandfears.com/hopes/culture/music/168579-max-msp-primer>.

side of music history, I found it challenging to unveil detailed and accurate information. In some situations, I had even seen that achievements made by certain women (e.g., Joan E. Miller) had been falsely attributed to men and/or that their academic/job positions were misrepresented as smaller than they were.⁴ Joan's full name is even listed incorrectly in many sources; for example, her most important work isn't listed on Wikipedia.⁵ I had to find the original publications of her work with Max Matthews to corroborate the accuracy of my research.⁶ As explained by Katherine Maher, CEO of Wikimedia Foundation: "*When computer programming, computer science first emerged ... the computers were the women.*" (Maher, 2019, *POLITICO* interview) In the beginning, computer electronics were considered low-value, so working with them was initially assigned to women. As soon as computer technology became "cool", cis-white men suddenly overtook it.⁷ Upon trying to search for important female inventions in the field, I did not initially even encounter individuals like Daphne Oram, Delia Derbyshire or Laurie Spiegel. My attention was drawn to them after my supervisor's recommendation.

As someone belonging to multiple underrepresented groups, getting involved in some form of activism is essential to help myself and others whose work is overshadowed by their cis-white male counterparts. During interviews conducted or analysed in this thesis, the inequality was visible. With this thesis, I would like to provide resources to members of marginalised groups in the industry. This is done by describing what other non-cis white male individuals have done throughout history, what is currently being done, and providing resources and organisations that help push women/LGBT/POC people in the industry. There is also information on how to get started more quickly and where to find supportive groups and organisations helping, e.g. women learn more about music and technology. I also provided a guide on how to turn a personal project into a start-up, get female-founder grants, and how I did it. Lastly, I created actionable steps that I plan to take to aid the inequality/diminishment issue.

Sensor-based technology particularly interested me after seeing how intuitive the controls it produces are. Laetitia Sonami's Lady's Glove showed us how sounds could be triggered by the slightest motions of her body being picked up by high-resolution sensors. This interface also involved magnets and proximity sensors to create music using the distance between the performer's limbs. Sonami went on to create an instrument with even more advanced sensor technology based on a neural network developed by Rebecca Fiebrink.⁸ More recently, I can reference Imogen Heap as another pioneer in sensor-based interfaces. Her mi.mu gloves use bend and flex sensors as input controls for controlling music.

⁴ Park, Tae Hong. (2009). An Interview with Max Matthews. *Computer Music Journal*. 33. 9-22. 10.1162/comj.2009.33.3.9.

⁵ "Pril Smiley." *Wikipedia*, Wikimedia Foundation, 20 Aug. 2022, https://en.wikipedia.org/wiki/Pril_Smiley.

⁶ Matthews, Max, and Joan Miller. "Music IV Programmer's Manual : Max Matthews, Joan Miller." *Internet Archive*, Internet Archive, Sept. 2018, <https://archive.org/details/music-iv-programmers-manual>.

⁷ Stanton, Zack. "The Dumb Stereotype about Women and Tech That Will Not Die." *POLITICO*, Women Rule Podcast, 7 Mar. 2019, <https://www.politico.com/story/2019/07/03/women-technology-katherine-maher-1389966>.

⁸ "Laetitia Sonami: Ideas & Machines." *CCRMA*, Department of Music, Stanford University, 22 Jan. 2019, <https://ccrma.stanford.edu/events/laetitia-sonami-ideas-machines>.

I wanted to take the most intimate portion (in my opinion- emotions) of the body and use that as my music controller. I dug through many different sensor-based solutions and devised a way to improve on the previous developments by other non-cis male creators in the industry. The classification of sensors can be wide, even in the context of music production. These can be knobs, faders, motion, tactile, bend or even health-tracking sensors. The latter ones will be described further in Chapter 3.5, where I mention how Laetitia Sonami uses them. There is a distinction in how these sensors work, which can be classified into active and passive interaction sensors. Health-tracking sensors could be classified as passive because they do not require the user to take any conscious action. They can be actively manipulated, but it is not necessary to get an output.⁹ There are not as many projects with health-tracking sensors as there are with motion sensors or knobs. This seemed like an opportunity to contribute to the sphere. Health-tracking sensors are basically all sensors that can track the body's physiological responses - for example, sweat, heart rate, pressure, brain waves, etc. The best way to use our emotions for music production is through these bodily responses, as many of them directly respond to our momentary emotional state. The most significant ones, in this case, are galvanic skin response and brain waves. These two physiological responses have the most significant fluctuations in values across short periods and also create specific intervals which have been used for emotion recognition in some studies.¹⁰¹¹

Sensor-based interfaces have a relevant use in the industry. I believe that further developments in this field would result in musicians having the ultimate connection to their music and being able to instantly translate their emotions into music. Additionally, using health-tracking sensors while creating music could benefit mental health. According to a study from 2022 performed by WHO, mental health struggles have been increasing globally. Suicide is the fourth leading cause of death among 15-29-year-olds. Using interfaces with advanced health-tracking sensors would make the user more mindful of their stress levels due to the live and audible connection to music. Mindfulness is known to reduce common low to moderately severe types of common mental health problems, like stress, anxiety and depression.¹² My utopian vision of the future is that we can use music as an additional medical treatment option and that non-cis white male musicians and technology makers would be credited the same as their cis-white male counterparts.

⁹ Montague E, Xu J. Understanding active and passive users: the effects of an active user using normal, hard and unreliable technologies on user assessment of trust in technology and co-user. *Appl Ergon*. 2012 Jul;43(4):702-12. doi: 10.1016/j.apergo.2011.11.002. Epub 2011 Dec 20. PMID: 22192788; PMCID: PMC3422026.

¹⁰ Dutta, Stobak, et al. "An Analysis of Emotion Recognition Based on GSR Signal." *IOPScience*, 2022, <https://iopscience.iop.org/article/10.1149/10701.1857ecst/meta>.

¹¹ Gannouni, Sofien, et al. "Emotion Detection Using Electroencephalography Signals and a Zero-Time Windowing-Based Epoch Estimation and Relevant Electrode Identification." *Nature.com*, U.S. National Library of Medicine, 29 Mar. 2021, <https://www.nature.com/articles/s41598-021-86345-5>.

¹² "How to Look after Your Mental Health Using Mindfulness." *Mental Health Foundation UK*, <https://www.mentalhealth.org.uk/explore-mental-health/publications/how-look-after-your-mental-health-using-mindfulness>.

The product of this thesis will also be developed within the framework of an incubator beyond the academic part. There has never been more support for start-ups, which can be seen in the many funding opportunities offered in Austria and Europe. There is an increasing number of non-cis white male-specific funding available as well. For example, most Austrian funding agencies addressed this by adding a “female founder bonus” to all grants. Additionally, funds like *Female Creatives*¹³ from Wirtschaftsagentur Wien are explicitly created to help people in the creative industry develop their products and hire staff. While there is certainly value in having a purely artistic personal project, much more support can be found in the start-up atmosphere. The variety of available funding makes it a much easier road, especially for those with great ideas and a solid business plan to sustain the company after investments.

1.1. Chapter Summaries

The first two chapters introduce the chosen thesis topic, providing the reader with a brief overview of the intention of this thesis, as well as proposing a few questions that guided the project's development. Some statistics were given to back up the claim that there has not been enough focus on female/LGBT and POC creators. Further, the chapter explains why the product of this thesis could be relevant by outlining and comparing it to other popular and critically acclaimed products in the same field (interactive music tools).

Chapter 3

This chapter gives some background on the history of interactive tools to establish the possible routes the thesis product might take. It focuses on extracting key learnings through history that relate to the author's interest in interactive music controllers, as well as biosignal controllers.

The second part focuses on the software part of history. I first give an overview of MUSIC, the basis for most modern sonic interaction software. Then I describe how MAXmsp evolved from there. Both software was created by Max Matthews, while MUSIC was co-developed with Joan Miller, who, as already mentioned in the introduction, was falsely credited or diminished in most sources. Lastly, I tie in Ableton Live and its developments, as it will be used alongside MAX to create a soundtrack with the final thesis product.

Chapter 4

Chapter 4 pertains to the socioeconomic situation in the music and music technology industry. It addresses and backs up claims of inequality and discrimination in the field today. There is also an exploration of how social media, like TikTok, helped amplify the voices of minorities in the music industry, as well as a brief look behind the scenes taken from a few online interviews with prominent LGBT figures in the scene. Information in this sub-chapter is further backed by statistics from mental health-related studies conducted on the target groups of this

¹³ “Female Creatives Funding.” *Wirtschaftsagentur*, <https://wirtschaftsagentur.at/foerderungen/aktuelle-programme/female-creatives-178/>.

thesis. This chapter determined that a lot of statistics conflate many different sub-communities in the industry, thus not enabling a focus specifically on music technology producers.

Chapter 5

The next chapter explores the struggle of non-cis white male people through the history of music technology and highlights some significant projects from these people. It starts by analysing the careers of the most prominent female/LGBT creators in the industry throughout history. It lists their achievements, academic positions and struggles of operating in a cis-male dominant sector (where information was available). It is easy to find famous female/LGBT musicians (e.g. David Bowie). Still, finding factual information on the same groups in the area of music technology proved challenging. In this sub-chapter, the conclusion is reached that even though non-cis-male creators are not talked about enough, they have directly contributed to developing software and programming languages that are the basis for modern interactive music control software.

The next part focuses on the female/LGBT music tech creators in modernity (1990 all the way to 2022). It explores creators who developed sensor-based music controllers, as this technology was already quite accessible in the period mentioned above. Furthermore, the chapter sources two online interviews and two conducted exclusively for this thesis. These interviews aimed to gain insights into the chosen creators' perspective of operating in a cis-male-dominant world. The findings were interesting because they confirmed my assumptions before starting this project.

Chapter 6

This chapter explores the thesis project from a commercial aspect, giving an insight into the start-up environment in Austria from my own experience. The chapter outlines the essential components necessary to develop a good business and secure funding. This includes the business model, user personas/target audience and the business plan. I also provide examples of successfully funded female/LGBT-led start-ups in the music technology industry to demonstrate how others overcame covert inequality through great business plans. The chapter also includes a list and description of significant Austrian funding programs with either a female/LGBT bonus or grants aimed explicitly at non-cis white male individuals. This is a small guide for anyone who wants to take the start-up route but does not know where to find funding and which type of funding is the best for a specific idea.

Chapter 7

This chapter is dedicated to developing a prototype centering on all the research performed earlier in the thesis. The prototype has been created in three different stages, each of which has been evaluated separately. The final product is a music production controller based on health-tracking sensors that uses our body's responses to emotions to control music.

Prototype 0 (MVP) focuses on ensuring the sensors will perform the desired actions and creating the MAX patch. The components are assembled on a preliminary breadboard, where every step is reversible.

Prototype 1 is an evolution from the breadboard to a cardboard prototype with a soldered PCB as the base. This version was built to fit the form of a hand, which is the final intended placement. This stage aimed to figure out how to build a wearable, sturdy prototype. This stage was evaluated with a few live testers and a small online participant group, which assessed a video.

Prototype 2 is the product's final form within the framework of the thesis. At this stage, a sturdier, more polished product was designed based on feedback from prototype 1. The prototype was tested again with two separate groups of participants (online and in-person). A final evaluation is made to compare the outcomes with the aims and objectives set up in the beginning. The final video performance is made using this prototype.

Chapter 8

This chapter explores the possible future development paths for the project. The first section mentions the three possible paths an idea could take- private personal project, bootstrapped small business, or commercial start-up. The following section summarises how my start-up plans to get to the go-to-market phase. Afterwards, I explain how I plan to add an aspect of gamification to the product. I also explain how and why this product could be used in fields like health monitoring or stress tracking. I present my ambitions of obtaining further financial support for the start-up and how the team will be expanded in the future. I also explain why it is important to vouch for gender/race/social equality in start-ups and which steps I will take to ensure my project amplifies the voices of marginalised groups. Lastly, I highlight the statistical inadequacies that prevented me from accurately determining to what extent is the problem described in the thesis still present.

Chapter 9

This chapter outlines research recommendations that are valuable for anyone who also wants to enter the world of interactive music projects and sensors. I explain why creating a music start-up is difficult and propose a possible workaround that can be applied in some cases, depending on the nature of the idea. I list Austrian funding calls that are appropriate for a music-oriented idea. Next, I give a list of initiatives in Austria that focus on amplifying the voice of non-cis white males in the industry and providing a safe space for those who want to learn. I also list the most relevant resources I used while learning how to create the software and program the sensors of my product. Additionally, I give some helpful resources on how to assemble electronics and how to solder.

2 Topic Choice

During my studies at FH Joanneum, I have widened my interests beyond just music production. Some new topics I learned include sonic interaction design, sound programming, and product design. I wanted to combine my love of music production with these technical aspects that I have learned the basics of during my studies. I also wanted to learn more about each area. On top of that, my entrepreneurial spirit has led me to pick something that has genuine utility in the music industry so that the project doesn't just stay a master thesis that sits on the shelf and collects dust. I wanted to pick something I could turn into a start-up and hopefully create a real business. The master thesis is an excellent opportunity to conceive important ideas that one could continue developing past academia. Thus, I picked something that is challenging, and that could result in much personal growth.

Keywords: Embodied interaction, sonic interaction design, entrepreneurship, female founders, start-up funding generative music, mental health, inclusivity

2.2. Statement of Research Problem

To properly formulate my research problem and questions, I wrote out a set of questions that will help me express myself in a structured manner:

- *What do I already know?*
- *What is the problem?*
- *Why does the problem matter?*
- *How am I going to prove it?* I will demonstrate the problem's validity through research, peer testing, peer interviews, and, finally, producing a piece of music live with the device.

In the frame of this thesis, the following research question is explored, analysed, and assessed: How can sensor-based immersive music production tools be designed by centering the experience of LGBT/Genderqueer & Female performers/creators?

To start addressing this question, the market size must be considered. The female/LGBT-owned market share is meagre- between 2.6/0.4% (producers) to 2.7/1.4% (pop chart artists). This indicates that there is still a need for better opportunities for the groups above. On the product side, many products explore embodied interaction, which is the chosen field for this thesis project. There have been projects using sensors for music in the past. However, each uses a different approach to sonifying the human body and to a different level of complexity. The projects mentioned in the next paragraph served as inspiration for using technology and human-body interaction. One of the goals of this thesis was to explore how to use the already existing technology to build on top of previous music tool concepts, with plans of going beyond the current state-of-art technology. Another goal is to take up a new challenge and acquire new skills.

Innovation comes in two forms- creating an entirely new product/service or creating a better version of an already existing product/service. This thesis takes the second approach during the product production process. What follows is a

quick overview of a few interactive sound projects that serve as a good foreshadowing of what will be explored and researched in this thesis project.

The Human harp relies on movement and sensors that control music based on the length of the wires spanned on the bridge. As the user moves in the strapped bodysuit, the change of wire length on each section is picked up by the sensors and transmitted into music. The usage is limited to a series of presets created by the artist. Hence, the product cannot create a wide range of custom music. Moreover, the Human Harp project did not originate as a start-up and did not provide any guidelines or resources that would be useful for future founders in the music tech industry. This thesis aims to provide the guidelines above, as the project is also a part of an accelerator program. More on this will be elaborated on in chapter 7.

Mi.Mu Gloves is run by a female founder (Imogen Heap). This company supports a lot of musicians, a large portion of which are women (e.g., Chagall and Ariana Grande, as listed on their website). MI.MU Gloves focuses on embodied interaction; however, the product does not utilise sensors that connect the user's momentary emotions and music directly. The product of this thesis will rely on the emotion-to-music link through health tracking. Details on this company, its founder, and Chagall will be outlined in chapter 4.

2.3. Hypothesis

Based on my personal experience and what I have seen from the musicians and music tech engineers I follow, I assume that any group excluding cis-white males has some negative experience in the industry and some hardships due to the discrimination present in the industry. I was already aware of the stigma of men being better engineers than women before I started this research. This was a stigma related to engineering in general, but I can imagine that the outcome is similar in music technology. I can also presume that creating a sensor-based music control solution centering on the female/LGBT experience would contribute to the field from a non-cis male perspective, as I am also part of the minority group in the industry. Raising my voice to promote other non-cis male counterparts would help. Lastly, providing a comprehensive guide in the form of a written dissertation will help other non-cis male creators reach their goals quicker and have valuable resources to refer to for different specific situations.

2.4. Methodology

The focus of this thesis lies heavily on physical product development, so many steps need to be completed to allow for proper evaluation of the hypothesis and the process of creating a product. This chapter outlines under what standards the research will be conducted and how the project will be evaluated. At the beginning of the project itself, a table with aims and objectives was created to act as a guide on how to break down and assess different aspects rising from the given research question:

“How can sensor-based immersive music production tools be designed by centering the experience of LGBT/Genderqueer & Female performers/creators?”

The incremental evaluation of the thesis throughout the writing and product development process will be guided by a series of questions, helping to stay focused on the main objectives set out during the thesis ideation phase. These sub-questions arise from the main research question. are listed below and branched out into aims, identification, assessment, development, learnings, and outcome. This serves as an action plan for addressing each question throughout the thesis. The following table summarizes all of this:

Question	Aims	Identify	Assess
Interactive music production with a focus on LGBT/ Genderqueer & Female Creators. What are the most prominent musical projects by LGBT/ Genderqueer & Female Creators	Establish the historical and current position of this demographic within the music tech industry. Offer possible solution for the future growth of the demographic	It seems to be hard to find founder or majority-owners of interactive music projects/ companies that are not cis-male	Compare succes of these comapnies/ individuals to the state of cismen individual/ companies. Compare accuracy of representation in information
What is the current development of immersive interactive music hardware?	Analyze the scope of current sensor-based interactive music tools	The possibilities are endless! From interactive synths, to people using brainwaves to control MIDI (Mind-2MIDI).	Compare and analyze most awarded hardware on the market
How can I make my product portable and reasonably light?	Define a product design standard for portable/ wearable music tools	component size, flexibility, comfort	Test product on myself, testers, passive observers
How can I bring value to the market with this product	Assure that the thesis product can help alleviate a target user’s painpoint	Every creative struggles with creative block from time to time. Musicians and producers are always looking for cool new ways to interact with their music and speed up their workflow or make it more intuitive and more efficient	Alpha testers, Self-testing, questionnaires, interviews with testers

Question	Aims	Identify	Assess
How could this product inspire other musicians to expand their interests into the technical side of music?	Define a simple and fun way which demistifies technology/ programming and makes it less intimidating for non-technical musicians.	People are more likely to try and learn a new skill if it is presented in a novel and fun way. It wakes up the competitive and inquisitive spirit naturally present in people	Play testing, demos, final performance
What is the current state-of-art level of interaction between music and emotions?	Define the current scope of interaction	Through music, we express our feelings and they impact the outcome of our creations. Some attempts of more intuitive and direct influence of emotions on music- brain2Midi. Movement-based and tactile devices like soundprener pulse and MI.MU Gloves	Compare existing solutions to my prototype idea

Question	Develop	Evaluate	Outcome/ Learnings	Output(s)
Interactive music production with a focus on LGBT/ Genderqueer & Female Creators. What are the most prominent musical projects by LGBT/ Genderqueer & Female Creators	1) Take part in developing the industry with my own product 2) Learn from the experiences of those before me	Product - relevance to the chosen focus group.	There have been some incredible and innovative products created by non-cis white male individuals from the industry. E.g. the Lady's Glove, Mi.Mu Gloves	Product that highlights the experience of the female/LGBT community in music tech, Actionable steps to promote the community
What is the current development of immersive interactive music hardware?	Feedback, design iteration, comparison, market analysis	Novelty factor of the product	Similar products have been done before, just with different combination of biofeedback sensor inputs	Prototype reflecting learnings from previous significant commercial projects

Question	Develop	Evaluate	Outcome/ Learnings	Output(s)
How can I make my product portable and reasonably light?	Prototyping , iterative design	Weight, size, mobility	Design standards for portable sound devices	Light, comfortable device
How can I bring value to the market with this product	Iterations through feedback	Tester satisfaction, wow-factor, inclusivity	Unique combination of product features derived from existing technology, SDG 10 - Reduced Inequalities implemented in business idea	Product with market-relevant value propositions. Inclusive. Promotes/ highlights marginalized groups
How could this product inspire other musicians to expand their interests into the technical side of music?	Gamified product testing, feedback	Product demo, tester feedback	We need to increase accesibility to the industry to marginalized communities through awareness-raising, approachable documentation and increase the strength of the community through collaboration and co-creation	Written documentation/ guide, TEDx Talk (raising awareness), pitch deck (raising money)
What is the current state-of-art level of interaction between music and emotions?	Iterative design, research	feedback, level of intuitive control	While the technology being used in my product is not new, it is possible to create a new product through creating a unique combination of interactive inputs.	Wearable with health-tracking sensors that convert emotional responses into music

After coming up with the technical idea of a sensor-based music controller, I decided to research the field, focusing on the perspective of marginalised creators in the music industry. My start-up experience would serve as a great extension to this by proposing possible ways to improve/amplify the voices of the group above in the music industry.

Exploratory research is conducted to collect preliminary data and establish a preliminary structure and the desired research direction. Statistics were looked up to back up an initial assumption about gender, race, and sexuality inequality in the music industry (including music hardware). It was surprising how there were not enough statistics available, meaning that the focus groups of this project were overlooked, hence birthing the conclusion that inequality is, in fact, present to an extent.

Conclusive research is performed by analysing scholarly thesiss and interviewing experienced music industry members. Through academic thesis research, I have found out the extent of gender/race/sexuality inequality after not being able to find enough information on historical figures, as well as discovering that some technological advanced were misattributed to cis-white male counterparts. In contrast, the role of their female counterparts was diminished.

Inductive/deductive reasoning was also performed. It was based on the availability of desired data in general and the data chosen as the focus of this research. The emphasis was mainly put on data from the US and UK markets, as the most significant activity within the music industry can be attributed to these geographical zones. For example, in a statistical report by PR Newswire, the US and UK are listed among the top 5 most significant consumers and producers of music production software.¹⁴ It is also documented that in the segment of music production equipment, 41% of the growth is attributed to a group of 5 countries, including North America.¹⁵

The final thesis product was created by researching previous practical examples specific to chosen sensors and the type of material suitable for a music technology wearable. Product evaluation occurred in two phases. After the MVP (Prototype 0) creation, a concept feedback form was created and sent out to music producers and hardware experts to fill out and evaluate how strong the artistic concept of emotion translation is. Then, after the completion of Prototype 2, live testing was conducted with participants consisting of friends and dorm residents. The goal was to evaluate how easy the final product is to use, whether it withstands moderate use, and how appealing/ergonomic it is.

Co-design was the first design method utilised in developing MVP (Prototype 0). With the help of my start-up team member, I learned the essentials of programming necessary to use the functions of the chosen health-tracking sensors. I had been coached on the basics of prototype assembly, where I learned which sensors can be connected to which I/O on the ESP32. This could also be called the

¹⁴ Maida, Jesse. "Music Production Software Market: USD 369.87 Million Growth from 2021 to 2026, High Competition among Vendors - Technavio." *Music Production Software Market: USD 369.87 Million Growth from 2021 to 2026, High Competition Among Vendors - Technavio*, Technavio, 22 Aug. 2022, <https://www.prnewswire.com/news-releases/music-production-software-market-usd-369-87-million-growth-from-2021-to-2026--high-competition-among-vendors---technavio-301609488.html>.

¹⁵ Maida, Jesse. "Music Production Equipment Market Size to Record USD 1.27 Billion Growth, Rising Number of Music Festivals and Live Events to Be a Key Trend - Technavio." *Music Production Equipment Market Size to Record USD 1.27 Billion Growth, Rising Number of Music Festivals and Live Events to Be a Key Trend - Technavio*, 10 Oct. 2022, <https://www.prnewswire.com/news-releases/music-production-equipment-market-size-to-record-usd-1-27-billion-growth-rising-number-of-music-festivals-and-live-events-to-be-a-key-trend---technavio-301643618.html>.

“lean learning method,” as it saved me much time and answered specific questions.

After the MVP was done, a concept feedback questionnaire was created to evaluate the desirability of the implemented features and gauge the potential customer desire for a product like Sensim Artis in the market.

The iterative design was used to bring the prototype to life in 3 different stages. The second stage (Prototype 1) includes a soldered PCB and a cardboard housing to gauge the sizing possibilities before the final product is created. The evaluation of this prototype stage was performed through a small test group. The aim of the testing was to receive feedback on the form factor of the prototype and confirm that the construction plan of the final prototype would serve its purpose well.

The last iteration of the product was prototype 2, where the final assembly happens. After soldering, gluing, and cutting, the product is tested with random willing participants. The final testing aims to establish to which extent the project has been successfully implemented and how are the research goals met.

3

Research & Background



The following chapter lays out a theoretical background relevant to the research question and the technology that will be explored in the final product of this thesis. An important remark regarding the first sub-chapter is that it might seem more focused on cis-male inventions. However, it is vital to keep in mind how researching the history; it took a lot of work to find accurate information regarding non-cis male music technology inventors. Many women found during this research were either falsely described as ranking lower than they were or wholly removed from resources about their inventions/achievements. This chapter focuses only on conclusive data that has been found; however, a lot of the work done in the field by non-cis individuals may not have been listed.

Some falsely diminished women have been listed and explored in Chapter 3.4. Katherine Maher, the CEO of the Wikimedia Foundation, highlights how once computers got into our homes, they were heavily marketed toward boys. Maher aims to use her influence to abolish the widely-present societal stereotype that women are not good with technology. On POLITICO's "Women Rule" Podcast, she points out that computers and computer science were first populated by women. Computer work was undervalued, hence why it was assigned to women, the "inferior" gender. As soon as the value of computer technology went up, women were pushed out of the industry. Maher claims that this trend is still present today. She also points out how only 18% of biographies on Wikipedia are about women, which Maher considers quite inadequate. She is confident that one of the reasons for that is that Wikipedia writers rely on external sources. If there are no records of notable women in specific areas, there will not be an article about them on Wikipedia. Katherine claims that women are generally not well-represented in the media. This also explains why it has been so hard to find the information that would answer some of the questions in this thesis. Maher's conclusions match my assumptions made in this chapter.¹⁶

3.1. History of Interactive Music Projects

The technology aspect of the research question will be the first part to be researched and analysed in this thesis. This section summarises the historical projects, as well as explanations that are taken as the most relevant basis and point of technical inspiration. Understanding the history and logic behind different interactive music tools is essential. I analysed different approaches to interactive instruments to expand my horizon on control options and use the examples as an aid while building my prototype.

The Microphone as a Controller

Aside from sensor controllers, there were also developments to the microphone itself. Researchers found ways to use audio input to control and synthesise music. The information on musical gestures could be extracted and mapped to sound parameters. This has been extensively used at the IRCAM institute and has influenced the development of Max/MSP. Composers Cort Lippe

¹⁶ Stanton, Zack. "The Dumb Stereotype about Women and Tech That Will Not Die." *POLITICO*, Women Rule Podcast, 7 Mar. 2019, <https://www.politico.com/story/2019/07/03/women-technology-katherine-maher-1389966>.

and Zack Settel were instrumental in developing the software, creating different synthesis and analysis patches for various instrumental compositions.¹⁷

“Lippe’s ‘Music for Clarinet and ISPW,’ and Settel’s ‘Hok Pwah’ for voice and percussion and ‘Taudrium’ for contrabass are emblematic of this microphone-as-sensor approach.”(Tanaka, p. 244-245.)

Biosignal Instruments

For a long time, musicians have tried to incorporate physical gestures or musical thoughts directly into the musical output. Biofeedback systems were the most commonly used to monitor the body’s responses. This marked the development of biocontrol. The connection between the brain and the computer has recently become a popular notion and has some potential for music as well. In the 60s, David Tudor and John Cage used biofeedback in the signal chain to control audio directly. “Music for Solo Performer” by Alvin Lucier is a highlight in this field of musical research. He controlled an array of drums and percussions with his brainwaves. The performer had to stay almost paralysed in the chair, only changing his visual attention and focusing on activating his brain.¹⁸ David Rosenboom created a collection of biofeedback work, stating:

“The term ‘biofeedback’ will be used herein to refer to the presentation to an organism, through sensory input channels, of information about the state and/or course of change of a biological process in that organism, to achieve some measure of regulation or performance control over that process, or simply for internal exploration and enhanced self-awareness” (Rosenboom, 1976)¹⁹

Since the developments made by these two composers, it was possible to create advanced multi-channel systems that track brain activity more precisely. The decreasing cost of electronics made biofeedback affordable for all artists. The signal remained low in amplitude and high in noise, so it was still hard to gather any meaningful data. However, it was possible to perform extensive studies of musical intent through EEG. Peter Desain from the Netherlands studied how the brain responds to rhythmic stimuli. He tried to examine whether it was possible to detect changes in the EEG when a subject imagines a rhythm. These BCIs (brain-computer interfaces) were expanded into musical interaction. In the 80s, the development of digital signal processing enabled a more stable control of interactive elements. There was a complete shift from purely artistic use to the actual concept of biocontrol. Biofeedback only allows the translation of physiological markers to other media through visualisation or sonification, while on the other hand, biocontrol creates reproducible voluntary interaction from physiological signals. This brought a series of projects, like the BioMuse, that modulated and controlled sound through EEG (brainwaves and muscle tension) and

¹⁷ 28 - Ibidem

¹⁸ “Alvin Lucier - Music For Solo Performer’ (1965).” *YouTube*, Carlos Conceição, 27 Nov. 2010, <https://www.youtube.com/watch?v=bIPU2ynqy2Y>.

¹⁹ Rosenboom, D. 1976 . Biofeedback and the Arts: Results of Early Experiments. Vancouver:Aesthetic Research Centre of Canada.

EOG (electrooculogram- eye-tracking). More recently, Miguel Ortiz Pérez collaborated with Knapp (BioMuse inventor) to create the commercial version called BioFlex, which is used to analyse muscular movements in performances.²⁰

The International Conference on New Interfaces for Musical Expression

This conference focuses on hosting various artists creating unique interaction interfaces. Today, NIME hosts a series of international conferences hosting different research groups in the field of human and computer interaction, interface design and computer music. These conferences are crucial for people working with music technology.²¹ One such group created an article titled “Principles of Designing Computer Music Controllers”. The thesis describes the HIRN wind controller, which, among other things, includes breath pressure and lip muscle tension detection. The inputs were used to control a physical model of a wind instrument. However, this physical model was built with no musical composition that could be controlled with it, resulting in no real-world utility. Another product described in this thesis is the Tapshoe, which includes force-sensing resistors and an accelerometer. It controlled a shaker algorithm and a small percussive loop. The algorithm could create a small groove that could be manipulated by the shoe’s wearer.²² The Augmented Violin Project thesis describes a “super-instrument” Violin that contains a radio transmitter with an accelerometer, detecting collisions of the Violin bow. It tracks the different expressive movement vocabulary of violin players. The Augmented Violin is used to control different MAX objects, such as the granulator.²³

3.2. Music Production Software for Interactive Projects

The previous section describes essential interactive music tools and instruments, but as has been seen, these tools need some software interface and written programming to perform the desired functions. This part explores software that will be used for the thesis product concerning my programming capabilities and the span of intended future commercial use of the software.

3.2.1. MUSIC by Max Matthews

MUSIC was the first sound production software that gained mass appeal. Simply put, it directly synthesised digital audio waveforms with standard PCM (pulse-code modulation) waveforms. The first performance with *MUSIC I* was done with an IBM 704 machine in 1957. The sound was simplistic and digital, but the technological progress was impressive for that period. This led to increasing popularity in *MUSIC*, which resulted in the software being updated all the way to the fifth version, *MUSIC V*. Aside from the original developers, *MUSIC* was expanded by others, resulting in spin-offs, like *Music 10*, *Music 15*, *Music 360*,

²⁰ 28 - ibidem

²¹ “Home”. *NIME Conference*. <https://www.nime.org>. n.d.

²² Cook, Perry. “Principles for Designing Computer Music Controllers.” *NIME*, Department of Computer Science (Also Department of Music), 2001, https://www.nime.org/proceedings/2001/nime2001_003.pdf. p. 2-3

²³ Bevilacqua, Frédéric & Rasamimanana, Nicolas & Fléty, Emmanuel & Lemouton, Serge & Baschet, Florence. (2006). The augmented violin project: research, composition and performance report. 402-406.

Csound and Cmix, the latter two also being a significant part of music development history. Except for Csound and Cmix, the MUSIC series also became a foundation for synthesis in MaxMSP and SuperCollider as well. Back in the days of early MUSIC software, real-time synthesis was still unavailable due to the clunkiness of the current IBM machines. New chip developments led to the introduction of real-time synthesis. With the development of better chips, computer sound synthesis became more widely available and affordable. Matthews spent most of his career working on different MUSIC series.²⁴

3.2.2. Max/MSP

Another relevant thing to mention related to Mathews is that he is also the creator of the MAX interactive music program, which will be used in creating this thesis product. Max is a programming environment that allows the building and implementation of various music controls using a combination of pre-built blocks that can be easily used for real-time digital music performance.²⁵

Max was first conceptualised at IRCAM in the 80s. Initially, it was only possible to control the MIDI information of external synths. Initially, audio couldn't be processed with it. It was named after Max Mathews, an electronic music development pioneer at Bell Labs. Later on, audio processing functions were added. Opcode continued the development of Max as a commercial product. The original author, Miller Puckette, developed PureData after he saw the development of computer performance at the time. It was similar to Max in some ways, except it was only capable of audio processing. Opcode fell through in 1999, and Cyclings got the rights for both PureData and Max.²⁶ Combining these two ultimately led to Max/MSP. This allowed developers to sell software synths and plug-ins that do not need the Max environment to run. This is how many popular plug-ins were written without the users knowing that Max/MSP was behind the user interface.

Max can be considered a successor to Mathews' MUSIC language. Just like MUSIC-N languages, MAX can recognise two levels of time- event schedule and DSP. Max and its sibling programs work on a data-floe system. MAX patches are created through building blocks of objects inside a patcher. These objects are dynamically linked libraries. All of them can receive input and generate an output. Messages are passed from an outlet of an object to an inlet of another. Max patchers can also be made into stand-alone applications. In Ableton, Max can be used as the Max for Live extension.²⁷

²⁴ "Music N", Max Vernon Mathews, USA, 1957." *120 Years of Electronic Music*, Musica in Informatica, 9 Aug. 2021, <https://120years.net/wordpress/music-n-max-mathews-usa-1957/>.

²⁵ Sheffield, Mike. "Max/MSP for Average Music Junkies." *Hopes&Fears*, 20 Nov. 2015, <http://www.hopesandfears.com/hopes/culture/music/168579-max-msp-primer>.

²⁶ "Opcode's Future in Question." *Harmony Central*, 27 Oct. 2007, <https://web.archive.org/web/20071027094815/http://news.harmony-central.com/News/1999/Opcode-Changes.html>. Retrieved via *Wayback Machine internet Archive*.

²⁷ Cornutt. "Max/MSP." *Electronic Music Wiki*, 24 June 2015, <https://electronicmusic.fandom.com/wiki/Max/MSP>.

Max/MSP is now widely used by various creatives: performers, composers, sound designers, researchers, and artists. An application programming interface enables users to develop new controls through external objects. This is why there are many programmers who are not directly involved with Cycling '74. There are a lot of commercial and non-commercial software enhancements done to Max. This is why Max has been described as the lingua franca of interactive music performance software. Max/MSP finally integrated with Ableton Live in 2011. This was possible after adding a new 64-bit compatible audio engine and Gen, an extension that enables compiling optimised, higher-performance Max patches. In Max 7, the focus was put on improving 3D rendering. Ableton purchased cycling '74 in 2017, but MAX and David Zicarelli remained with the company.²⁸

The most recent Max 8 was released in 2018. Now, it is possible to work with multiple channels: JavaScript, Node for Max, and Vizzie 2.²⁹

This program plays a vital role in the creation of my thesis product. Max will be used to receive values, and there will be mapping controls inside the patch, allowing the user to control different aspects of their music production or even generate melodies.

3.2.3. Ableton Live

Ableton Live is a very popular DAW (Digital Audio Workstation) founded in 1999. The first version was released in 2001. Throughout the development of the DAW, some integral features remained the same, like the session/arrangement view and play/pause button positioning. The interface and colours became more pleasant and user-friendly, and the stock plug-ins were largely improved. In 2010, a significant addition of Max integration was made. All of these features make it revolutionary software.

The first version was mainly used for live performances for recording all instruments. There was an early edition of time-stretching algorithms integrated, which enables tempo matching of the recording with the desired BPM (Beats per minute). This version wasn't prevalent due to the lack of MIDI clips. Live 2 added multitrack recording, tap tempo, and the possibility of saving and loading presets. The Simple Delay, Vinyl Distortion, Redux, and Reverb could now be used as effects. These plug-ins have changed remarkably little since the beginning.

Live 3 included individual clip envelopes, MIDI mapping, the Resonator Plugin, EQ 3, and the Utility. Live 4 had the most dramatic overhaul to date. MIDI support and built-in soft synths were added, like Simplr, Impulse, Operator, and more. Performance and music production were combined in the interface, which made it look more like what we now see in Ableton. MP3 support was added in Live 5, as well as the Phaser, Flanger, freezing tracks, and the MIDI Arpeggiator. Live six finally made Ableton a complete DAW, with performance features, music

²⁸ Kirn , Peter. "Exclusive: Ableton Acquires Max Maker Cycling '74; What You Need to Know." *CDM Create Digital Music*, 6 June 2017, <https://cdm.link/2017/06/exclusive-ableton-acquires-max-maker-cycling-74-inside-the-deal/>.

²⁹ "Max 8 Features." *Cycling '74*, <https://cycling74.com/products/max-features>. n.d.

production, and even video editing. The EQ got upgraded to 4 additional EQ bands, which improved audio quality. With Live 7, Ableton first introduced the Suite version. More effects and instruments were added, and a lot of attention was put into Drumrack. It was now possible to fill up to 122 slots with different samples for every note. Live eight added improvements to the time algorithms, and audio clip fades. The following additions were made: Frequency Shifter, Multi-Band Dynamics, Vocoder, Overdrive, and the groove pool. Live nine was when Max was implemented. The layout finally reached its current design.

Audio-to-MIDI enabled the conversion of drums, melodies, or harmonies to MIDI. However, the feature is still unreliable. The hardware controller Push was released and enabled workflow improvements. Ten brought the Wavetable, Drum Buss, Delay, Echo, and MIDI capture. Grouping pre-existing groups were added by popular demand. The last Live 11 release enabled vocal comping from multiple takes. Hybrid Reverb, Spectral Resonator, Spectral Time, Pitch Loop, and Bouncy Notes were added. BPM can now follow live playing.³⁰

The current chapter laid a foundation of historical knowledge necessary to understand the technology development relevant to this thesis project. As I have been working the longest with Ableton, since I plan to use Max4Live, this will be my DAW of choice for the product composition. Before starting with the technical development of the project, I wanted to explore the experience of musicians and music technology developers who belong to any group other than cis-white male, as the focus of this research is centred around the experiences of marginalised groups in the industry. The following chapter aims to establish how much more significant the barrier to entry into the music industry is for the aforementioned marginalised groups to their cis-white male counterparts.

³⁰ Feron, Feron. "Ableton's Development from 2001 to 2021." *We Rave You*, We Rave You, 28 Mar. 2021, <https://weraveyou.com/tech/ableton-development-live-1-to-live-11/>.

4 **Inequality in the Music Industry**

After gaining an insight into the history of technical developments in the field, the sociopolitical background connected with the research question must also be explored. This chapter aims to determine to what extent gender inequality is still an issue in the industry and what non-cis male musicians and music technology creators have been doing to raise awareness and help others facing inequality in the industry. Some examples of these actions include female-led initiatives and organisations, as well as LGBT communities on social media, like TikTok. Firstly, statistics about gender and sexual preference inequality are addressed. Then, the information is backed up by referring to relevant communities present on social media and the influence of social media on the development and impact of the target groups. A history of the most influential members of the target groups is elaborated to compare the experiences of female/LGBT musicians across different periods.

Moreover, statistics are backed up by behind-the-scenes experiences of relevant musicians in the form of interviews, some of which were found online and others conducted personally. The last section defines what interactive music tools and instruments are. The history of developments in music technology was explained, and the most relevant music tools were described.

According to statistical data and personal experiences, the distribution of genders in the music industry is unequal. This section analyses the statistics and explores the scope of the gender issue. Several interviews provide a closer and more personal insight into the problems in the music and music tech industry and how it has affected the individuals who were interviewed. Some of these interviews were taken from news websites, while section 4.5. includes interviews explicitly conducted for this thesis by speaking to the artists directly.

4.1. Binary Genders

According to a study from *USC Annenberg Inclusion Initiative*, titled “Inclusion in the Recording Studio? Gender and Race/Ethnicity of Artists, Songwriters & Producers across 900 Popular Songs from 2012-2020”, the statistics for each category mentioned were as follows:

- **Popular music:** only 20.2% of the Billboard Hot 100 charting artists were women. There was no significant difference in previous years, except in 2016 (28.1%).
- **Groups/Solos:** Women made up 30% of solo artists, only 7.1% in duos, and only 7.3% were in bands across the nine years of study.
- **Songwriters:** In 2020, 12.9% were women. Women songwriters mostly wrote EDM songs (20.5%) and Pop (18.7%), and they participated the least in creating Hip-Hop/Rap (6.3%) and R&B (9.1%).
- **Producers:** This category has the most shocking inequality- only 2% were women. This percentage barely changed over nine years. Only 20% of women producers were nominated for the Producer of the year award, but that percentage was 0% in other years.³¹

³¹ Smith, Stacy L., et al. “Inclusion in the Music Business: Gender and Race/Ethnicity of Artists, Songwriters & Producers across 900 Popular Songs from 2012-2020.” USC Annenberg, Mar. 2021, <https://assets.uscannenberg.org/docs/aii-inclusion-recording-studio2021.pdf>.

THE GENDER GAP AT THE GRAMMYS® IS REAL

Percentage of Women Nominees by Category, 2013-2020

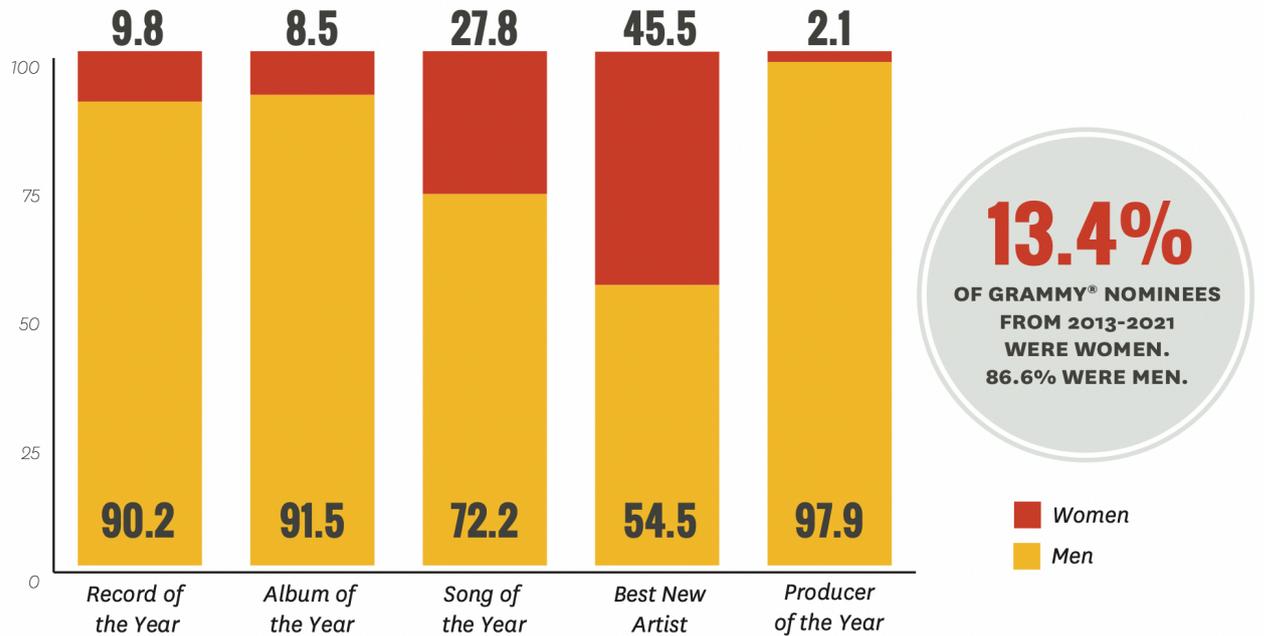


Figure 1.1: The Gender Gap at the Grammys. Provided by Spotify and the USC Annenberg Inclusion Initiative.

CREATIVE CONSTRAINTS: FEW WOMEN PRODUCERS WORK IN MUSIC

Percentage of men and women producers by year...

	2012	2015	2017	2018	2019	2020	TOTAL
Men (Male Icon)	97.6%	98.2%	98.2%	97.7%	95%	98%	97.4%
Women (Female Icon)	2.4%	1.8%	1.8%	2.3%	5%	2%	2.6%

Figure 1.2: Few Women Producers Work in music. Provided by Spotify and the USC Annenberg Inclusion Initiative.

Aside from black-and-white statistics, there is more hiding behind the scenes. Digging deeper reveals how women are gate-kept in the industry even to this day. Chloe Bailey, who was discovered with her covers of Beyoncé³², tells the story of her own experience. In an interview for the Terrell show, she uncovers the dark truth:

³² Denis, Kyle. "Beyoncé & Chlöe's Sweetest Moments." *Billboard*, 25 July 2022, <https://www.billboard.com/lists/beyonce-chloe-best-moments/>.

“I learned this because I would produce systemised records. Producers outside will get paid a considerable lump sum, but because I would produce systemised records, I couldn’t get paid because I was the producer within the group...

...And also, I don’t know if it changed within Grammys, but you know how they have producer of the year? I learned it from Imogen Heap- She produces a lot of her stuff, so does Grimes, so does Björk. They couldn’t be contenders for Producer of the Year cause they were the ones producing their own bodies of work, and not for others. And notice how those are just women I named!” (Bailey, Chloe, Interview on the Terrel Youtube channel, 22 Apr 2022)³³

This section has shown that women aren’t given the deserved awards and credit in many cases. The nominating agencies, like the Grammys, tend to make implausible reasons why some of the women could not qualify. The following section sheds light on how the experiences of non-binary-gendered people compare.

4.2. Non-Binary Genders

Before getting into the statistics, it is important to define which groups of people are considered for this section. The data that I found pertains to the following gender identifiers, as described by Michelle Yuen, who wrote the following article for Chartmetric:

- **“They/them:** often used in the plural sense to refer to groups of people, this pronoun is also commonly* used singularly to refer to non-binary individuals or those who have not yet expressed particular pronouns
- **Neopronouns such as Ze/zir, ze/hir, xe/xem, e/em, ae/aer, fae/faer, it, per, etc.:** These are just a few examples of neopronouns, which have existed since the 1800s and are often associated culturally* with non-binary identities (e.g., transgender, genderfluid, etc.)
- **Multiple, other, or custom pronouns**:** Some people use multiple specific pronouns (e.g. he/she), others are comfortable with any pronouns or none at all, and still, others only use their name or custom pronouns (e.g., v)” (Yuen, Michelle, 2021)³⁴

It is hard to find definitive statistics about people in the industry who do not identify as either of the traditional binary genders. Thankfully, the situation has been improving for the last few years. Female:pressure has performed the most comprehensive research I could find. Through their FACTS survey, the organisation compiles statistics based on data from hundreds of music festivals internationally

³³ Terrell. “WHO IS CHLÖE...really?! Vocals, Music Industry Tea, and New Music!” *YouTube*, Terrell, 21 Apr. 2022, <https://www.youtube.com/watch?v=8CX7ubYBeB8>.

³⁴ Yuen, Michelle. “Gender Equity & Gender Equality in the Music Industry.” *Chartmetric*, 11 Aug. 2022, <https://blog.chartmetric.com/gender-equity-empowerment-music-data/>

every year. A website called Austrian Music Exports explains more about the organisation:³⁵

“The FACTS Survey, like the female:pressure network, is the result of grassroots activism, conducted independently from any for- or non-profit organisation and without external funding.” (Austrian Music Export, n.n., 3 Aug 2020)³⁶

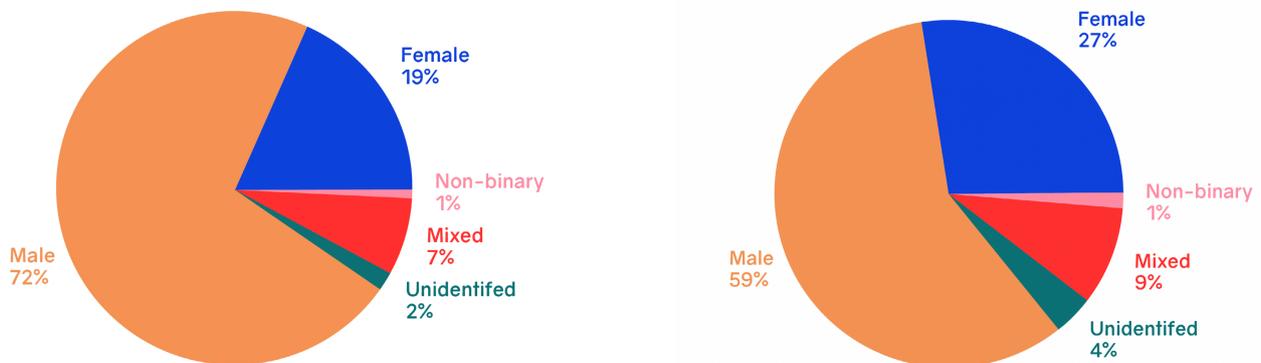


Figure 2.1 and 2.2: Data regarding gender allocation in the music industry (USA) from 2012-2021 (left), only 2020-2021 (right). Courtesy of female:pressure.

Unsurprisingly, the data for non-traditional gender-identifying people showed how critically low their inclusion in the industry is. The left pie chart below illustrates data collected from 2012 to 2021, while the right one pertains to 2020–2021:³⁷

Firstly, although the statistics look grim, they show a noticeable increase in non-cis-male acts. There are almost 30% more female musicians and three times more Non-Binary acts (from 0.4% in 2012 to 1.3%). The graphs show data rounded out without decimals. The charts cover more than just non-binary people. The “Mixed” category represents everybody who identifies with a combination of genders. The “Unidentified” groups together all people whose gender could not be determined through surveying.

The analytics company Chartmetric has also started collecting data both manually and through automation scripts; however, they warn that this list is not yet definitive- the list is ever-expanding, based on artists personally contacting the company. The company itself also claims to be no expert in the field and is inviting everyone to contribute to improving the accuracy of data representation.³⁸

³⁵ The female:pressure Trouble Makers. “FACTS 2022”. Female:pressure. 25 Mar 2022. <https://femalepressure.net/FACTS2022-femalepressure-print.pdf>

³⁶ “Female:Pressure Releases Facts Survey.” *Austrian Music Export*, 3 Mar. 2020, <https://www.musicexport.at/femalepressure-releases-facts-survey-on-international-womens-day-2020/>.

³⁷ 3 - *Ibidem*

³⁸ 3 - *Ibidem*

4.3. TikTok's Sub-Community- GayTok

TikTok has played an enormous role in giving underrepresented communities a voice and earning the likes of the mainstream public with their relatability. This includes the LGBT Community. I personally witnessed the significant favourable influence on the mainstream by LGBT artists on TikTok. For example, a gay Pop-Punk band called ur pretty has amassed over 2 million video creations based on their explicit song "Keep Riding Me".³⁹

Lil Nas X, one of the most famous LGBT musicians, has amassed over 28 million followers on TikTok. Thanks to this social media platform, his career was given a monumental push. In February 2019, he independently released "Old Town Road Independently" with Billy Ray Cyrus. The song didn't gain traction until he uploaded it to TikTok and used it to create a challenge. A significant amount of users participated shortly after, giving the song a record-breaking push. The single then got signed by Columbia Records and stayed at number 1 across all Billboard charts for an astonishing period of 17 weeks.⁴⁰

Lizzo is another example of this- seven of her singles ended up on the Billboard charts, thanks to TikTok's influence. Lizzo is a plus-size black musician and vocalist who, just like Nas, hasn't really propelled her career before TikTok. Her songs regularly end up in dancing trends- for example, the last single, "About Damn Time," was used more than 800,000 times in different TikToks. The app has also made her much more prominent and famous in the LGBT community, which earned Lizzo a cult following.⁴¹

The amount of people in the Gay TikTok community proves the overwhelming need for representation in mass media. According to a 2020 survey from Gallup (via Washington Post, Feb. 2021), an estimated 1 of 6 GenZ Adults on TikTok is a member of the LGBT Community. However, this number could be even more significant, as the population sample that was polled only included GenZ Adults aged 18 to 23 in the US. Compared to a percentage of approximately 16% from this sample group, the previous⁴²

In 2021, 430 songs got more than 1 billion views, which indicates the app's influence over the music industry. Over 175 viral songs on TikTok ended up on

³⁹ Henderson, Taylor. "TikTok Is Obsessed with This Horny Gay Pop-Punk Song." *Gay Pride - LGBT & Queer Voices*, PRIDE.com, 19 Nov. 2021, <https://www.pride.com/music/2021/11/19/tiktok-obsessed-horny-gay-pop-punk-song>.

⁴⁰ Yglesias, Ana Monroy. "Lil Nas X's No. 1 Run Began with TikTok, Now the Music Industry Is Taking Notice." *Recording Academy Grammy Awards*, 27 Aug. 2019, <https://www.grammy.com/news/lil-nas-xs-no-1-run-began-tiktok-now-music-industry-taking-notice>.

⁴¹ Dellatto, Marisa. "Lizzo's 'about Damn Time' Goes Viral on TikTok-but Still Hasn't Cracked Billboard Top 10." *Forbes*, Forbes Magazine, 13 May 2022, <https://www.forbes.com/sites/marisadellatto/2022/05/12/lizzos-about-damn-time-goes-viral-on-tiktok-but-still-hasnt-cracked-billboard-top-10/?sh=182433453c41>.

⁴² Schmidt, Samantha. "1 In 6 Gen Z Adults Are LGBT, and This Number Could Continue to Grow." *The Washington Post*, WP Company, 9 June 2022, <https://www.washingtonpost.com/dc-md-va/2021/02/24/gen-z-lgbt/>.

Billboard's Hot 100.⁴³ The sheer size and popularity of TikTok make it an integral tool in promoting musicians and new creative technology. This is no surprise, given that the app has over 1 billion mobile downloads.⁴⁴ Li Nas and Lizzo were picked as relevant examples for the thesis because Lil Nas X is by far the most popular Gay musician who originated from TikTok (based on numbers)⁴⁵. At the same time, Lizzo is the most prominent plus-size artist and advocate for black people, plus-sized people, and the LGBT Community.⁴⁶

TikTok has had an impact on my work as well. Even though it is challenging to get pushed by the algorithm, I have had one video amass 50.000 views and another that resulted in 150 new followers and 100 new people engaging with my music (pre-save, favourite, or buy). I plan to continue learning how to captivate people's attention on TikTok and share exciting updates about my project. My TikTok account aims to provide helpful advice and resources and share my experience as a marginalised individual in the industry, with all its ups and downs. This way, I can achieve one of the goals of my thesis of shining a light on marginalised music producers and technology enthusiasts.

4.4 Behind the Scenes Experiences

Analysing how inequality has affected musicians and producers from their own behind-the-scenes perspectives is essential for the general discussion of inequality across the music scene. This is because, according to previously explored statistics from female:pressure and USC Annenberg, the rate of gender inequality is almost equally present across different aspects of the music industry. Anecdotal evidence taken directly from target groups (in this case, LGBT people) is just as valuable as empirical evidence. It gives insight into the nuances and scope of a research problem, while statistics only provide generalised results.

In 2021, Billboard interviewed 4 LGBT artists to understand better how far we as a society have come and what needs improvement. The interview starts with a successful writer named Justin Tranter, who recalls an unpleasant e-mail correspondence with another queer artist's team:

"I won't say their name, but they were queer — 'in a room, but we're worried that it just might end up being too gay,'" they recall with a grimace. "Their management actually said to me that it might be too gay if we were on a song together because the mainstream would just never digest it. It's exhausting." (Tranter, 2021)

⁴³ TikTok. "Year on Tiktok 2021 Music Report." *TikTok Newsroom*, TikTok, 16 Aug. 2019, <https://newsroom.tiktok.com/en-us/year-on-tiktok-music-report-2021>.

⁴⁴ Doyle, Brandon. "Tiktok Statistics - Everything You Need to Know [Aug 2022 Update]." *Wallaroo Media*, 13 Aug. 2022, <https://wallaroomedia.com/blog/social-media/tiktok-statistics/>.

⁴⁵ Brown, August. "How Lil Nas X Made the Most Radical Run of Queer Music Videos in Pop History." *Los Angeles Times*, 23 Sept. 2021, <https://www.latimes.com/entertainment-arts/music/story/2021-09-23/lil-nas-x-queer-music-videos>.

⁴⁶ Setoodeh, Ramin. "Lizzo on Being an LGBTQ Ally, Rihanna and Meeting Sandra Bullock." *Variety*, 27 June 2019, <https://variety.com/2019/music/features/lizzo-lgbtq-ally-rihanna-sandra-bullock-1203255011/>.

In the past few years, there has been a rise of LGBT artists making chart-topping music, but those are just the few people that made it. The other hundreds of thousands from the LGBT Community never make it through the filters of top-level executives in the music industry.

. *“It feels like there are a lot more of us,” Tranter says, referring to LGBTQ songwriters. “But it’s still not nearly enough.” (Tranter, 2021)*

Ladyfag, an event producer, describes how it was never an option for her to have a role in the significant productions back at the start of the 2000s when she was trying to make it. This is why she decided to show everyone what they were missing out on by starting her own production company and becoming a staple in New York’s nightlife scene.

“I think what’s missing is the actual seat at the table. And that goes for everything that’s behind the scenes — producers, promoters, booking agents — we’re not always invited to a seat at the table. So, I didn’t wait for my seat, I created my own table.” (Ladyfag, 2021)⁴⁷

However, it’s not all bad. Although it might be harder to enter the industry as an LGBTQ person, queer performers have been present since the 60s- Freddie Mercury, Grace Jones, and David Bowie. Bowie’s gender ambiguity is why he amassed such a big LGBTQ community around his music. Today we see artists like Honey Dijon, a House music veteran, and a black transgender woman, playing prestigious locations from the rave culture (e.g. Boiler Room Berlin).⁴⁸ On the 9th of June, the UK organisation CIPA shared an analysis of the history of modern music, stating that “music has almost always been synonymous with the LGBT Community” (CIPA, 2021). Artists like Madonna, Lady Gaga, Bowie, Elton John, and Janelle Monáe are all associated with a cult LGBT following.⁴⁹

In short, the data and experiences outlined indicate that LGBT musicians are still viewed stereotypically and grouped with other members of the community, being pushed to produce stereotypical content together. Often, managers and promoters do not consider “gay people” music to be marketable enough for the mainstream. Despite that, there have always been at least a few musical icons who gained a cult LGBT following (Elton John, Lady Gaga, and others mentioned in the previous chapter).

The data available and analysed in this chapter pertains mainly to musicians and music producers, most of whom are famous. More interviews are explored and conducted in the following chapters, where I interview music technology makers as well. I could not find any statements from other groups, including composers, audio engineers, and vocalists.

⁴⁷ Daw, Stephen. “LGBTQ Representation within the Music Industry: ‘It’s Still Not Nearly Enough’.” *Billboard*, 9 Dec. 2021, <https://www.billboard.com/music/music-news/lgbtq-representation-music-industry-1235007091/>.

⁴⁸ “Music History: How LGBTQ+ Community Has Influenced the Music Industry.” *Music History | How LGBTQ+ Community Has Influenced The Music Industry*, 17 June 2021, <https://blog.songtrust.com/how-the-lgbtq-community-has-influenced-the-music-industry>.

⁴⁹ Espino, Kathryn. “Music and the LGBTQ+ Community over the Years.” *CIPA*, 9 June 2021, <https://www.cipa.org.uk/diversity-inclusion/music-and-the-lgbtq-community-over-the-years/>.

4.5. Mental Health in the Community

The previous section lays out statistics regarding marginalised groups in the industry (e.g. LGBT and non-binary people). In this section, I dive into the impact of all the problems mentioned above on the mental health of music creators. I assumed there could be a specific correlation between inequality and mental health issues, which is why this chapter attempts to evaluate the strength of this correlation through empirical data. Moreover, I am someone affected by mental health issues, so I wanted to find out how many others have been explicitly affected by inequality in the industry. I also wanted to explore the mental health statistics generally related to music producers and music technology makers.

According to statistics from [Helpmusicians.org.uk](https://www.helpmusicians.org.uk), about 71% of independent UK musicians and music producers experience anxiety and panic attacks, while 68.5% experience depression. 54% stated that there are gaps in the current system of available help. Even though it is not a global study, based on these statistics, it can be said that mental health struggles are a problem that is important to address in the industry. All 2,211 participants that were interviewed showcased signs that their experiences impacted their mental health.⁵⁰

Focusing on the marginalised non-cis white male participants in music history, [guitarworld.com](https://www.guitarworld.com) has collected statistics from a few sources, which indicated that the previously bad mental health situation within the LGBT music scene has worsened during the COVID pandemic. They highlight a study conducted by the US-based LGBT organisation called Trevor Project. Their survey included 35,000 members of the LGBT youth aged 13-24, out of which 42% stated they seriously considered suicide in the past year. 48% wanted to seek mental health help but could not for various reasons. In the UK, the charity Help Musicians reported they experienced a 40% increase in mental health assistance, which increased to 65% in 2021. Of the musicians surveyed, 87% reported COVID-related mental health struggles. The charity previously mostly had classical musicians reaching out, but this has been changing in the past few years. Help Musicians has been actively trying to reach musicians across all disciplines and marginalised communities in the industry. Organisations collaborating with Help Musicians, like the Black Mental Health Alliance, have reported that a significant factor in the worsened mental health situation is that opportunities for all music industry members vanished during the pandemic. This includes everyone from singers to audio engineers, technicians, and people working in studios.⁵¹

Finding specific data proved to be more difficult than expected. Firstly, most publicly available research focuses on the US and UK markets. To an extent, this makes sense, as these two countries contribute to about 40% of the market share of two specific markets relevant to this thesis- music production hardware and

⁵⁰ University of Westminster, MusicTank. "Study into Mental Health in the Music Industry." *Music Minds Matter*, HelpMusicians, 2016, <https://www.musicmindsmatter.org.uk/can-music-make-you-sick>.

⁵¹ Richter, Alison. "We Need to Talk about Mental Health in the Music Industry – and How You Can Get Help If You Need It." *Guitarworld*, Guitar World, 5 Aug. 2021, <https://www.guitarworld.com/features/mental-health-music-industry>.

music production software.⁵²⁵³ Moreover, data specific to industry members like synth makers and other technology creators was not found. Most of the studies group all music industry members together, making it impossible to find out how many people from every discipline in the sector participated in the research. Help Musicians is actively trying to find and help individuals from more diverse industry segments. Still, they have not provided any data listing which segments have been identified in research so far. There could be a significant change that groups relevant to this thesis research have not been included at all.

The conclusion to the exploration of mental health in the industry is that more studies need to be conducted on different segments of the music industry. By focusing primarily on performing musicians, a large portion of the populus is ignored in the conversation about mental health help. Chapter 3.5 solidifies this point through 2 interviews conducted with non-cis white male music producers and music technology creators.

⁵² “Music Production Equipment: Global Strategic Business Report.” *Research and Markets*, Global Industry Analysts, Inc, <https://www.researchandmarkets.com/reports/5030711/music-production-equipment-global-strategic>.

⁵³ Technavio. “Music Production Software Market: USD 369.87 Million Growth from 2021 to 2026, High Competition among Vendors - Technavio.” *Music Production Software Market: USD 369.87 Million Growth from 2021 to 2026, High Competition Among Vendors - Technavio*, 22 Aug. 2022, <https://www.prnewswire.com/news-releases/music-production-software-market-usd-369-87-million-growth-from-2021-to-2026--high-competition-among-vendors---technavio-301609488.html>.

5

**Female/LGBT Music
Tech Innovators**



After establishing the present state of (in)equality in the general music industry, this chapter will focus more on the music tech innovators through history, as well as the modern-day pioneers. In the previous chapter, it was observed that music and queer culture have always had a significant impact on each other. So, why are the numbers not following the same trend in the music technology industry? It was easy to find famous artists who are genderqueer/LGBT/female, but it proved to be challenging in the case of music technology. This section discusses the pioneers in electronic music, as well as musical tools and technology, ranging from researchers to founders of companies in the field. The following women/LGBT individuals were picked based on their importance for the historical development of music technology and software. The second section focuses on some of the relevant modern music tech developers, as well as providing highlights from interviews conducted for the purpose of this thesis.

5.1. Female/LGBT Pioneers of the Industry Through History

Daphne Oram

Daphney Blake Oram is considered an electronic music pioneer. In 1942, she was invited to apply for the position of Junior Studio Engineer at BBC. She was known as a visionary turntablist who made sure to sync up pre-recorded records of orchestras to play if any interruption happened during live orchestration. Her composition *Still Point* is believed to be the first to combine acoustic orchestra with electronic manipulation. It was rejected by BBC and was not heard for over 70 years until it was performed in 2016 by the London Contemporary Orchestra. In 2018, an updated version was played at the BBC Proms. When she was promoted at her job for BBC, she experimented a lot, recording sounds onto tape and manipulating them in different ways to create something new. This technique is known as *musique concrète*. In 1957, she was hired to create music for a play called *Amphitryon 38*. She used a sine wave, a tape recorder and DIY filters, resulting in the first completely electronic score in BBC history. In 1958, BBC gave her and her new colleague funding to create the BBC Radiophonic Workshop. Thus, she became the first woman to create an electronic music studio independently. She created a technique called the *Oramics*, which creates electronic sounds from drawn sound.⁵⁴ As mentioned before in this thesis, computers were not “cool” until the late 90s, before which women were given tech jobs. Nonetheless, Daphne’s achievements regarding her high job position and electronic music studio show how unrelenting brilliance and innovation can help combat gender stigma.

Delia Derbyshire

Delia is yet another extremely talented artist who was involved with the BBC Radiophonic Workshop. Stories about her life have been told everywhere- from the stage to screens and radios. She was gifted in music and mathematics, enjoyed the works of classical composers and even managed to secure a scholarship from Cambridge. Her interest in electronic music was aroused in 1958 when she saw Edgard Varèse’s interdisciplinary *Poème Électronique* at the Brussels World Fair. It

⁵⁴ “A Brief Biography.” *Daphne Oram*, [Daphneoram.org](https://www.daphneoram.org), <https://www.daphneoram.org/aboutoram/>.

had a profound impact on Derbyshire's future work. She was rejected by Decca, a studio that did not employ women, so she went to BBC in 1960 to work as a trainee assistant studio manager. Two years later, she managed to transfer to the BBC Radiophonic Workshop, where she stayed until 1973. Her early assignments included music for *Time On Our Hands* (1962) and the opening for *Know Your Car* (1963). Her most famous works were created between 1963 and 1964. One example of this is the *Doctor Who* theme, which led to the popularisation of electronic music in the UK. Some elements from the original composition can still be heard in the 2018 theme, showing just how important Delia's work was. She then received a chance to create much longer pieces by collaborating with Barry Bermange on four *Inventions for Radio*. These pieces were a collage of electronic music, soundscapes and interviews with random individuals from the public. The topics of these conversations painted an image of the British working class, who were asked profound life questions. In the second *Invention*, *Amor Dei*, the existence of God was discussed with participants. The whole composition of this piece was extracted from one boy chorister's vocal takes. *The Dreams* included edited resonances from a lampshade being struck. Bermange partially downplayed her role, but he could not hide his admiration due to her talent. The BBC also had a policy of not giving credit to Workshop staff members. However, evidence shows that she was still highly respected by seniors at BBC. A 1964 memo from Martin Esslin, the Head of Radio Drama, talking about her work *The Tower*, proves this point:

"I have just been listening to the playback of the completed version of "THE TOWER" and should like to express my deep appreciation for the excellent work done on this production by Delia Derbyshire and John Harrison. This play set them an extremely difficult task. They rose to the challenge with a degree of imaginative intuition and technical mastery, which deserves the highest admiration and will inevitably earn a lion's share of any success the production may eventually achieve. I only wish that it were possible for the names of contributors of this calibre to be mentioned in the credits in the Radio Times and their contribution to this production as being at least of equal importance to that of the producer himself. (Esslin, 1964)⁵⁵

One of Delia's most refined works is said to be *Blue Veils and Golden Sands*, created for an event of people on a journey across the Saharan desert. She used her voice and her favourite lampshade recording by re-pitching them, creating a melody complimenting the sounds of camels walking through the searing desert. Delia became quite an established sound artist, resulting in collaborations with Peter Hall, Yoko Ono, Ted Hughes, and later with pioneer artists like Elsa Stansfield and Madelon Hooykaas. She worked with everything from soothing atmospherics to rough and aggressive industrial sounds. In 1973, she felt compelled to leave BBC, as the work was becoming increasingly commercial and not what it used to be. Afterwards, her health started rapidly declining. She progressively worked less and less, even on personal projects. Finally, in 2001, she started a collaboration with Sonic Boom after realising she was no longer ahead of technology advancements. This collaboration abruptly ended due to her death in the same year. Many appreciated her works, including Pink Floyd, Orbital and even

⁵⁵ Memo from Martin Esslin to Desmond Briscoe, 30 June 1964. <https://www.bbc.com/historyofthebbc/100-voices/pioneering-women/women-of-the-workshop/delia-derbyshire>

Portishead. A charity called Delia Derbyshire Day was created in her honour. Delia's story is one of beating the barriers of gender prejudice through creativity and tenacity.⁵⁶

Joan E. Miller

Miller was a programming pioneer who worked alongside Max Mathews in Bell Laboratories to create a music synthesis software called Music IV. Her name is often not highlighted, with most sources only throwing her name in 1 sentence and some not even mentioning her. For example, archive.org has a digital copy of the Music IV Programmer's Manual, which Miller and Matthews co-wrote. In the description of the website, it states that Matthews wrote the music software. It does not mention in any capacity what Miller's role in the book was.⁵⁷ It was much easier to find information for Matthews (as evident in Chapter 3) than for Miller. Based on the little information available about Joan, it is evident that she played an important role in the first developments of synthesis software. Miller was a mathematical acoustician trained at Columbia University. In the early 60s, they started collaborating. Both Joan and Max were violinists, and together they worked on producing the Music IV, programmed in FORTRAN, using an IBM 7094. This program is the predecessor of many popular modern synthesis software (MAXmsp, SuperCollider, Csound). Miller also developed the revolutionary colour frame buffer in 1969, yet another significant invention in the development of electronic music. Both Max and Joan passed away in 2011.⁵⁸

Pril Smiley

Smiley was born in 1949 in New York. In the 60s and 70s, she was later employed at the Columbia-Princeton Electronic Music Center. There, Smiley worked alongside Milton Babbitt, Otto Luening, Vladimir Ussachevsky, Mario Davidovsky, and Alice Shields. She was the centre's director and one of the four leading electronic music instructors. She was a consultant in the Lincoln Center Repertory Theatre between 1968 and '74, and in '75, she was awarded the Guggenheim Fellowship. She stopped making music in the 80s but kept teaching until 1995 at Columbia. She composed a total of 44 films and plays. The most

⁵⁶ Butler, David. "Delia Derbyshire <https://www.bbc.com/Historyofthebbc/100-Voices/Pioneering-Women/Women-of-the-Workshop/Delia-Derbyshire>." *BBC 100*, BBC, <https://www.bbc.com/historyofthebbc/100-voices/pioneering-women/women-of-the-workshop/delia-derbyshire>.

⁵⁷ "Music IV Programmer's Manual: Max Mathews, Joan Miller." *Internet Archive*, 14 Sept. 2018, <https://archive.org/details/music-iv-programmers-manual/page/n27/mode/2up>.

⁵⁸ *Chromatic Algorithms: Synthetic Color, Computer Art, and Aesthetics after Code*, Carolyn L. Kane, University of Chicago Press, 13.08.2014 -p 154

famous were *Eclipse* (1967), *Kolyosa* (1970), and *Forty-Three* (1984).⁵⁹ Some sources call her “One of America’s leading female music Composers”.⁶⁰

Wendy Carlos

Wendy is another American musician and composer. She created a foundation for modern new wave and EDM music. She was the assistant of Robert Moog during the development of the legendary Moog Synthesizer. Her music was so unique and revolutionary that she was asked to take part in composing two Stanley Kubrick films (*A Clockwork Orange*, *The Shining*), as well as *Tron* by Disney. She was accomplished even more than just in music and technology. Carlos was an avid activist for most of her life, striving to raise awareness about transgender issues. One of the ways she did this was by publicly coming out. She decided to reveal the truth- that she started the transition in 1968 and finally went through a complete sex-change surgery.⁶¹

5.2. Female/LGBT Pioneers in Today’s Music Tech

In the previous chapter, I explored the history of music technology advancements from the perspective of non-cis white male individuals. The goal was to learn about the hardships of being a marginalised group in the industry and establish how vital these individuals' inventions were/are. The following list describes selected female and LGBT creators whose expertise matches the goals of this thesis the closest. The thesis product will be constructed using health-tracking sensors and offer controls that are akin to a modular synthesiser or controller. All of the people mentioned in the list have developed some sensor-based or modular instrument, as well as used different programming environments (e.g., MAX, which is relevant to this thesis project). Laetitia is especially relevant, as she creates instruments and tools using unorthodox sensors and other music control principles. Additionally, these creators were picked based on how inspiring their inventions were and how they influenced the conception of the thesis project idea. Hence, it is essential to draw lessons from the experiences of the following music tech creators.

Laetitia Sonami

Sonami is a sound artist, performer, and researcher originally From France. In 1975, she moved to the USA to follow her intrigue with the newly emerging field of

⁵⁹ Keathley, Elizabeth L. (2009). "Women Composers and Music Technology in the United States: Crossing the Line". *Women and Music : A Journal of Gender and Culture*. Women and Music: A Journal of Gender and Culture, Volume 13. doi:10.1353/wam.0.0017. ISSN 1553-0612. S2CID 145415699.

⁶⁰ *Music at Michigan*. Vol. 7, ser. 3, University of Michigan School of Music, September 1973. <https://books.google.at/books?id=7nQJAQAAMAAJ&pg=RA23-PA11&lpg=RA23-PA11&dq=pril+smiley+director+of+electronic+music+center&source=bl&ots=eY7oYAMEvR&sig=ACfU3U1WoBVTn5OafcOH5eBAHkM5MaN-bA&hl=en&sa=X&ved=2ahUKEwjmrYyHn-b3AhUC-qQKH9BacQ6AF6BAgfEAM#v=onepage&q=pril%20smiley%20director%20of%20electronic%20music%20center&f=false>

⁶¹ “7 LGBTQ Creative Thinkers Who Helped Change the World.” *PILGRIM SOUL CREATIVE*, 30 Sept. 2021, <https://www.pilgrimsoul.com/home/7-lgbtq-creative-thinkers-who-helped-change-the-world>.

electronic music. Her performances, installations, and collaborations focus on presence and participation. She came up with innovative movement-based controllers for performance, in which she uses new technologies and derivative media to express immediacy through sounds, places, and objects. She is best known for her invention, the Lady's Glove, an elbow-height arm instrument that tracks even her slightest movements. She has performed internationally and has earned a renowned status. Sonami won numerous awards, fellowships, and residencies between 200 and 2003. She moved on from the Lady's Glove in 2015 to start the development of a new instrument called the Spring Spire, which applies neural networks to audio synthesis in real time. She is currently performing a set of 5 live compositions called Magnetic Song Cycles. Her recent sound installation, *Le Corps Sonore*, done in collaboration with Eliane Radigue and Bob Bielecki, spans over six floors of the Rubin Museum in New York City. Soon, she plans to start the development of a new fantasy instrument called the Lady's Balls.⁶² Laetitia's inventions are what first lit a spark in my own concept, as her creations are pushing the limits of what's possible in human body interaction. The explorative spirit and experimentation with unexpected forms of interaction (e.g. magnetism, neural networks) served as an example for my project.

Imogen Heap (MI.MU Gloves)

Imogen Jenifer Heap was classically trained and already playing several instruments by the age of 13. She attended a private boarding school, where she exhibited a dislike for her music teacher. She slowly taught herself sequencing, sampling, production, and music engineering. She later went to the famous BRIT School for Performing Arts and Technology in Croydon. Heap had outstanding albums from the start but struggled to find commercial success in the beginning and get a record deal. After, she became part of Frou Frou with Guy Simsworth. After touring, they eventually got dropped again due to poor sales. She put a second mortgage on her flat to be able to fund her next album, released in 2005- "Speak for Yourself". The album slowly started gaining traction, with her success being boosted after a few of the singles got featured on shows like "Grey's Anatomy", "Six Feet Under" and "The OC". Then her song was featured in "The Chronicles of Narnia: The Lion, the Witch, and the Wardrobe".⁶³

In 2010, Imogen began creating her own unique music production tool called MI.MU gloves. Her goal was to offer expressive ways to produce music. She built her first prototypes in a home environment and tested them during her performances and shows. In 2014, a small group of aspiring music pioneers started contributing to the development by testing the gloves in their own shows. Those individuals came from various musical backgrounds: vocalists, beatboxers, classical pianists, guitar players, and artists controlling visuals. The most prominent individual using the gloves was Ariana Grande on her 2015 world tour, where she used the gloves to bend and twist her vocals.⁶⁴ Heap was my main inspiration

⁶² Sonami, Laetitia. "Laetitia Sonami Biography." *LAETITIA SONAMI*, <https://sonami.net/bio-2/>. n.d.

⁶³ Anonymous. "Imogen Heap Biography." *IMDb*, IMDb.com, <https://www.imdb.com/name/nm2133880/bio>. n.d.

⁶⁴ Ariana Grande - *Mimu Gloves and "Why Try" (Live in Anaheim 4-10-15)*, TheRealConcertKing, 11 Apr. 2015, <https://www.youtube.com/watch?v=1Kv2ozAJTOE>. Accessed 17 Sept. 2022.

during the project, as her company's development process is something I strive to achieve. Her road from idea to start-up aligns with what I have to go through, so following her process and roadmap serves as excellent preparation for the future of my project.

Through industry connections, I had the opportunity to talk with mi.mu Gloves' managing director Adam Stark to learn more about the hardships behind the scenes. More details about the correspondence can be found in Chapter 5.

Chagall

Chagall Van der Berg is a pop and electronic producer and vocalist. She is originally from Amsterdam but currently lives in London. She is one of the early adopters of Heap's MI.MU Gloves. She uses her gloves not just to add sensuality to her music but also to control her shows' visuals. She shared some of her background and career progress in an interview conducted by a music blog called Musicmap:

- **You're one of the early adopters of mi.mu gloves - can you explain their use and how you use them?**

"The mi.mu gloves are gestural controllers & musical instruments that take the movement of your hands and turn it into any sound or effect. I use them in my show Calibration to control almost all of the electronic sounds and layers of my music and also the visual[s] react to my hand movement."

- **What led you to start experimenting with mi.mu, and how did you come to work for them?**

"I went to Reverb Festival at the Roundhouse where Kelly Snook & Adam Stark hosted a mi.mu gloves workshop. Kelly then told me they needed an extra "hand" to produce a bunch of gloves, so I started helping them out."

- **The nature of mi.mu means it involves a lot of expressive movement, more so than most traditional instruments. Did the techniques involved come intuitively to you, or were they something you had to work on?**

"They actually allow you to create a very personal music/movement relationship. I've never felt I've played music more intuitively than I do now!"

- **Does your local area influence the music you make?**

"Yes definitely. I've moved to London because that city just breathes music and has such a powerful musical history to it. I now live in Peckham, which is the home to a crazy crossover between African and underground youth culture. It's slowly getting pretty gentrified, but the neighborhood is doing well I think at maintaining real, hosting cheap artist studios, parties, concerts, exhibitions, etc. I live on a street with lots of Nigerian hair salons, where they throw pretty rowdy parties during the Summer blasting out the high life music. I absolutely love it (even when it's 2 am and it's so loud I can't hear the

tv indoors) and those rhythms are slowly creeping into my own music too.”
(Chagall for Musicmap, 2017)⁶⁵

Émilie Gillet (Mutable Instruments)

Émilie Gillet is a revered Eurorack module producer from Paris. She is the person behind the whole operation of Mutable Instruments.⁶⁶ The Mutable Instruments website has a section introducing the founder in the following manner:

*“My name is Émilie and I am Mutable Instruments’ product designer, hardware/software engineer, salesperson, and customer support representative. Mutable Instruments has, by design, no employees! Just me! Prior to starting Mutable Instruments, I implemented some of the massive user profile and query analysis systems that power services like Google AdWords or Last.fm, researched drum transcription and demixing algorithms, and developed obscure music software like granulèse, a BeOS granular synthesis tool; or Bhajis Loops, the most awesome (by lack of competition) PalmOS DAW.”*⁶⁷

Her pre-Eurorack prototypes date back to 2009, when she started building and later selling DIY kits. The first in line was Shruti-1, which became profitable in 2010 which led to the formation of Mutable Instruments one year later. She was interviewed by TechCrunch, where she was asked to talk about her company:

“I quit my main job in February 2012 because the company I was working for was going nowhere, while Mutable Instruments’ first quarter showed that I could live decently off the DIY kits even if we weren’t quite there yet.”

The first four Mutable Instruments modules were designed simultaneously, with Braids, a “macro-oscillator” that digitally modelled a vast range of synth voices and timbres, proving to be the most popular.

Because of Gillet’s reputation for designing DIY kits and music software, unlike other modular companies, Mutable Instruments did not have to face a “cold start”. Retail partnerships were forged early on, and the company only needed to sell directly for a short time. Today, Mutable Instruments modules can be found in most independent stores and big box shifters in the U.S. and Europe.

Gillet typically prototypes new digital modules by writing C++ code and a command-line tool to process or generate audio files. She’ll also write a patch for the visual programming language Pure Data. To get more of a feel for how the software will interact with hardware, she may write an alternative firmware for an existing module so it’s directly testable with CV inputs and physical knobs.

⁶⁵ MusicMap. “Chagall.” *MusicMap*, 25 July 2017, <https://musicmap.global/article/chagall-mimu-london-amsterdam>.

⁶⁶ O’Hear, Steve. “Meet the Makers of Modular.” *TechCrunch*, 28 Sept. 2019, <https://techcrunch.com/2019/09/28/meet-the-makers-of-modular/>.

⁶⁷ “Mutable Instruments: About.” *Mutable Instruments*, <https://mutable-instruments.net/>. n.d.

Analogue modules are prototyped on a breadboard, sometimes with interconnected through-hole PCBs. *“I actually made a very large through-hole PCB for my latest analogue design,” Gillet explains. “It’s easier for me to replace components, and build little networks of extra diodes, capacitors, and resistors in 3D above the board when it’s made of large parts. I maintain in parallel LTSpice simulations and python notebooks with all the calculations for part values, cutoff frequencies, gains, etc.”*

*“Obviously I don’t build anything with my own hands,” says Gillet. “I receive the modules in their box, ready to ship to dealers. My contract manufacturers take care of everything i.e. board assembly, panel assembly, testing, and packaging. Thank god for that”.*⁶⁸

5.3. Interviews

In the following section, I outline and analyse the most critical findings from two interviews I have conducted with LGBT women who have made a mark on the industry and whom I was able to get in touch with. I asked questions that had been raised during my thesis research as I could not find statistics related to specific segments of the music industry relevant to the thesis research. Some of the answers from the interviews were surprising, but unfortunately, mainly in a negative way. Both interviews have some similarities. However, the outlook of these two people is entirely different. One has a more positive attitude, while the other one clearly shows signs of how much constant harassment can negatively impact a person.

Elysha, most known by her stage name Ill-Esha, is a very versatile Canadian creator. She is the perfect story subject in the context of this thesis, as she deals with both music production and building equipment. Ill-Esha started DJing in her early 20s but soon progressed to producing music, tinkering with tech for performances, and singing and playing the keyboard live. As she gained significant traction in 2013, she toured with Bass music giants like Bassnectar and Beats Antique. She is also the admin of the largest electronic music production server on Discord, called EDMP (where I first met her in 2016).⁶⁹ She is currently based in Spain, where she works at Berklee Valencia. I have asked Elysha to participate in a Zoom interview. During the call, I found out which hardships she faced based on her gender and sexual identity and compared them with the statistics analyzed in this thesis.

Elysha grew up in a musical environment and was encouraged by her family to pursue her passion. She was part of different segments of the music industry—from classical music, evolving to electronic music production and even music technology. Elysha confirms that she has experienced inequality due to her gender, stating that women (including her) get paid less. She also confirmed that COVID had set her back significantly, which coincides with the statistics previously explored in Section 3.3.5 of the thesis. She stated how to this day, she has encountered sexism on stage from managers assuming she is some performer’s

⁶⁸ 42 - *Ibidem*

⁶⁹ Zaide, Elysha. “Ill-Esha Bio.” *Audio Designer*, <http://ill-esh.com/biography/>. n.d.

girlfriend and not being taken seriously when she says she is a performer. Elysha states how there are only 2% women in the industry because of it, and it is harder to break in. She has had multiple encounters in the industry where she felt unsafe; however, not in recent times. In 2018, she was sexually assaulted by a hospitality manager (male). I asked if there were any instances of women assaulting women. She stated that in the rare cases it happens, women use the excuse that they “also have boobs” and “it’s totally fine”. I asked if the presence of non-cis white male individuals in the music and technology industry is improving, to which Elysha confirmed a positive trend. However, she still believes some changes need to be made since many labels, and companies in the industry will take on more women/LGBT people who are “manufactured” and only taken to meet a certain diversity quota.

An example of this are women DJs who do not make any of their music but are assigned a “ghost producer” to create everything for them. She says that many women would like to be more technical and nerdy, but they do not feel like there is someone whom these women can learn from in a safe, non-judgmental environment. She believes that education and modelling for such individuals are essential steps to solving the issue. Elysha has partnered with multiple music software/hardware companies to provide free/budget classes to women/LGBT people who want to become good at music and engineering but don’t know where to start. Lastly, she stated that no matter the gender stats, the music industry is undoubtedly saturated, with over 60.000 songs released daily on Spotify alone. But she says that women, for example, could improve their position in the industry much more if they had more support in learning the technical side of music production and creating their own music technology, as she considers it rare in this specific demographic. She closed the interview by stating that knowledge should be the ultimate weapon for minorities in the industry.

The full interview with more details and interesting facts can be found in *Appendix 1*. I have corroborated the market saturation statistics that Elysha gave me and confirmed the statistic related to Spotify.⁷⁰ Additionally, there is some more information that is telling about the size of the industry. The global music market was worth 64 billion USD in 2021⁷¹, while the global market share for music production software was 34 billion. Lastly, the global market share for music production tools (hardware) was 9 billion⁷². If we refer back to the gender statistics, only 2.4% of the last two numbers is what women were part of, and 1.3% out of the whole market can be attributed to genderqueer and LGBT people.

The second interviewee asked to remain anonymous to avoid further harassment after experiencing so much of it throughout their life. The interview was conducted over e-mail, as they no longer wished to show their face or answer

⁷⁰ Ingham, Tim. “Over 60,000 Tracks Are Now Uploaded to Spotify Every Day. That’s Nearly One per Second.” *Music Business Worldwide*, 24 Feb. 2021, <https://www.musicbusinessworldwide.com/over-60000-tracks-are-now-uploaded-to-spotify-daily-thats-nearly-one-per-second/>.

⁷¹ Savage, Mark. “The Global Music Market Was Worth \$26bn in 2021.” *BBC News*, BBC, 22 Mar. 2022, <https://www.bbc.com/news/entertainment-arts-60837880>.

⁷² “Global Music Production and Distribution - Market Size 2005–2027.” *IBISWorld*, IBISWorld, 13 Aug. 2021, <https://www.ibisworld.com/global/market-size/global-music-production-distribution/>.

questions on video or live due to previously received harassment. The participant quotes that the extreme nature of this harassment has resulted in the closing down of their business. This participant is creating well-known eurorack synth modules, making them a great candidate to talk about the technical segment of the industry. The person in question is transgender. This interview posed a perspective different from Elysha's, indicating that transgender people might be experiencing more stigma in the industry than women. The second participant had the same experience as Elysha in not being taken seriously, adding that it extends even to technical partners and suppliers as well.

Additionally, the interviewee mentions assumptions of technical incompetence and lack of qualifications. The participant feels extremely unsafe and targeted, especially on social media. They have experienced transphobia and very negative remarks about their appearance and voice. Surprisingly, the participant also mentions that a lot of harassment has come from other members of the LGBT Community as well (e.g. fetishisation, sexual advances, invasion of privacy). This person strongly believes that fixing the gender issues in the industry should begin with more moderation, more online protection of marginalised groups, and having safe spaces in festivals/venues and non-mixity. Unlike Elysha, this participant believes that the situation in the industry got worse over time, with social media acting as a "larger attack surface". They also mentioned the role of music blogs and then making headlines from "whatever they find online" for more clicks. Lastly, this person highlights how their experience is limited to the US and may vary in different parts of the world.

5.4. Problems in the music industry and how to stay safe

Before even getting into the project itself, it was essential to first look into how difficult it would be to enter the market, as I planned to create a start-up out of my thesis idea. I had to look at the statistics and stories that directly relate to the demographics I belong to or that I am close to (women, LGBT, non-binary). In this part, I concluded that there is still a lot of gatekeeping and internalised phobia (Homo-, trans- and genderphobia). Additionally, the industry can be very unsafe for individuals from the demographics I chose to analyse. Based on my interviews, I saw how much danger Elysha was put in throughout her career. The other person I interviewed did not even want to have their name attached to my research, as they had already faced too much harassment (online and offline) based on their gender and appearance. It seems like women/LGBT people are still not taken seriously when they delve into music technology, as some still think they are "not technical enough for that". The second interview also suggested safeguarding our privacy and not giving out information that could expose us to unfair treatment. Elysha advises to stand one's ground and become part of female-led music initiatives, as well as projects and events explicitly geared towards women and/or LGBT people. Strength and safety are in numbers, which is why being an active member of different rights groups in the industry is so beneficial. In the next chapter, I will focus on the business side of the project, as the thesis has inspired me to take this project beyond just the scope of academia. Chapter 5 explains how I was able to receive support as a female start-up founder and what is involved in the process of creating a start-up.

6

The Thesis From a Start-Up Perspective



The previous sections focused on analysing the history of technological developments in the field and then on the sociopolitical implications of being a non-cis white male music and music technology member. As this project is being explored in the context of a start-up in parallel with academic research, some noteworthy developments on the commercial side were relevant to explore in this thesis. This chapter describes the ins and outs of creating a start-up from a music technology project. It also provides valuable guidance about how a start-up should be worked on and where to find funding in Austria specifically. Additionally, the chapter explores a few prominent female/LGBT-led start-ups to demonstrate the possibilities present when an individual can overcome inequality through unique ideas. The start-up created during the thesis project is called *Sensim Artis* (lat. *Sensim* - senses, *Artis* - art, intended translation- the *art of the senses*).

6.1. Sensim Artis in Start-Up Programs

Out of my desire to turn Sensim Artis into a future company, I took the fastest road to business education and setting up through accelerators and incubators. These programs can last anywhere from 3 to 18 months, designed to expedite the process of going from an idea to a business. All of these programs offer free coaching and training sessions, while some more serious ones provide financial support (primarily for research and development). There are different programs designed for various fields of start-ups. However, many have no specific niche and offer support to a wide range of start-up genres. Most of the programs also have a “final pitch competition”, where participant start-ups present their idea in the form of a short pitch deck that is no longer than 3 minutes in most cases. All of the free resources and training, as well as a lean, holistic approach, is what makes accelerators so efficient at knowledge transfer. The focus is fully put on bringing a business to a good point in the shortest amount of time and providing specialised help tailored to the specific needs of every business.⁷³ I have personally experienced the difference between starting a business by yourself and on your own learning schedule versus being in an accelerator program. It took me years to gain half of the knowledge presented to us, and I developed industry connections I never had before. After talking about which programs Sensim Artis has participated in, this section will lay out the four key takeaways from experience- the business model, business plan, user personas, and funding.

Gründungsgarage

Simultaneously starting the thesis semester at FH, I was also accepted into an accelerator program called Gründungsgarage. This program is meant for start-ups at different stages- from an idea to a product already selling. It is geared toward students and easy to get in, as long as the concept has some potential. The program is part of the non-profit initiative between the University of Graz and the University of Technology. GG (short for Gründungsgarage) has two semesters per year, synchronised with university semesters (winter and summer).

⁷³ Hathaway, Ian. “What Startup Accelerators Really Do.” *Harvard Business Review*, 14 May 2016, <https://hbr.org/2016/03/what-startup-accelerators-really-do>.

After sending out an online application form, candidates are invited for an interview at the TU Campus, where they are asked to give a 1-2 minute pitch about their ideas without needing a presentation. The jury asks questions, and a week later, decisions are received. In my opinion, the program was quite intensive, as all meetings were mandatory, and 90% of them were in person. Meetings were held 2-3 times per week for 3-6 hours per day, covering essential business topics in detail, workshops where participants applied the learned knowledge, and some workshops related to boosting wellness (the Wim Hof breathing method and ice baths). The first day was the most intense- the official part started at 8 am and ended at 8 PM. During this day, we were establishing where our project is currently heading, creating a business model and doing a short 1-minute pitch in front of a live audience at night. This audience consisted of partners of GG, including personal mentors, investors, and specialised coaches working for GG. After the presentations, we were encouraged to “mingle” and gather contacts, as well as to go meet our assigned personal mentor, who would be “in charge” of our progress during the program. After the end of the official program, most people stayed to get to know each other better and talk to their coaches.. The last day included final pitches, where teams competed for prizes, including access to co-working spaces for free, free legal advice, and small financial bonuses that could be applied to funding applications to one of the Austrian funding agencies. My key takeaway from the finals is that I needed to improve my storytelling and include a product demo during my pitch. Without a live demonstration of how a product works, the crowd will simply not understand the idea well enough to rate it highly. I was mostly going through the program alone until my colleague Daniel Benedeti joined me, intending to take over the development of the product in a more advanced manner than I have done during this thesis project. Most notably, he is working on designing a custom PCB, as well as one or two custom sensors, to improve the accuracy and sleekness of our product. Our team did not receive any of the prizes. However, we got reached out by a few important contacts, including investors, funding agencies, and partners with contacts of significant music technology companies.

Science Park Graz

As this thesis turned out to be technically more challenging than I had hoped for (due to my lack of engineering skills beforehand), the thesis was extended by another semester. Before the start of the second semester, my start-up team had been contacted by Science Park Graz, which markets itself as a “high-tech incubator”. We were asked if we would like to join their Academy, which lasts about the same timeframe as GG. However, it is much less time-consuming and is held entirely remotely, with complete flexibility according to participants’ schedules. This Academy will end with a pitch in front of a live jury, which will then decide which start-ups are accepted into their 18-month-long incubation program that offers not only coaching but also financial support. Due to its flexible and lax tempo, we have decided to take the offer after a 1-hour online interview. So far, the program has been surprisingly good, as everything is tailored specifically to each start-up’s needs, unlike GG, which is more general and pushed at times for things that we did not need at our stage of business. Most importantly, SPG (Science Park Graz) can even provide technical support/coaching, which our start-up will benefit significantly from. This incubator is not specifically geared toward women and

LGBT people but specialises in finding business support tailored to each start-up. This means, for example, that the incubator can help teams find funding for women and LGBT people in start-ups. Official entry into Science Park happens after presenting in front of the Project Advisory Board on the 6th of December. Many plans listed in the future research chapter will be done under Science Park's coaching and professional guidance.

6.2 Business Model

The first and most important thing that was discussed during start-up coaching was the business model. It is the basis on which every company is built. In essence, the business model demonstrates what the company is making, its costs, and how it is making money. The heart of a business model is the unique value proposition because how everything else will be set up depends on this statement. In short, with the USP, we state what our business can do that others can't, and the rest of the business model focuses on how we plan to achieve that. The illustration below showcases how the basic business model for Sensim Artis is set up:

To come to the final representation of a business model, as shown above, there is a handy tool widely used to aid companies- the business model canvas. It was created in 2004 by Alex Osterwalder from Strategyzer and thoroughly explained in his book *Business Model Generation*.⁷⁴ The business model canvas consists of marketing channels, essential resources, key partners, key activities, customer relationships, customer segments, cost structure, revenue streams, and channels. The canvas can be easily found online, presented in a visual form that helps start-ups. Business plan creation was part of every start-up program and camp I attended while working on the thesis project. Working with coaches and re-iterating the business plan helped formulate the business and determine the product's market potential. This has also allowed me to improve my pitch deck (short business pitch), which increases the chance of getting the project funded and scaling it commercially in the future.

6.3. User Personas/Target Audience

The following core agenda in creating a company is establishing different user groups that could benefit from the product in the future. This is especially important for projects like Sensim Artis, which are explored both from an academic and business perspective. The success of a company, as well as its funding options, depends on how clear the problem definition is, as well as the target users, which are described in this chapter.

User group aspects

The broadest user group that can be described for this project are music producers. This group can then be segmented into multiple subgroups:

⁷⁴ "Business Model Canvas." *Business Model Toolbox*, 23 Mar. 2021, <https://bmtoolbox.net/tools/business-model-canvas/>.

- The first sub-group will be people aged 18 to 45, as this is the most common demographic I've seen in the electronic music industry.
- The second sub-group will be music producers with mental health and stress concerns, as this product is supposed to partially have value in alleviating this problem. I've previously discussed statistics (71% of musicians have depression, anxiety, and panic attacks).
- The third group will be the one I have highlighted in this research and the one I would like to help further strengthen. I am referring to any music producer who does not identify as a straight, white cis-male.

User Persona(s)

I've created two persona graphics that I consider the "perfect candidate" in the context of this thesis. I've built a complete image around them and who they could be as a way to put myself in the shoes of others and try to evaluate my own product from an outside perspective. I asked myself: "what would this person think about the product? How can I help highlight these people better through my project?"

I started with myself as the user, and that's how one persona was made up. The other one was inspired by multiple famous music personalities from YouTube and TikTok (like Andrew Huang). These personas were not made based on empirical data, but through intuition, so the following two persona cards could be considered Proto-personas.

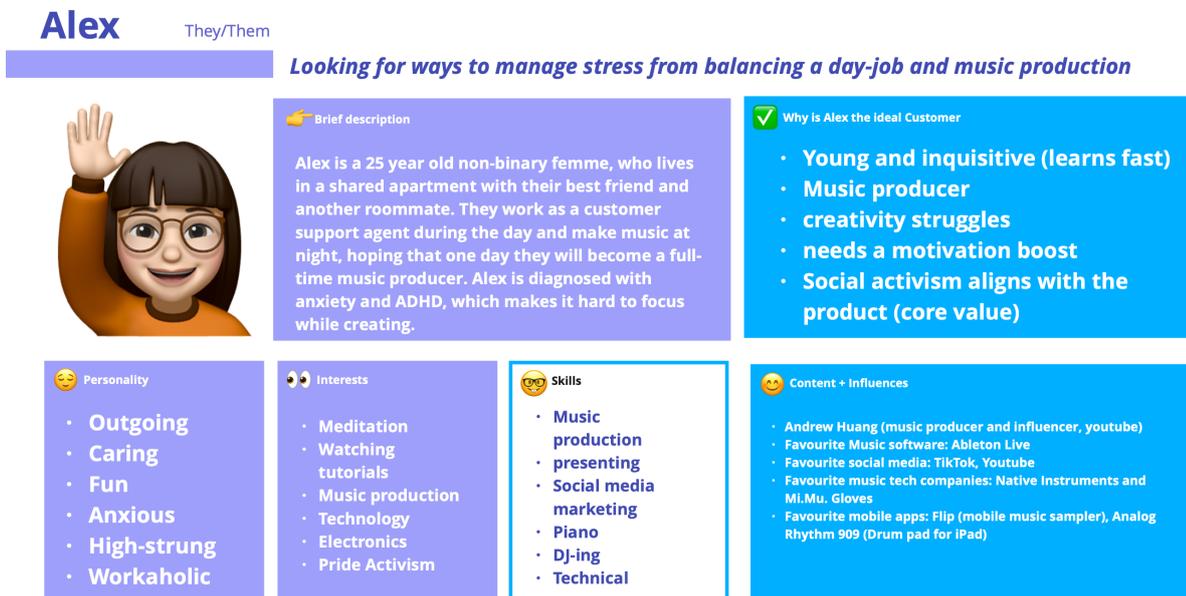


Figure 3.1.: User Persona named Alex, created for this thesis product concept

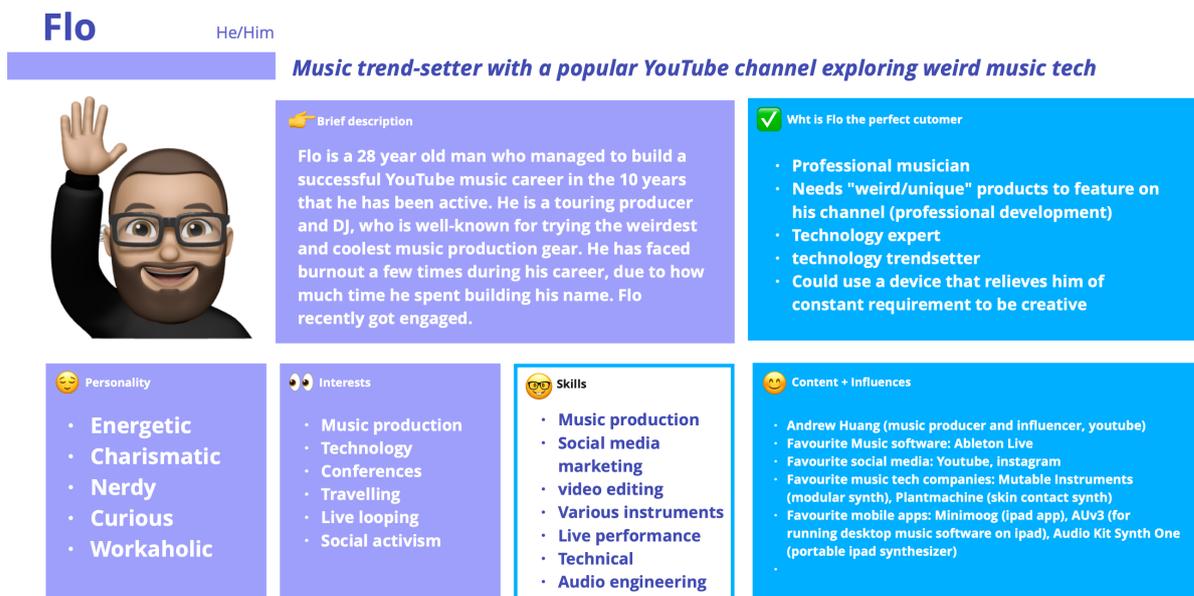


Figure 3.2.: User Persona named Flo, created for this thesis product concept

6.4. Business Plan

The third integral part of preparing a start-up for its operations is creating a business plan document. Every company must have this document, which is always asked for when a start-up is applying for funding. The business plan is a comprehensive overview of a start-up's products and market potential. The following summary is based on a template provided by Austriawirtschaftsservice.⁷⁵

A business plan needs to be able to "sell" the company to investors through confident language and beautiful design. It should describe every aspect of the business model canvas and intellectual property protection if needed for a specific business. The language used should be easy to understand, and any data provided needs to be backed up by references. The centrepiece of every business plan is the financial plan. It shows investors how much money they could make back on their investment and how long it will take. The first important part of the business plan is the market potential section. It outlines the size of the marketplace for a specific product/service and shows investors whether this business could pay off for them. The second most important part is the competitor analysis, which proves that a business either has an innovative product or has upgraded a previously existing concept/product. The analysis needs to show why a company's product is better than the rest. The business plan should utilise as many graphics and illustrations as possible. Numbers and statistics are easier to understand if they are presented in a visual form.

During the creation of Sensim Artis' business plan, I was made aware that it is essential to incorporate the UN's Sustainable Development Goals, as this is

⁷⁵ Muster-Businessplan - Austria Wirtschaftsservice Gesellschaft. n.d. Austrawirtschaftsservice, https://www.aws.at/fileadmin/user_upload/Downloads/ergaenzende_Information/aws_PreSeed_Seedfinancing_Muster_Businessplan.pdf.

important for getting funding in Austria. I took this opportunity to think about how Sensim Artis, as a start-up, could help decrease inequality in the industry. One of our chosen SDGs was 10 - Reduced Inequalities. Currently, Sensim Artis is going through the Science Park Graz academy. The next goal is to get accepted for incubation after the academy itself. A portion of the incubation investment will be used to find and hire non-cis male tech-savvy individuals. This would be a direct, actionable step toward achieving the goals of this thesis project - amplifying equality. The exact information given in our Business Plan is as follows:

“Sensim Artis strives to alleviate all kinds of inequalities in the industry – gender, social and racial inequalities. This will be achieved by hiring a diverse staff and working with partners and alpha testers who belong to different social/racial/gender groups. Female, non-binary, POC, and LGBT tech innovators don't get enough recognition, so we plan to highlight musicians across the whole spectrum through partnerships, influencer marketing, musical event, and every other way we can think of.”⁷⁶

I have also been invited to Perform a TEDx talk about user interaction in music, which will be connected to this thesis project. Another way in which I plan to highlight non-cis white male voices is by talking about the interactive projects described in this thesis.

After concluding the essential parts of a business plan, it is crucial to understand where to get your idea funded. The following section will explain funding opportunities for start-ups led by non-cis-white male founders. It should provide a good base for finding appropriate funding in Austria.

6.5. Funding for Female/LGBT-led Projects

The following section lays out start-up funding and venture capital relevant to non-cis-white male start-up founders. An in-depth list and description of different funding options will be provided in chapter 10.3. (Research Recommendations). In this part, I want to highlight that female and LBGT creators should be on the lookout for female-led company bonuses. In Austria specifically, most funding agencies give a 10-20% increase in funding allocation if the majority-share founder is female, non-binary, LGBT, or any other type of non-conforming identity. The bonus is called the “female founder bonus”; however, it is meant for all different kinds of minorities who have not had equal rights to industry access compared to cis-white males.

FFG FEMTech

FFG stands for *die Österreichische Forschungsförderungsgesellschaft*. The organisation funds a wide range of research projects, academia, and start-ups. This particular funding is geared toward women but also other marginalised groups in start-ups and different research fields. The grant is aimed at high-tech projects by female founders. To receive this grant, a start-up or research project must contain some gender relevance. That means the projects must somehow improve the lives

⁷⁶ Taken from Sensim Artis Business plan Lite

of marginalised gender groups. Each year, there is a different topic for the funding call, but it gives leeway to many industries. It is important to note that most FFG grants only cover 60% of business costs, so the rest must be self-financed or covered by a different grant.⁷⁷

AWS Female Entrepreneur Bonus

Austrawirtschaftsservice has a female entrepreneur bonus of 10% on top of every funding program available on their website. This bonus is not only intended to boost the entrepreneurial possibilities of women but also every other marginalised group in the start-up world, which, just like music, is dominated by cis-white males. Coaches have told me at AWS that the last round of their AWS First Incubator had the highest rate of people who fall under the female entrepreneurship umbrella (all non-cis-white males). It was about 40% unofficially. This is excellent news for the start-up industry, as their bonuses are influencing more marginalised groups to take a brave leap into the start-up world and bring us closer to equality. AWS has programs intended for start-ups at different stages. The first one a start-up should apply for is the AWS First Incubator, which offers up to 50.000 EUR for research, development, and personnel costs. It is intended for a wide range of start-ups that are still in a very early stage and still need to be registered. The program offers both financial help and coaching, which is what young ideas need. After that, a start-up can choose to apply for Pre-Seed Funding, which is for companies that have some sort of MVP and have been registered for a maximum of 1 year before applying. If everything goes well, the start-up can later apply for Seed Funding at AWS, intended to help expand the production capabilities of a company's final product and deliver it to the consumer. Only AWS First is wholly financed, while other grants finance 80-90% of the total business costs. The founders need to provide evidence that they can cover the rest of the expenses listed in their application documents. This is a simplified and shortened explanation retold in my own words, according to my previous experience with the AWS staff and their informative e-mails.

6.6. Female-led Music Tech Start-ups

This section will explore female-led start-ups that are currently active and have received a substantial investment (500.000 EUR and above) or have made revenue of at least 1 Million EUR. I will only include start-ups with an established product or online presence. I will not be including start-ups that have not yet reached mass operational capabilities. When digging through different start-up databases (Wellfound, Crunchbase, LinkedIn), I was surprised at how difficult it was to find a company that would match what I wanted to analyse in this section. When looking through Wellfound (formerly Angellist), I could find many companies including racial minorities (e.g. in Spotify, Deezer, Groover, SongKick, Audiotool, etc.). However, all founders listed were male. According to this list, it appears that racial minorities in the start-up scene are treated almost equally to their white male counterparts.⁷⁸ Female-led companies mostly seem not to have received enough funding to be found on these lists.

⁷⁷ "Chancengleichheit - Femtech Forschungsprojekte." FFG, <https://www.ffg.at/femtech-forschungsprojekte>.

⁷⁸ "Best Tech Companies and Startups to Work for in 2022." Wellfound, Wellfound, <https://angel.co/startups//europe/music>.

My assumptions are backed up by an article by Forbes, which examines how venture capital investors take much more time to reach a funding decision for female-led projects. It also mentions how women are expected to fail more often than men; hence they are asked more difficult questions implying that they do not have a failsafe plan. The article proposes a possible future solution- to anonymise and depersonalise start-up pitches, which would remove the gender aspect from VC investor decision-making.⁷⁹ According to another article by the European Investment Bank, the percentage of successfully-funded female-led start-ups in 2021 was meagre- it only accounted for 1% of the whole market. While the statistics outlined here are related to the general start-up field, my independent research proves that the numbers are similar in music tech start-ups.⁸⁰

Luckily, the Austrian start-up scheme incorporates UN's SDGs as some of the core elements in a start-up's business plan. During pitching at Science Park and AWS, all participants were encouraged to employ inequality-related SDGs in their "Team" slides. This shows that Austrian organisations are currently actively trying to improve gender statistics. The situation is similar in neighbouring countries. When looking at the Music WorkX Incubator (Hamburg) website, the gender balance among participants in 60/40 men-to-women is already much above the general European statistics.

I will refer back to mi.mu Gloves by Imogen Heap as one of the best examples of what is possible in the start-up scene for non-cis white male individuals. According to correspondence with Adam Stark, the managing director, the project was mostly funded with personal capital and some small grants/investments. It has been nearly 10 years since mi.mu was first shared via Kickstarter, and according to an online article, the gloves started selling in 2019, which is a long time period.⁸¹ Heap's company now has a team of 15 people- a big change after the first few years when she worked solo. Currently, the production of mi.mu Gloves is paused due to global chip shortages.⁸² Unfortunately, even seasoned start-ups can be severely endangered due to external factors. The company will not fail due to the forced break; however, their plans have been significantly delayed. These types of situations are something every technology start-up should be prepared for. Mi.mu is currently mostly selling its software, and it has recently launched a new addition- a software granular synth.⁸³

The road for music start-ups is long and hard but worth it for those who are passionate about what they do. Female-led start-ups have a sizeably harder time finding investments due to the observed gender biases in the environment. The

⁷⁹ Post, Corinne. "Investors Could Be Missing out on Women-Led Startups. Here's How They Can Fix That." *Forbes*, Forbes Magazine, 18 Oct. 2022, <https://www.forbes.com/sites/corinnepost/2022/10/17/investors-are-missing-out-on-women-led-startups-heres-how-they-can-fix-that/>.

⁸⁰ Czerwinska, Teresa, et al. "Investment in Women Entrepreneurs Delivers Higher Returns." *European Investment Bank*, European Investment Bank, 11 Mar. 2022, <https://www.eib.org/en/stories/investment-in-women-entrepreneurs>.

⁸¹ Cooper, Daniel. "Imogen Heap's Musical Gloves Are Finally Available to Everyone." *Engadget*, 13 May 2021, <https://www.engadget.com/2019-04-26-mi-mu-imogen-heap-musical-gloves-price-launch-date.html>.

⁸² "Mimu Gloves." *MiMU*, MiMu Gloves, <https://mimugloves.com/gloves/>.

⁸³ "Mimu Gloves." *MiMU*, MiMu Gloves, <https://mimugloves.com/plugins/the-jellyfish/>

situation is slowly improving due to European demands to incorporate the UN's SDGs into the business models of every start-up that wants to compete for European funding. I have personally observed this during start-up camps and competitions I was part of. The case study of mi.mu Gloves proves it is possible for women to From the case of mi.mu Gloves, I learned the importance of having a contingency plan (e.g. backup products).

6.7. Learnings

In the first part, I explored the hardware and software technology relevant to the scope of this project. I mentioned how most of this section was attributed to male music technology inventors but pointed out that my research led me to find women whose importance was misrepresented in this part of history.

In the next part, I focused on non-cis white male innovators and their contributions both with technology used in this thesis, as well as other historically significant developments in the field. I concluded that it is difficult to find these non-cis white male creators due to improper attribution in literature and online. The only way to find accurate information is through primary-source material, like the MUSIC V guide created directly by Max Matthews and Joan Miller. Luckily, this manual was available at Archive.org, which has a scanned collection of historical source material. This type of information should be more readily available and pushed to Google's first page when searching for it. This analysis confirmed my assumption that women and other non-cis white male creators are not highlighted enough.

I continued the research and analysis by exploring the situation among musicians and music producers. Excerpts were taken from interviews with LGBT community members, expressing how boxed in they felt due to stereotypes about sexuality and what type of music a "gay person" should be making. Statistics showed the large number difference between cis-white male, female, and LGBT musicians. Shockingly, no female music producer was ever nominated for a Grammy, despite the presence of award-winning musicians like Grimes and Imogen Heap, who produce a lot of music entirely by themselves. I could not find statistics regarding the mental health among non-cis white male individuals in the community, so I could not explore the impact their position in the industry has on the target group.

Next, I shed light on established non-cis white male music technology creators. I analysed their products and used them as a guideline for my own project. Two prominent individuals from the target group were interviewed, and both of them shared negative experiences. However, one of them presented the problems as minor to moderate, while the other stated unfair treatment has had such a bad impact on them that they chose to remove themselves from the internet, closed their well-known business and asked to remain anonymous in this thesis. This showed me how, even though the situation is getting much better, some individuals are still experiencing inequality to an extreme level.

After the theoretical research, I transitioned to my experience as a start-up owner to tie in my own perspectives with what I have researched and concluded so far. Chapter 5 was structured as a guide for anyone who would like to start their

own start-up in the future, and it also provides a few tips on how to get funded as a non-cis white male business. One section explored how difficult it is to get a female-led start-up funded successfully. Statistical data is very skewed towards men, no matter their racial profile. Gender stereotypes hence seem to outweigh any other. An opportunity to change this has presented itself in the past few years through the mandatory inclusion of SDGs into funding pitches, especially ones relating to inequalities. When I joined start-up programs, I was surprised to learn how intensive they are. For example, GG had meetings 2-3 times per week, and one was always a longer workshop. The goal of GG was to transfer the most knowledge possible in the shortest time, resulting in a rigid structure of long, mandatory presentations and practical workshops. The first and the last workshop lasted from 8:30 until 21:00, which is quite long. Other workshops lasted 3-5 hours. Missing any meeting/workshop would result in being kicked out of the program. When it comes to funding, it appears that there are plenty of grants available, especially for non-cis white male individuals in European start-ups, which hopefully encourages more marginalised groups to start their own businesses. Getting funding is a very long process, so patience and constant iteration are crucial.

All the learnings from previous chapters serve as a guideline for building my own product. The experiences of other start-ups from target groups act as preparation for what I, or any other music tech start-up founder, could face. The exploration of the theoretical, historical, and sociopolitical factors served as inspiration in building up the practical part of the project. This has led to building a product that was made using non-cis white male achievements and inventions as the building blocks for the development of technical knowledge.

7

Product Development process



The previous chapters focused on theory related to the chosen topic, while the following chapter explores the topic strictly from a technical/practical viewpoint. After researching other sensor-based projects, I wanted to choose an interactive music production solution utilising emotions. The reasoning is that traditionally, femininity is attributed to being able to express emotions. This also holds in the LGBTIQ+ community, as we often see activists trying to spread positivity and organise LGBT parades, which are displays of boundless, free love. A music control device that somehow converts emotions into controls for music would be a fitting analogy. As pure emotions are pretty esoteric, I have to focus instead on how our body responds to them, which could be done through health-tracking sensors. These sensors can track signals like heart rate and temperature. Further in this chapter, I explain which exact sensors will be used, why, and in what form the controller will be produced.

7.1. Prototype 0 (MVP)

After evaluating different available options, costs, and availability of components, the decision has fallen on the resources described in this chapter. From the start, I had the idea of using biosignals to control and generate music. The “brain” of the product will be an ESP32 board, as well as four different sensors, each of which is meant to follow specific signals from the body. Leading back from my research, I’ve established that there is a lot of stress and mental health struggles among music industry members (even more so for female and LGBT creators). I want to build a product that can help with stress symptoms. Another thing I want to do is to contribute to the numbers and hence the strength of my targeted audience in the music industry (female/LGBT). This is why I have decided to turn my idea into a start-up. In the future, I will hopefully be able to highlight suppressed members of the industry through the start-up’s business model (e.g. cross-promotion, sponsorship, and future job openings). In the prototype, my goal is to measure specific emotions, like stress, anxiety, and happiness, and track health status while wearing the gadget.

The Main Board

This project will be programmed through a board called ESP32. I have chosen this board because it is smaller and cheaper than a comparable Arduino board. The desired features for the final product’s board were for it to be powerful, able to store a lot of data and to have built-in Bluetooth and WiFi capabilities (for future developments). For example, if we look at Arduino Uno WiFi Rev2, the price is 42,80 EUR, with 14 digital inputs/outputs and dual-core processing.⁸⁴ On the other hand, the ESP32 has 38 input/output pins and all of the other features I listed for Arduino while only costing 10 EUR at a local store.⁸⁵ The ESP32 Dev Module (my specific chosen board) can also be purchased at a much lower price from

⁸⁴ “Arduino Uno WiFi REV2.” *Arduino Official Store*, <https://store.arduino.cc/products/arduino-uno-wifi-rev2>.

⁸⁵ Hübschmann, Ida. “ESP32 For IOT: A Complete Guide.” *Nabto*, 28 Aug. 2020, <https://www.nabto.com/guide-to-iot-esp-32/>.

AliExpress (3,54 EUR).⁸⁶ ESP32 is also considered a generic board, which can be modified on a deeper level than Arduino (e.g. with C# or even lower-level Assembly programming language). ESP32 is based on a 32-bit architecture, has 520KBs of RAM, 16Mbs of Flash Memory, 22 GPIO (general-purpose input/outputs), 2 DACs (digital to analog converters), and 18 ADCs (analog to digital converters).⁸⁷

Sensors

In chapter 5, I talked about how biofeedback is being explored in a musical context. I've chosen to focus on this technology in my product, as I want to attempt to create a device with 2-fold benefits- both health-tracking and music production. I see this type of tool as a possible solution to one of the abovementioned problems in the industry relating to mental health. All of the advice from interviews, as well as the warning stories, have been used as an insight that will help me keep a thick skin and also know where I can turn for support, whether it be financial or social. This section gives an overview and technical explanation of the sensors that have been used in the prototype.

When talking about biofeedback, the most obvious control input to consider would be our heart rate. The apparent pulse intervals, as well as the ease of speed changes, makes this a very reactive input source. To detect and measure the heart rate, I will be using the Joy-It SEN-KY039HS heart sensor. The principle on which it works is based on an infrared or green light and a photoresistor. When integrated into a small finger holder, it will detect heart rate with these lights. The method is called the Photoelectric Pulse Wave method. The value readout is based on how much light is absorbed into the finger. When a blood vessel expands (from a heart pump), the light gets absorbed more, and the vessel will shrink when the heart is between 2 pumps. This enables us to review data as heartbeats on a graph. The sensor should be used indoors because the infrared waves from sunlight can interfere with its functionality.⁸⁸ Green light has a much higher absorption rate, making it more accurate for measuring. The KY-039s sensor uses this light range, which is why I chose it. If a lot of light shines on the transistor or if it is bright outside, the voltage will be low- close to 0V. If the Transistor is in the dark, it lets through a relatively small current, slightly raising the voltage.

Another input that will be measured and could give cool outputs is galvanic skin response. It is also called Electrodermal Activity (EDA) or Skin Conductance (SC). This value measures the activation of sweat glands, specifically on our hands and/or feet. It is a good indicator of stress levels, as the sweat glands on our extremities are more active when stress or emotional stimulations are high. Stress can be distinguished from other emotional arousals due to distinct patterns present in the data that have been studied so far. As sweat glands secrete liquids, the balance of positive and negative ions changes, resulting in a change in skin conductance. This change is what we call Galvanic Skin Response (GSR). Sweating

⁸⁶ "Wireless Modul NodeMcu V3 V2 Lua WIFI Entwicklung Bord ESP8266 ESP32 Mit Pcb Antenne Und Usb Port." *Aliexpress.com*, ENLINCA Official Store, <https://www.aliexpress.com/item/1005003850296621.html>.

⁸⁷ 43- Ibidem

⁸⁸ "ROHM Semiconductor Pulse-Sensor", ROHM Semiconductor, <https://www.rohm.com/electronics-basics/sensor/pulse-sensor>.

is autonomous, meaning it cannot be controlled. Except for emotions, it has been discovered that skin conductance can also be triggered by motivational or attentional processing. Most notably, that relates to, for example, recalling a memory or performing a cognitive task. Since GSR is straightforward to measure and can show such a wide range of indicators, it is being used in many research fields. In psychological research, it is used to measure responses to different objects and establish personality traits (e.g. extrovert). In clinical research and psychotherapy, GSR is used to measure the progress of improvement in patients with various mental health conditions. Trauma reminders will also trigger an increase in GSR values. Another exciting field is consumer neuroscience, where GSR serves to establish consumer preferences. Ad testing through GSR responses can help advertisers improve their ads and cut out whatever doesn't work. Usability and UX testing can also be performed- stress levels will be higher if the user is frustrated and confused by the UX. To actually monitor GSR, one only needs two different electrodes (attached to fingers, for example), with constant low voltage running through them. The skin conductance level is then read from the difference in voltage between those electrodes.⁸⁹ The GSR sensor will be the emotion-tracking portion of my product, as the goal is to have a music device that creates music from our emotions- to some capacity. This is the premise I used to describe my product in Chapter 5, where I talk about this product from a business perspective. The prototype will utilise the Grove GSR sensor, which is quite popular based on the number of reviews I have seen and, during my own tests, proved to be very accurate and enjoyable to work with. This sensor works with an Input Voltage of either 5V, or 3.3 V. Its sensitivity can be adjusted through a potentiometer. This sensor includes finger cots, which is quite convenient. The sensor outputs analog data and, therefore, must be connected to an analog pin on a microcontroller.⁹⁰

The following graphs show how changes in GSR patterns indicate different emotions and physical states. In the future development of this product, I could create an emotion recognition algorithm that reads emotions in real-time. This could be a way to get even closer to “making music from emotions”. One could even track breath rate from the GSR graph, as there is a specific peak pattern present for different breathing patterns.

⁸⁹ “Galvanic Skin Response (GSR): The Complete Pocket Guide.” *Imotions*, 20 Feb. 2020, <https://imotions.com/blog/galvanic-skin-response/>.

⁹⁰ “Grove - GSR Sensor.” *Grove*, https://seeeddoc.github.io/Grove-GSR_Sensor/.

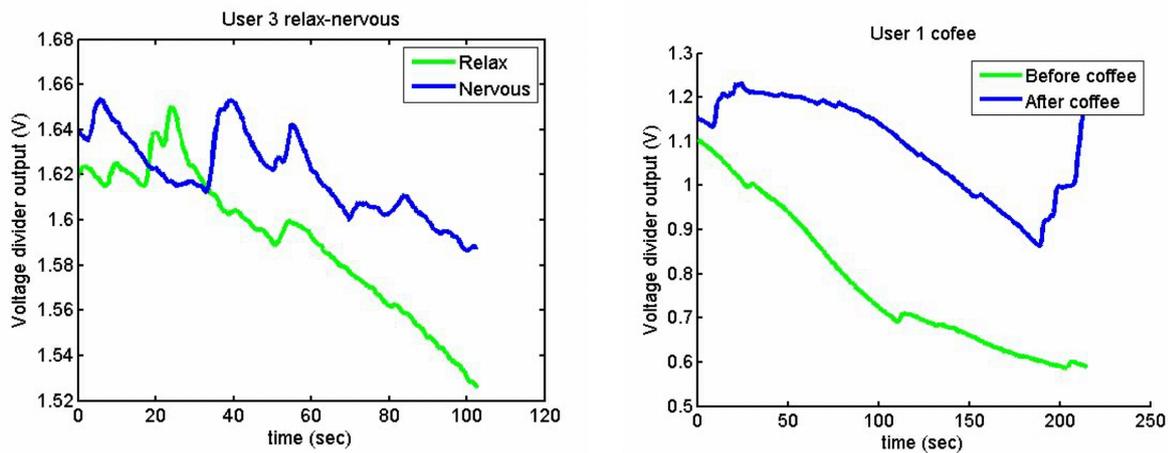


Figure 4.1. and Figure 4.2.: Graphs showing the difference in the GSR patterns between relaxed and stressed states (Graph 1) and Before and after coffee, which causes a rise in energy. Distinct patterns can be observed in each case. Taken from the study “A Stress Sensor Based on Galvanic Skin Response (GSR) Controlled by ZigBee” performed by María Viqueira Villarejo et al.⁹¹

Humidity measurements can be used in two ways- for surface skin humidity and ambient humidity. The body naturally cools down with the help of air in the environment. In very humid environments, moisture will stay longer on the skin, which slows down the rate at which our body cools down.⁹² It is well-known that the amount of humidity we are surrounded with affects our general well-being to an extent. For example, if the air is too dry, we could experience dry eyes, an itchy nose, skin irritations, or even a bloody nose. People with allergies and asthma will find breathing harder in a dry environment.⁹³ On the other side, if the environment is too humid, it could lead to dehydration, fatigue, cramps, or even heat stroke. A few studies point to the possibility of high humidity affecting mood-regulating chemicals in the brain. It can also lead to seasonal affective disorder, a type of depressive disorder, as well as anxiety. If there is a clear indicator that ambient humidity is high, it is essential to stay well-hydrated.⁹⁴

I could only obtain the DHT11 sensor for this project, an ambient humidity sensor. It works on the principle of a capacitive sensor and a thermistor, providing a digital data output.⁹⁵ A thermistor (thermally sensitive resistor) is a type of material that is somewhere between a conductor and an insulator. The temperature of a thermistor material depends a lot on resistance, which is the property buyers use to

⁹¹ Villarejo MV, Zapirain BG, Zorrilla AM. A stress sensor based on Galvanic Skin Response (GSR) controlled by ZigBee. *Sensors (Basel)*. 2012;12(5):6075-101. doi: 10.3390/s120506075. Epub 2012 May 10. PMID: 22778631; PMCID: PMC3386730.

⁹² Sarmiento, Samuel. “It’s Not Just the Heat, It Really Is the Humidity: Know the Risks.” *NBCNews*, NBCUniversal News Group, 12 Aug. 2016, <https://www.nbcnews.com/health/health-news/it-s-not-just-heat-it-really-humidity-know-risks-n629486>.

⁹³ “How Indoor Humidity Effects Your Feeling of Well-Being and Health.” *Advanced Solutions Nederland*, 24 Feb. 2021, <https://www.advsolned.com/indoor-humidity-wellbeing-health/>.

⁹⁴ 48 - ibidem

⁹⁵ “DHT11 Temperature-Humidity Sensor.” *Evil Mad Scientist Shop*, <https://shop.evilmadscientist.com/products/menu/716>.

determine which material to purchase. Thermistors are made from layers of different materials stacked upon each other, cut into the size of a chip. The precise ratio between the different layers is essential for the resistance ratio. The thermistor is what helps the humidity sensor read the temperature.⁹⁶ Since the reading of a DHT11 is not nearly as good as a DHT22, I went for a more cost-effective solution, while the DHT11 will measure just the humidity. This is where the capacitive sensor comes to play, measuring the relative humidity in the air, which is a ratio of the current humidity and the highest possible number. There is an excellent explanation from the Metropolia Wiki:

The relative humidity (Φ) of an air-water mixture is defined as the ratio of the partial pressure of water vapour (H_2O) ($e\omega$) in the mixture to the equilibrium vapour pressure of water ($e^*\omega$) at a given temperature. Relative humidity is usually expressed as a percentage and is calculated by using the following equation: $\Phi = e\omega/e^*\omega$ ⁹⁷

I will be adapting the DHT11 to read out my body's humidity through 2 different methods- encapsulating it in my hand and blowing air from my mouth (the second will give much more drastic readouts). For breathing itself, it would have been better if we could use a PLGA sensor (polylactic glycolic acid) because it is excellent at measuring relative breath humidity in a controlled environment and is reasonably fast.⁹⁸ However, I could not obtain this component. Another option for breath-tracking would be to measure CO2 levels instead of the breath rate itself. This component would require some hacking to adjust it to my needs, and I could also not find a sample that would arrive fast or be affordable enough.⁹⁹

Temperature is another critical health signal to track. A heightened body temperature is a clear symptom of many diseases, as the immune system works hard to fight them off. The most common reason for a pathological increase in temperature is fever. The progression of a disease can be followed through temperature changes. This is an important indicator of whether our medicine is effective. Another reason our body temperature can rise is due to exercise, but this is temporary and not as high, so it will go down quickly after ceasing physical exertion. Aside from exercise itself, our body temperature can change by more than half a degree throughout the day, depending on our activities (e.g. digestion also increases body temperature). There are two types of body temperature measurements- core temperature (measured from inside the body) and surface temperature (on the skin).¹⁰⁰ I will use a thermometer module to measure the

⁹⁶ "What Is a Thermistor and How Does It Work?" *Omega*, Omega Engineering Inc, 20 May 2022, <https://www.omega.com/en-us/resources/thermistor>.

⁹⁷ Kuusela, Jonne. "Capacitive Humidity Sensors." *Metropolia Confluence*, 12 May 2015, <https://wiki.metropolia.fi/display/sensor/Capacitive+Humidity+Sensors>.

⁹⁸ Soomro, A.M., Jabbar, F., Ali, M. *et al.* All-range flexible and biocompatible humidity sensor based on poly lactic glycolic acid (PLGA) and its application in human breathing for wearable health monitoring. *J Mater Sci: Mater Electron* **30**, 9455–9465 (2019). <https://doi.org/10.1007/s10854-019-01277-1>

⁹⁹ Nastybyte. "CO2 Breath Sensor, Point of Max. Curvature." *Arduino Forum*, 17 Mar. 2015, <https://forum.arduino.cc/t/co2-breath-sensor-point-of-max-curvature/298167>.

¹⁰⁰ "Why You Should Measure Body Temperature." n.d. *Microlife AG*, <https://www.microlife.com/magazine/fever/why-you-should-measure-body-temperature>.

surface temperature for this project. I will be using the TRU COMPONENTS DS18B20 temperature sensor devkit, which comes with all the parts I need to make it work seamlessly. This sensor is also waterproof so that it can be submerged in liquids- a waterproof probe covers it. It also includes an analog-to-digital converter so that it can be connected to a digital pin of a development board (for example, the ESP32, in my case) with a single wire. The temperature sensor works with a voltage range of 3 to 5V.¹⁰¹ The DS18B20 works on a principle similar to the DHT11/DHT22 (thermistor). It has a large temperature range, but what's most important to me is that it is very precise and can do temperature measurements with up to two decimals (9-12 bits). Our body temperature changes very slowly and slightly, so I need to measure the smallest changes to make this prototype work properly. The easiest way to measure our temperature would be to take the surface temperature by enveloping the metal probe part in the hand. The skin's average surface temperature is around 32 degrees, and it can rise by 3-4 more, depending on stress levels, our physical activity, and the state of our body. Surface temperature changes much more than internal body temperature, and it is a good indicator of emotional states. Adrenaline and cortisol change during emotional reactions, affecting blood pressure as well as directing whether more blood will go into the extremities or the core of the body. This affects surface temperature changes.

Some other sensors that we initially planned on were: blood pressure, muscle contractions (EMG), and EEG. Unfortunately, we either couldn't find samples that could be delivered in time; they were too expensive, or they were too complicated to install in the frame of the thesis. EEG may or may not be added in the future developments of the product only if the small form and portability can still be preserved.

Programming Controls - Arduino IDE, C#, and Libraries

Most people start programming sensors through the Arduino IDE, which is visually based on a hardware programming language called Processing, which is similar to C programming.¹⁰² Most commands are written in C++ (which is relatively high-level), with the addition of some unique methods and functions specific to controlling Arduino.¹⁰³ I used the latest version of Arduino IDE (2.0) for sensor programming. The commands which are used in programming every sensor are void setup() and void loop(). In "setup", variables are defined, and communication is established, and in "loop", the sensor is instructed to continuously cycle through the commands given in the code so that values outputs are always regularly updated.

Much attention was paid to the GSR sensor because it can deliver the most essential physiological information for the project itself. One of the goals is to be

¹⁰¹ Seeed Studio. "DS18B20 Waterproof Temperature Sensor." n.d. *Seeed Studio*, <https://www.seeedstudio.com/DS18B20-Temperature-Sensor-Waterproof-Probe-p-4283.html>.

¹⁰² Badami, Vasudhendra. "Arduino Programming for Beginners-1." *HackerEarth Blog*, 25 Oct. 2016, <https://www.hackerearth.com/blog/developers/arduino-programming-for-beginners/>.

¹⁰³ Team, Circuite. "Everything You Need to Know about Arduino Code." *Circuito.io Blog*, 11 Mar. 2018, <https://www.circuito.io/blog/arduino-code/>.

able to control music with our emotions, and the GSR sensor lets us do it well. GSR will also be very important for future developments, as this project also aims to provide the additional benefit of stress-tracking. In this section, I will explain my thought process and the basic version of coding I performed. I additionally tried outputting random values between 0 and 500 to explore what other outputs I could get from using this sensor. There are many different uses for the capacitive touch GPIOs- as a touch button (on/off), slider, value generator, or just the GSR itself. The main commands used for programming Grove GSR are described in the table below:

Command	Description
<code>#define GSRpin 12</code>	Tells ESP which pin Grove GSR is connected to (12)
<code>#define GSRthreshold</code>	Sets the minimum value at which GSR is activated, otherwise listed as 0
<code>GSRvalue = analogRead(GSRpin);</code>	Reads the value of GSR from the connected pin
<code>Void GSR_sensor_handling</code>	Starts the sensor without values, preparing it for use

For temperature, I used a readily available library that takes care of setting up the sensor, and instead, I can just focus on utilising received data right away. My choice was a well-known library called Dallas Temperature, which is compatible with all sensors starting with the prefix DS and DT. The following table gives an overview of the most important coding commands:

Command	Description
<code>sensors.begin()</code>	Starts up the sensor
<code>void loop()</code>	Sets up a continuous loop
<code>getTempCByIndex(0)</code>	The temperature values will be fetched in celsius

For humidity, I started by adding the Adafruit DHT sensor library and then wrote a piece of code similar to the one for Temperature. The first thing to note is that sensor reading with DHT11 take up to 2 seconds, which is slow. So, this sensor will probably be connected to a control parameter, like the lowpass filter, as it doesn't require a fast control reaction time to give interesting results. Slower speeds make it sound more smooth.

Due to the low response time of the humidity sensor, the readings jump suddenly from low to high. Even though this is not great for health tracking, it is still usable in music production. For example, through experimentation, I have discovered that cool glitchy or springy sound effects can be made using this control.

Transmitting sensor data into music

The programming language I chose for this project is Max because it is relatively accessible with my previous music programming experience. I already understood the logic behind Max before this project, thanks to PureData courses at the university. Max4Live provides seamless integration with Ableton Live, which I will use to create a piece of music that will be controlled and modulated by my prototype. In principle, Max MSP enables intuitive visual programming with pre-made objects. These objects can only communicate with each other and give audible results if they are connected with patch cords. Then, the patch reacts if a user takes an action (mouse click or MIDI note). The way MSP objects communicate is called the signal network. The smallest unit of time that can be used (e.g. for the metro object) is 1 millisecond. Audio is typically processed with at least 44000 samples per second. To combat the sample rate, Max constantly calculates all the upcoming numbers needed a few milliseconds ahead. These calculations are made on the level of individual objects. Real-time audio synthesis is possible because of this principle. Big calculations will be hard on the computer's CPU, so the better the processor a user has, the less latency (delay) or glitches there will be. Glitches or pops occur when the processor cannot make all the calculations fast enough to keep up with the real-time output.¹⁰⁴

Before starting this project, I wasn't sure how to receive data from sensors into Max, and I had no idea how to use those values. Then, through watching YouTube tutorials, I realised that Max could receive data from the serial port.¹⁰⁵ I have built a patch with Max4Live, as I will be using it inside Ableton to control my music.

The key objects used in my patch are explained in the list below (interpreted from Max's user manuals)¹⁰⁶:

Object Name	Description
Serial	Read ports and devices from standard serial driver
Sel	Outputs a bang when an inputs matched arguments listed next to sel
Itoa	Converts a list of up to 256 integers into a symbol
Unpack	Takes a list, breaks up the values, and sends each of them to a separate outlet
Scale	Scaling input float or integer values into a usable output range. Float values give more precise arguments. Can also be tweaked to scale exponentially
live.dial	Circular slider outputting number values based of the position of the dial on the slider
Id	Sends the object id to left and middle outlets. Id will show 0 if no object is selected

¹⁰⁴ "How MSP Works: Max Patches and the MSP Signal Network." n.d. *Cycling '74*, Cycling '74, <https://docs.cycling74.com/max5/tutorials/msp-tut/mspshowmbspworks.html>.

¹⁰⁵ mo_thunderz. "Arduino Based LFO+ADSR, Controlled through Ableton with Max for Live (Part 2: Installation and Code)." *YouTube*, mo_thunderz, 6 Jan. 2021, https://www.youtube.com/watch?v=HI7n_ObG3Go.

¹⁰⁶ "Max 8 Documentation." n.d. *Max 8*, Cycling '74, <https://docs.cycling74.com/max8>.

Object Name	Description
<code>live.remote~</code>	Remotely control parameters of devices in Ableton through Max patch
<code>live.thisdevice</code>	Reports a bang (when max patch is active), a 1 (for “enabled”) or a 0 (for “disabled”)
<code>live.path</code>	Navigate Live objects. <code>live.observer</code> , <code>live.object</code> and <code>live.remote~</code> work through it
<code>path</code>	Specify a path that should be reached within Ableton to fetch desired data to be controlled by Max patch
<code>live.object</code>	Perform actions on live devices after selecting them through the <code>live.path</code> object
<code>deferlow</code>	Puts all messages at the end of a low priority chain

Under each message is a “scale” object, which is necessary to ensure data received from the sensors fit the default automation range values of “live.dial” objects (Ableton’s knobs in Max). The knobs are always scaled 0-127 (default value) in my case. The other values are scaled based on the normal signal range from one of our body's health aspects. For example, looking at the heart rate, I scaled the knob to interpret 45 BPM as a 0 and 125 BPM as a 127. The same logic was applied to all other input values. The temperature was scaled further because I kept received values with two decimals, so I had to use float values. This is really important, as I’ve already mentioned how small the human body temperature changes are.

I have intentionally kept inputs and outputs for the purple mapping button, IDs, the min and max value outputs, as well as “live.remote” outside of the sub-patch, because for some reason, the patch would otherwise not work. There is a +10 before the “scale” object, as the patch was also for some reason not setting the correct minimum when being mapped to an effect. This meant, for example, that the lowpass filter (Auto filter) would only open to 12.000 Hz instead of the full 19.000. Adding +10 somehow shifted everything back to its usual values. Normally, this doesn’t have to be done, but it might be some glitch in my Max software version. I’ve created the first inlet for the knob itself to pass through the scale object. Outlet 1 sends the mapped value from the chosen Ableton effect to a message box, which is just there for proofing. The value displayed in the message box (called “automation” in my labels) should match the value that the user sees on the effect that was chosen for automation. The second sub-patch outlet is for the first inlet of “live.remote”, which is a receiving inlet. It enables us to control external effects inside our max patch (e.g. to be able to control a filter or delay from Ableton). The third outlet lets me connect the sub-patch to the “ID” message box. It is connected to the right inlet (“sets the message without output”). This way, I can receive the numerical identification of each parameter within an effect. For example, in the Auto Filter effect, the “Frequency” dial is marked as “id 486”. This is a way of identification specific to Ableton components.

The last two outlets are meant to route the mix and max values of the chosen aspect of an effect (e.g., frequency) to two more message boxes, also intended to make sure that the correct and desired parameter has been mapped to the right dial. Overall, the patch looks simplistic, but there were many obstacles in the

process. When the patch didn't work, I had to try re-grouping everything, and at some point, the message boxes below "unpack" were not showing any values. I accidentally unplugged one, and when re-plugging it, I realised that it now works correctly. There were many similar examples where the patch wouldn't somehow work until I re-plugged everything, as well as a few instances where I did not see that I accidentally patched the wrong inputs.

The first MAX patch has four controls set. Heart rate is mapped to the Beat Repeat Ableton effect, where the speed of the heart rate controls the beat repeat speed. It allows for creating cool, stutter/glitch drums, which are always kept in sync with the tempo, as Beat Repeat was set to count in bars. GSR will automate the Scale MIDI effect so that I can create random melodies with different GSR values. I've set the range from -14 to +14 semitones since, through testing, I established that this sounds the best. The temperature will be used to change the Arp MIDI instrument speed, which I think will give me some very cool effects. Lastly, humidity will operate one or multiple lowpass filters, one on each layer of sounds. A comprehensive overview of all the mapped controls is shown in the table below.

Sensor	Mapping
Heart rate	Beat repeat grid and quantization-glitches on percussions
Heart rate	Auto filter (lowpass) on atmospheric pad element
Temperature	Violin expression and loudness
GSR	Lead element. Ableton Arp - note transpose
Heartrate	Lead element arp speed

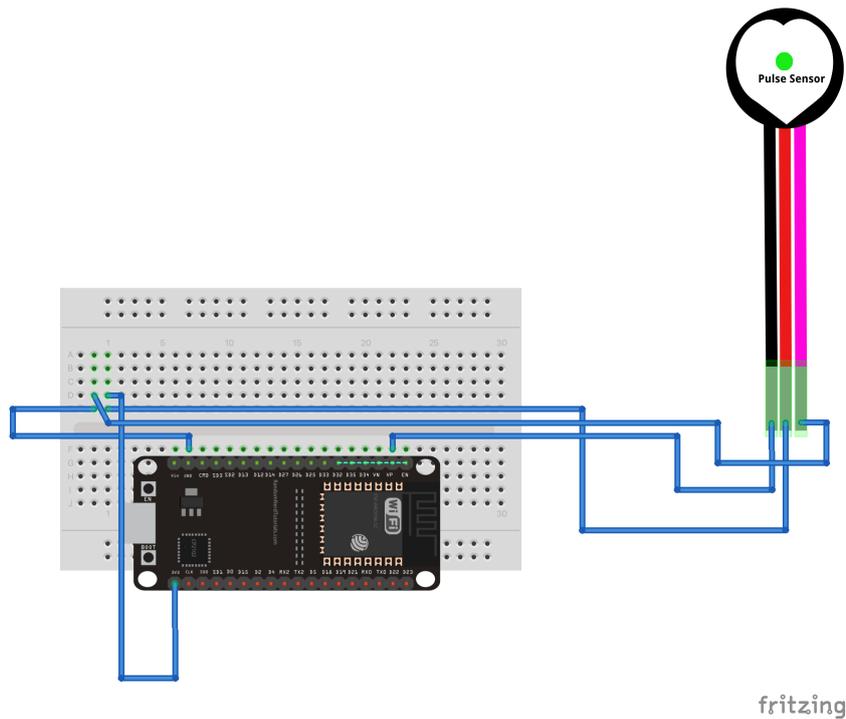


Figure 5.2.: Attachment of the heart rate sensor

The second sensor added was the DHT11 for humidity measurements. The sensor could be plugged into any row, so I chose the first (in the Fritzing breadboard, it is row A). Then, I added a 220 Ω pull-down resistor to control the current flow from the digital pin to GND. The GND pin is connected to the same column where the GND pin of ESP32 is also attached. Vcc is connected to a 3V3 pin, as this is how the sensor will be powered (it works with 3.3V). Lastly, the signal, or in this case, called the data pin, is connected to GPIO 23.

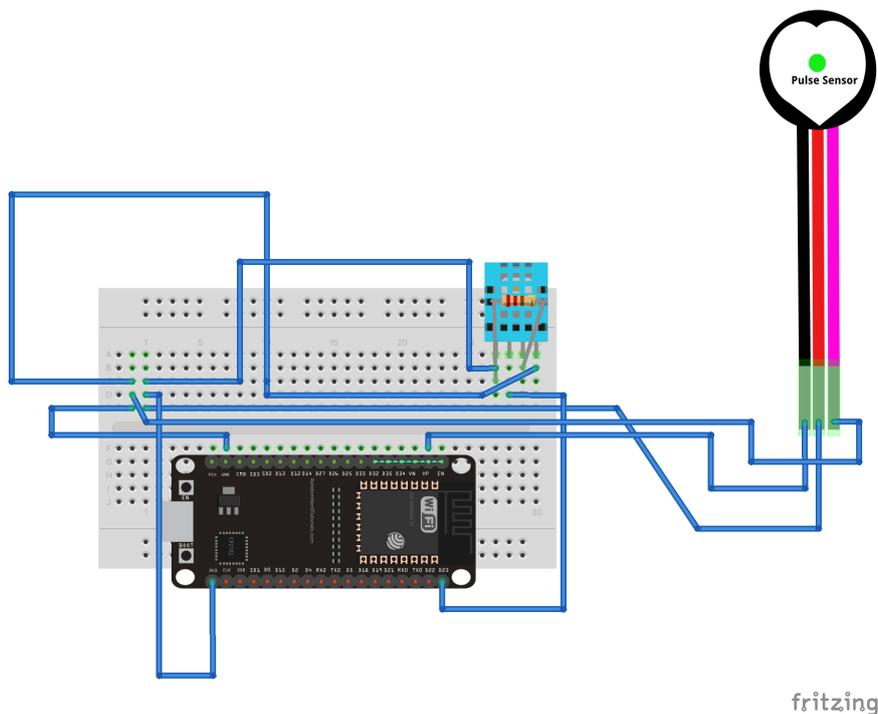


Figure 5.3.: DHT11 sensor wiring

Then, I added the GSR sensor. In the Fritzing prototype, the finger electrodes are represented by the two plates. Each of those needs to be connected to the pair of pins on one side of the GSR sensor. This allows for reading the currents of these two electrodes separately, as GSR will be measured based on the difference between these two finger electrodes. It is important to note that the fingers should not be touched together, as this will cause interference and result in inaccurate readings. Then, the first of the four pins on the left side of the sensor is connected to the D12 GPIO, as this is the SIG pin. The third pin is connected to the same row as the 3.3 V power supply from the ESP. Lastly, GND is connected to the second row from the left of the breadboard, where the GND pin of ESP is also attached.

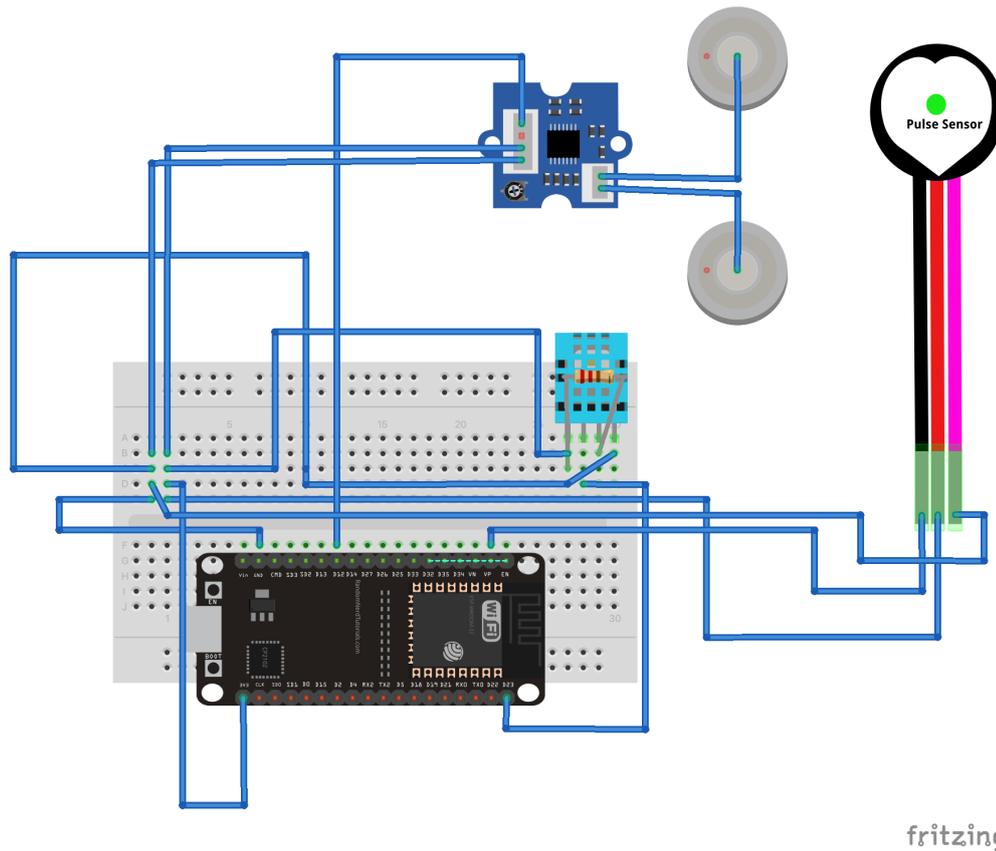


Figure 5.4.: GSR sensor and electrodes, wiring

Lastly, the DS-Temperature was set up. The physical version of the sensor comes with a pluggable terminal, as the wires don't have pins on the ends. The terminal provides an easy way to connect the probe sensor to the breadboard. The terminal was plugged to row a on the breadboard in a similar fashion to the rest of the sensors- GSR to GSR of the ESP, Vcc to 3V3, and lastly, SIG was connected to the same row as the D4 GPIO on the ESP (row E, 4th pinout).

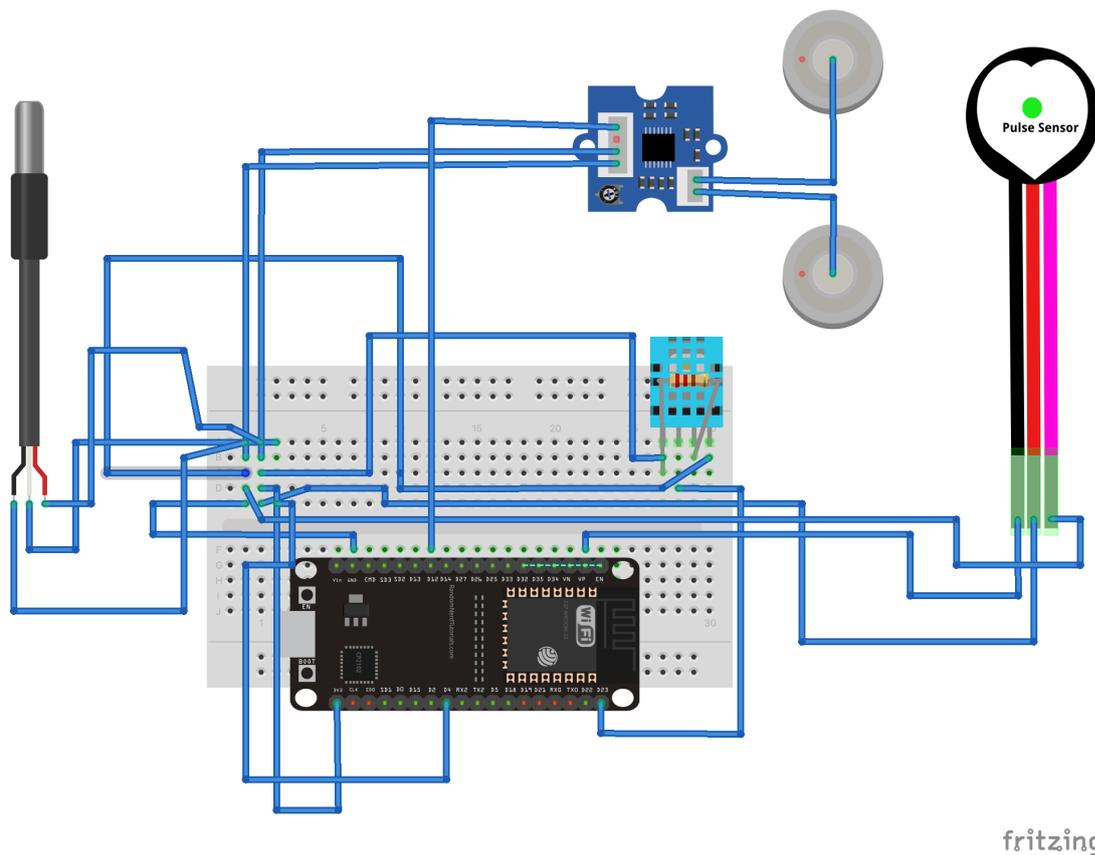


Figure 5.5.: All the sensors wired together on the breadboard

Prototype 0 Testing

This section outlines the process of using my music tool to create a piece of music. All the complications and what worked are laid out in the same order as the testing went. After finalising the code and testing outputs, the prototype was ready for practical use. My goal was to create a track with significant rises and falls to symbolise my emotional state since I started performing live. I recalled all my wins and losses, from getting my first gig to all the rejections I received on my demos and musical projects, including this one. The following section outlines all the steps in creating the final track. I decided to use a combination of samples (e.g., drums and percussions) and custom-made patches for synths, like Serum and Spire, which are my most commonly used plug-ins.

The first parameter I decided to control was the arpeggiator pitch on the Ableton Arp MIDI effect. This was the most straightforward way to change the melodic progression of the lead synthesiser. I loaded up my desired Spire patch and created a MIDI clip, where I placed eight notes from the chosen scale (D# minor). I set the arp to play one note at a time, and the pitch knob will modulate which notes are playing. This depends on the semitone range on the knob. The eight notes added are just there as a reference point for the pitch to change as I am controlling it. The most interesting control to use with pitch was galvanic skin response. I put on the electrodes and started recording the automation for the pitch. I first had to unlock the knob that I assigned GSR to, as I could not record automation otherwise. Right away, I learned that the patch wouldn't work exactly how I planned the way I programmed it. However, I did find a workaround. The

automation stays in place when I turn off sensor receiving (the big cross at the left side of the MAX patch). Otherwise, the sensor interference causes automation to turn off.

I let the automation record, and while wearing the GSR electrodes, I first tried to stay meditative so that the pitch remained lower. I attempted to progressively put my body in a more excited state by breathing deeply and thinking about anything that excited me. This had a nearly instant effect on the GSR readings, making the melody more high-pitched and diverse. I macro-mapped the pitch range from -14 to +14 semitones, as this range sounded the most pleasant. A video demonstrating usage can be found in Appendix.

The second parameter I decided to automate was the arpeggiator speed. Temperature was used to change these values. The macro mapping range was set from 1/1 to 1/48; anything lower than that sounded too frantic and unpleasant. I decided to use the temperature sensor similarly to how I would use a slider-gradually pushing the desired value up. I set the threshold at 27 degrees- this is the point at which temperature values will start modulating the macro knob. I started recording automation and let the arp play out the melodies generated by the GSR values at an arp speed of 1/1. Then, I held the sensor probe tightly in my hand to warm it up well; I also got up to run in place so that my body warmed up and registered on the sensor.

Humidity was by far the hardest to control. The slow sensor speed usually wouldn't be a problem, but values would jump instantly from 0 to a very high humidity value in this case. I realised that I would have to record the humidity controls for a bit longer than the other sensors (instead of 16 bars, 32 bars) and try to build up humidity very gradually. I did this by blowing one breath into the sensor, then pausing for 2 seconds before the next breath. The moisture from my mouth is what the sensor registered and applied to the chosen control. In this case, I chose a pad instrument in Spire and mapped its lowpass filter to humidity. Even with all the adjustments, it was still very hard to get steady changes; however, the glitchiness of sudden value changes made for a very cool effect, which I ended up using.

The heart rate sensor was particularly tricky to use. At first, I was not getting any readouts and no changes in the sound. I wanted to control the grid size of the beat repeat plug-in to get a glitchy effect on the chosen drum pattern. This control parameter is relatively unresponsive. I mapped the grid knob to a macro knob on the enclosing Audio Effect Rack, and then I mapped the macro to the heart rate knob of my custom MAX plug-in. The mapping was done in the same manner as all the previous controls described in this section. I had to experiment with macro-mapping ranges to get a good change in the sound. In the end, the minimum was set to 1/1 and the maximum to 1/48. I put the sensor on and started recording the changes, firstly trying to keep my body very calm. Then I stood up, ran in place, and breathed heavily to cause a dramatic shift in values. Sometimes the knob receiving heart rate values would jump back to 0, but I found that it starts working again once I move it with my cursor while recording automation. After all the adjustments mentioned above, it worked well enough. The video footage can be seen in Appendix, under the section *Appendices*.

Overall, both the coding and the sensors did not work correctly right away, which is typical and expected with such projects. I have not had much experience working on Arduino and MAX projects, so I was aware from the start that there would be a lot of room for improvement and a lot that would be left for future research. With some adjustments, like the macro range or simply by moving the knobs on the MAX patch manually, I managed to keep the effects working the way they should. In the process, I learned that the way I created the patch is acceptable for DIY use. However, I need to polish it and use different commands in some places to make it work seamlessly and professionally.

Concept Feedback

After the breadboard was assembled, I created a concept feedback questionnaire to evaluate how appropriate the emotion-to-music interaction is and how desirable the product would be in the market. I created a short video that represented how each of the sensors would work with music production to make it clear to participants what the device would be capable of achieving. Despite my efforts to source feedback from numerous sources (university network, Facebook, Discord, Instagram), there were only 15 responses given. A bigger pool of participants would have been desirable; however, the collected data still allows me to create some judgment on the concept of Sensim Artis. I acknowledge that before a commercial product is produced, Sensim Artis would need to collect a much larger data pool.

Question	Results
What is your age?	33% 18-24, 26% 30-34, 20% 25-29, 13% Prefer not to Say, 7% 35-29
What is your main interest in music (classical instrument player, DJ, electronic music producer, singer)?	47% music producer, 20% instrumentalist, 13% DJ, 7% Audio engineer & sound artist
How often do you use interactive music production gadgets (e.g. interactive tools and instruments)?	27% Daily, 20% a few times per month, 13% multiple times per week, 7% monthly & never, 27% less
How do you prefer buying your music equipment?	47% both, 40% online, 13% offline
How often do you face creative block?	38% never, 25% a few times per month, 13% sometimes & once a week
How often do you feel stress/anxiety/depression related to your work in the music industry?	25% a few times per week & almost never, 13% daily & almost daily & a few times a month & once a month
Are you on the lookout for cool new ways to control and make your music?	75% not sure, 12.5% yes & no
How much would you be able/willing to pay for a product that lets you create music parameters UNIQUE to YOUR body, giving you inspiration, while also tracking your stress, which helps you manage your well-being better?	40% 200-400 EUR, 33.3% up to 200 EUR, 6.7% 400-600 & 600-800 & 800-1000 & 1400+ EUR

Question	Results
Do you see any potential in using Sensim Artis as both a therapy and a music creation tool?	60% yes, 27% not sure, 13% no
How do you like the general concept of Sensim Artis?	27% 6 & 7 & 10, 7% 5 & 3 & 1
How easily could you understand the product from the description/video?	40% 10, 20% 6, 13% 8 & 9, 7% 5 & 7
How exciting does the product sound to you?	20% 7 & 8, 13% 6 & 10, 7% 1 & 3 & 4 & 5 % 9
How strong is the wow factor?	27% 9, 20% 6 & 8, 13% 10, 7% 1 & 5 & 7
Do you see how this product could be useful for creativity?	75% yes, 25% not sure
Do you see many tech-loving musicians purchasing this product in the future?	53% yes, 40% not sure, 7% no

One question had the aim of making sure that participants clearly understood the product from the video representation. As most of them found it completely clear (10 out of 10), I will assume that my video documentation was appropriate. When it came to the desirability of the product, the answers were quite polarised. I assume this is partially due to a slightly unclear value proposition statement, as well as the fact that participants could not see a finished product or video footage of producing music live with Sensim Artis. When comparing this question to the last one, the scale is contradicted- 53% of the participants stated that they think that many tech-loving musicians would buy this product, while 40% were not sure, and only 7% answered with a no. The table below summarises what the aims and goals of this prototyping stage were and what worked or didn't work:

Aims	Objectives	Evaluation	Result
Emotion-to-sound control	Find responsive, high-fidelity sensors	Test sensor speed with music production	Some sensors might have to be replaced
Emotion-to-sound control	Write code that will bridge the connection between sensors and music	Establish a successful and responsive connection between code written for the ESP32 and the MAX patch.	ESP32 code has been connected successfully to the MAX patch. The patch should be evaluated in the next prototyping step
Demonstrate the value of the product	Create a video that will clearly present the product's value for the user	Collect ratings from users on the quality of explanation and how much value they see in the product	Value was not shown clearly enough (some testers were confused). Description and question should be improved
Create a wearable structure	Find a way to create a reasonably small and flexible wearable that will house sensors and the microcontroller	Wearing the prototype, asking testers to wear it	At this stage, wearability has not yet been tackled

Aims	Objectives	Evaluation	Result
Make the product easily understandable	Define a simple and fun way which demistifies technology/ programming and makes it less intimidating for non-technical musicians.	Ask users to rate how well they understood and liked the product overall.	The product is not yet understandable to everyone due to not having a clear physical product shown and explained in the video

7.2. Prototype 1

In the first phase of product development, I focused on choosing suitable sensors and programming them to perform the desired actions (emotion-to-music control). I also created the MAX patch and ensured it worked with the breadboard prototype. The second prototyping phase involves turning the breadboard prototype into a cardboard version of the wearable device. Before the final prototype, there are several factors that need to be explored. These include soldering/circuitry, new sensors, and glove materials. Afterwards, the electronics and fabrics are brought together to be evaluated in the final prototype.

Sensor Improvements

At this stage of development, I decided to replace some sensors. The first change included removing the humidity sensor. It was too glitchy to work with, and GSR data already gives us insight into the body's humidity levels. Since GSR data can track multiple indicators, these could somehow be separated into multiple inputs in the future research of the project. The DS temperature sensor was replaced with a much smaller thermistor, a more responsive sensor with a higher resolution (2 decimals).

The following change happened with the heart rate sensor, which was replaced by the MAX30102, which also has Oxygen saturation tracking. The heart readings are more precise and have less noise, but unfortunately, the SPO₂ readings turned out to be practically unusable. I had not foreseen how tricky it would be to program sensors with an ESP32. The MAX30102 sensor seems to be working smoothly on the Arduino¹⁰⁷, but unfortunately, ESP32 seems to have its own set of problems that could be overcome only with a lot of experience working on this board. Hence, oxygen saturation readings will not be taken as a viable input source in the final product.

Circuitry & Soldering

Before being able to create a cardboard prototype, I first need to solder all my components together to have a final size and form. This will allow me to create housing that fits the components inside of it. The diagram below illustrates how everything will be connected together. The values on the left indicate ports on the ESP32 being used in the project. These include Digital I/Os, Voltage In, Ground and 3.3 V power supply. This schematic includes a few resistors to regulate current flow. The signal received from the thermistor is so small that it requires an operational amplifier for the ESP32 to pick up the values. On the schematic, this is represented by the component with a strike-through arrow on top of it.

¹⁰⁷ Last Minute Engineers. "Interfacing MAX30102 Pulse Oximeter and Heart Rate Sensor with Arduino." *Last Minute Engineers*, Last Minute Engineers, 6 Jan. 2022, <https://lastminuteengineers.com/max30102-pulse-oximeter-heart-rate-sensor-arduino-tutorial/>.

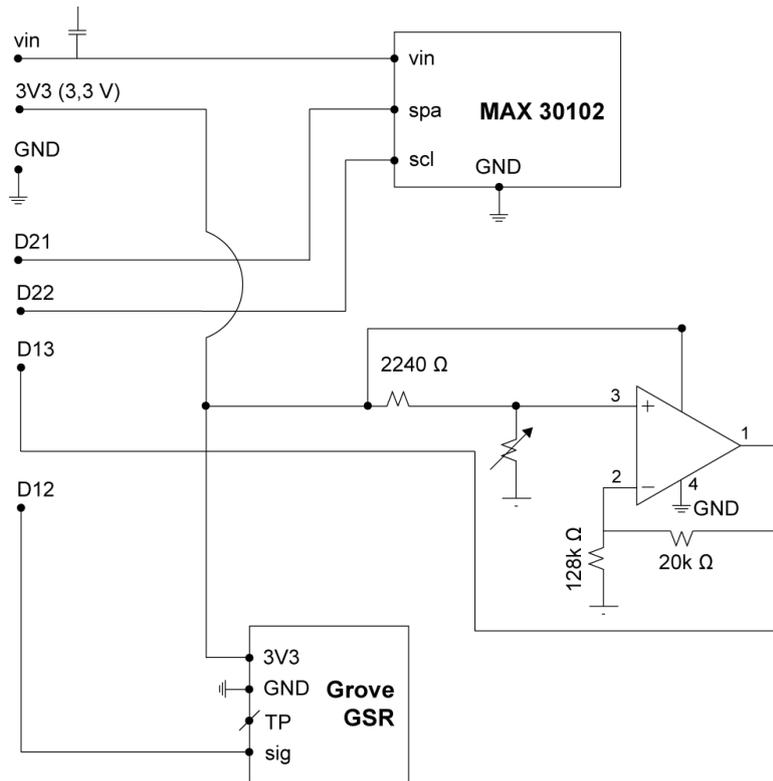


Figure 6.1.: Circuitry sketch for the PCB design used to plan out how connections will be made.

The next step is to solder everything to a PCB referencing the circuitry diagram. Each I/O of the ESP was bridged with a wire underneath to the corresponding pins where the sensors are connected with jumper cables. Since the PCB is perforated and hence easier to use for beginners, the soldering method used for this project was THT (Through-Hole Technology). This just means that soldering is done through holes in the PCB. The other technique of soldering that is used in electrical projects is surface mount, where components are soldered on top of a PCB surface.

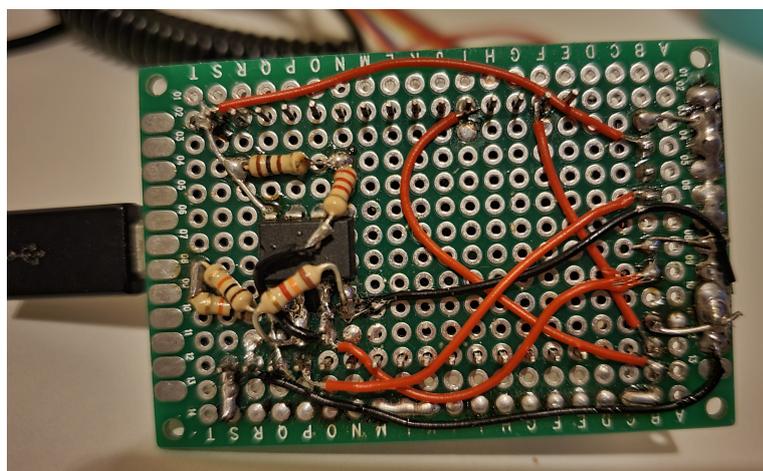


Figure 6.2.: Bottom view of the soldering, wiring, operational amplifier (black component) and resistors, soldered on a perforated PCB

Product Form and Factor

This chapter focuses on the research and planning behind the form factor and materials that are used for the execution of the product. The analysis will look into the history of the design of different projects that could be taken as a relevant starting point and inspiration behind the materials used to produce my prototypes. The first version built, which I would call the MVP, was focused only on the pure functionality of the sensors, hence there was no wearable solution yet. During the production of Prototype 1 and Prototype 2 (the final form that will be presented in the context of this thesis), there has to be a strong focus on wearability and usability conditioned by the form factor and weight of the prototype. The chosen form for the wearable prototypes will be gloves. This is because gloves have been used in many earlier music tool projects and are a reliable form for smaller, portable prototypes. This impression is based on projects like MI.MU Gloves and the Lady's Glove. Details will be discussed further under the section "Exemplary Glove Projects".

Exemplary Glove Projects

The chosen form for the product itself is a glove since the sensors work best on fingers, and with some additional adjustments and filtering from my side, some can also work on the wrist. This is why the following section analyses previous highly-regarded glove projects. The rating criteria for each chosen project were awards, publicity, and academic recognition of each project.

The Lady's Glove

In section 4.4. of the thesis, I wrote about the success of Laetitia Sonami and her Lady's Glove. This section will now focus on the form and factor of the glove prototypes. The first prototype of the Lady's Glove was made from a pair of rubber kitchen gloves with a hall effect transducer glued on every fingertip. Her next gloves model was made from golden lycra, and resistive strips were sewn along the glove. Each strip generated two datasets when bent. The gloves now had a magnet inside the thumb part. There is a pressure pad on the index finger and a transmitter inside the palm. The distance between hands and the height of the left hand are calculated by a receiver on the right arm and left foot. The transmitters allow the use of the glove without spatial references. All the signals are transmitted into Sensorlab, which converts everything into MIDI signals. Different sound control parameters are mapped to the MIDI signals through MAX/MSP. The mapping and sonic interactions are changed for every show.¹⁰⁸

MI.MU Gloves

Mi.Mu Gloves are made from recycled fabric, with sensors lined out inside the glove. There are also LEDs and vibration motors that give the user visual and haptic feedback. The gloves have open fingers, which allow the user to play instruments. The fabrics are thin, elastic, and can be washed. The sewing and pattern are also made specifically to be resistant to wear and tear. There are 8 individual finger flex sensors, along with accelerometers, gyroscopes, and

¹⁰⁸ Sonami, Laetitia. "Media Art Net: Sonami, Laetitia: Lady's Glove." *Medien Kunst Netz*, Media Art Net, <http://www.medienkunstnetz.de/works/ladys-glove/>.

magnetometers. Lastly, a battery indicator lets the user know if the gloves need to be charged.¹⁰⁹ Through my connections in the start-up network, I have gotten in touch with Adam Stark, who is the head engineer at MI.MU gloves and I have asked him to provide me with more details about the material build of the gloves.

Remidi T8

The Remidi T8 is another type of musical Glove, which allows users to play different sounds by pressing their fingers on various surfaces. This is achieved through pressure sensors on each fingertip, with the glove acting as a MIDI device, which can be used with any software plugin the user chooses. Remidi uses high-quality stretchy textiles and smart fabrics with a wristband as the brain of the operation. There are 3 buttons on the wristband that allow for a quick switch in Remidi's functionality. To some extent, it feels like the Remidi T8 may have been inspired by the MI.MU Gloves, however, taking a different approach with the addition of pressure sensors. RGB LEDs on the wristband, as well as indications on the app, give the user feedback on the status and glove actions.

Anatomy of Gloves

In the previous section, an overview of different gloves was given across several successful music tool projects. In this section, each of those materials is listed and analysed in depth to figure out why and how they work for music production tools. The goal is to determine which material would be the most feasible to use for this specific thesis project. According to the research conducted in the previous section of this chapter, the most popular glove materials are textiles with a moderate to high percentage of elastane inside, which allows gloves to conform to different forms and shapes of hands and cover a broader range of sizes. Elastic gloves also provide a tighter, more secure fit. Different sewing patterns offer a varied degree of durability. The precise blend of materials used (except elastane) doesn't play a massive role in the functionality/wearability of the glove. It only depends on the personal values of the creator. For example, whether sustainability is important or not. In the case of MI.MU Gloves, the focus on sustainability resulted in using recycled textiles and cardboard packaging for the product.

When analysing the Remidi T8 gloves, this is the first time I have seen the words "smart fabrics", which I have heard before, but did not really understand precisely what this term meant. Based on research about what smart fabrics mean, I have concluded that most projects described in this thesis could be classified as having "smart textiles" and that the concept itself was not new to me, however, I was unaware of what they were called.¹¹⁰

Multiple glove projects mentioned in this research have used some sort of user feedback, be it visual or haptic, or a combination of both. This detail will be kept in mind, as it is obvious that feedback will be important in letting the user know if everything works properly.

¹⁰⁹ "Mimu Gloves Overview." *MiMu Gloves*, MiMu Gloves, <https://mimugloves.com/documentation/mimu-gloves-overview/>.

¹¹⁰ Barrera, Thalia. "Smart Textiles in Fashion: What They Are, Types & Exciting Examples." *The Tech Fashionista*, 6 Nov. 2021, <https://thetechfashionista.com/what-are-smart-textiles-and-examples>.

Strength is also measured in tensile, tearing or bursting strength. But, so many factors are related to the fabric strength like yarn count, twist, fibre fineness, stiffness, fibre density, fabric structure, cover, yarn density, number of layers, tightness factor, and so on.¹¹¹

Sensim Artis Glove Design

After examining previous successful glove products and analysing my own product aims, I decided to use stretchy fabric gloves for my build. One of my long-term goals is to create sustainable products, however, this will be researched more in the future development of my product. I chose to focus on rapid prototyping for the thesis, where the focus lies on achieving the basic functionality of a product as fast as possible and focusing on the details later.

Cardboard Prototype

In the first part of prototyping (Prototype 0), I focused on ensuring the sensors could perform what I envisioned. The next stage of prototyping focuses on creating a cardboard model that will be used to evaluate whether the final product could have the desired form (textile glove). This stage aims to build a lo-fi iteration that resembles the final envisioned product (with some limitations due to material properties). A cardboard prototype is relatively quick to render, allowing me to evaluate its effectiveness before committing to a non-reversible final implementation.

Before physical prototyping, I created a sketch on an iPad to envision where and how I would like each component to be placed. This sketch is what the final prototype should look like. Using a final product sketch made it easier to envision how I could cut and shape the cardboard to be close to what the final product should be.

¹¹¹ Danielle Co. LLC. "Textile Durability for Consumer Products." *Sutherland Rub Tester*, 8 Sept. 2017, <https://www.rubtester.com/improve-textile-durability>.

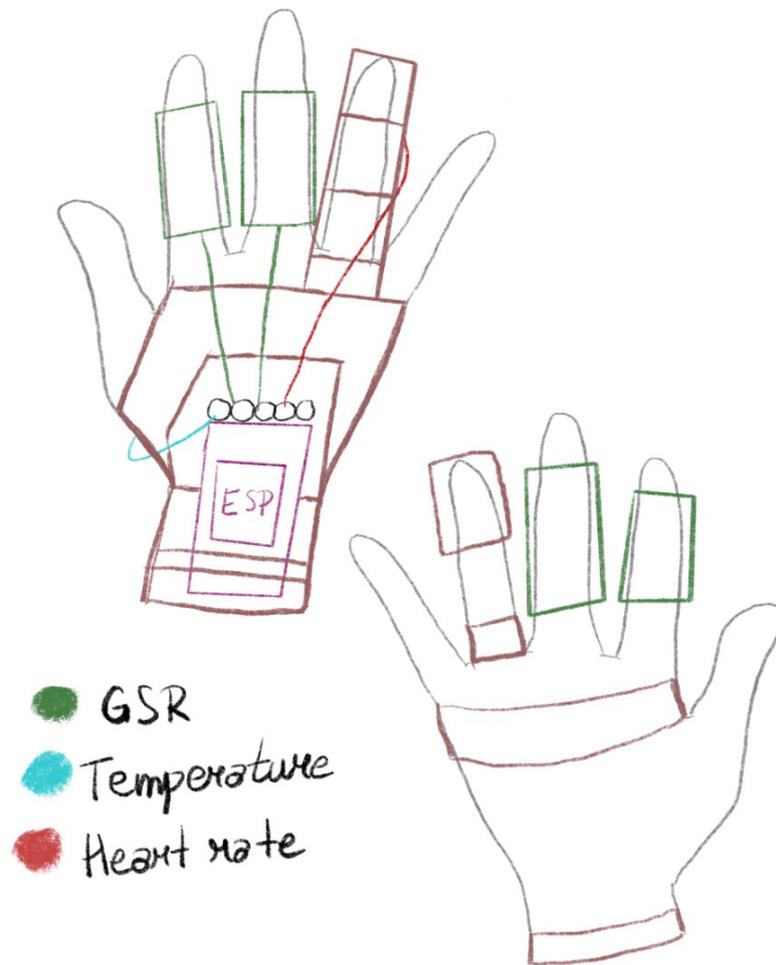
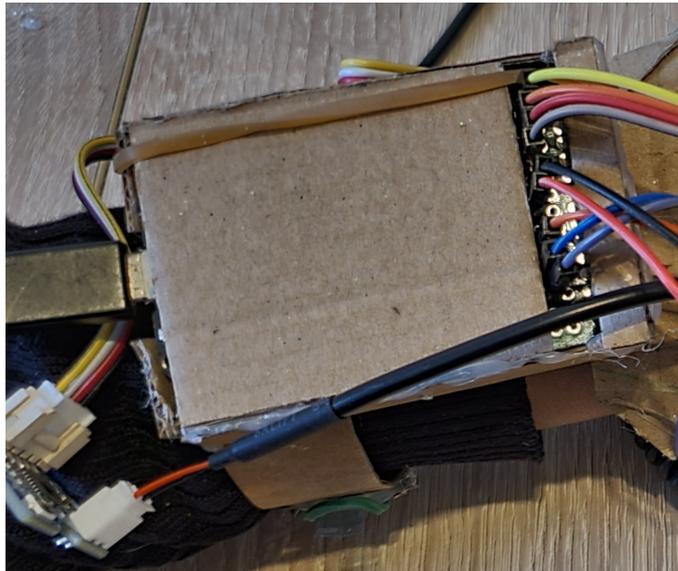


Figure 7.1.: Sketch for the cardboard prototype, indicating the planned glove design and sensor placement

I first created a single-finger attachment that would house the heart rate sensor during cutting and shaping. When worn, the fit is tight from the sides, keeping the sensor snugly in place. This reduced a lot of noise during sensor readings. I also built a cardboard shell for the whole hand since I will need a closed space to place the temperature sensor in. Lastly, I added housing for the microcontroller, with openings for the USB port and jumper cables. The top lid was fastened with a small rubber band just to prevent the board from falling out by accident. The external parts (finger and casing) were fastened to the prototype by using rubber bands underneath. I created hooks from pieces of a plastic bottle and placed them around the front straps and inside the cardboard glove for the finger and ESP32 casing. The tension keeps these components both in place while also providing some flexibility to the prototype, making it possible to move one's hand.

Figure 7.2.: Cardboard case for ESP32, with openings for wiring and the USB cable. The top part can be opened and fastened back down with a rubber band.

The only sensor that is not attached to its intended point of contact is the thermistor. I could not have it attached, as putting on and removing the prototype would damage the whole casing and the sensor itself. Instead, I compromised by manually placing it in place every time I put on the glove. Input readings were performed with no issues. The size of the new sensor is significantly reduced from



the first one, which will make the final prototype less bulky.

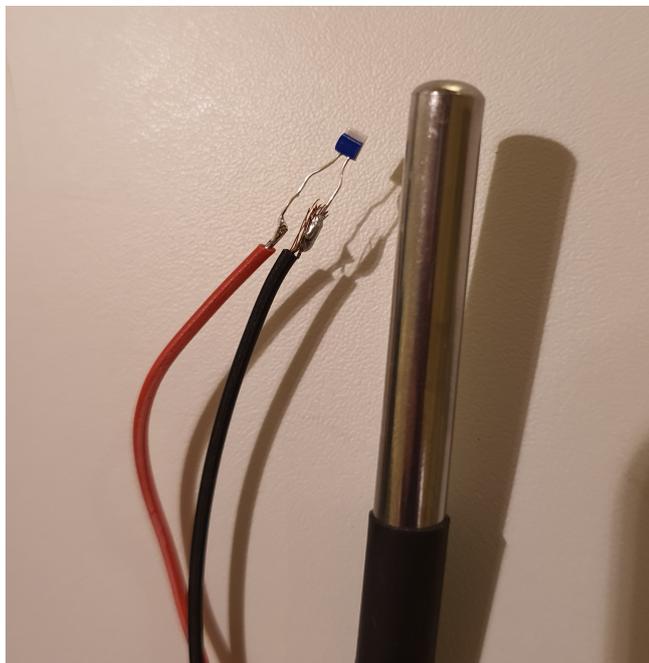


Figure 7.3.: Size comparison between the DS18B2B Temperature sensor and the new TE pt100 thermistor

The full cardboard design can be seen in the image below:

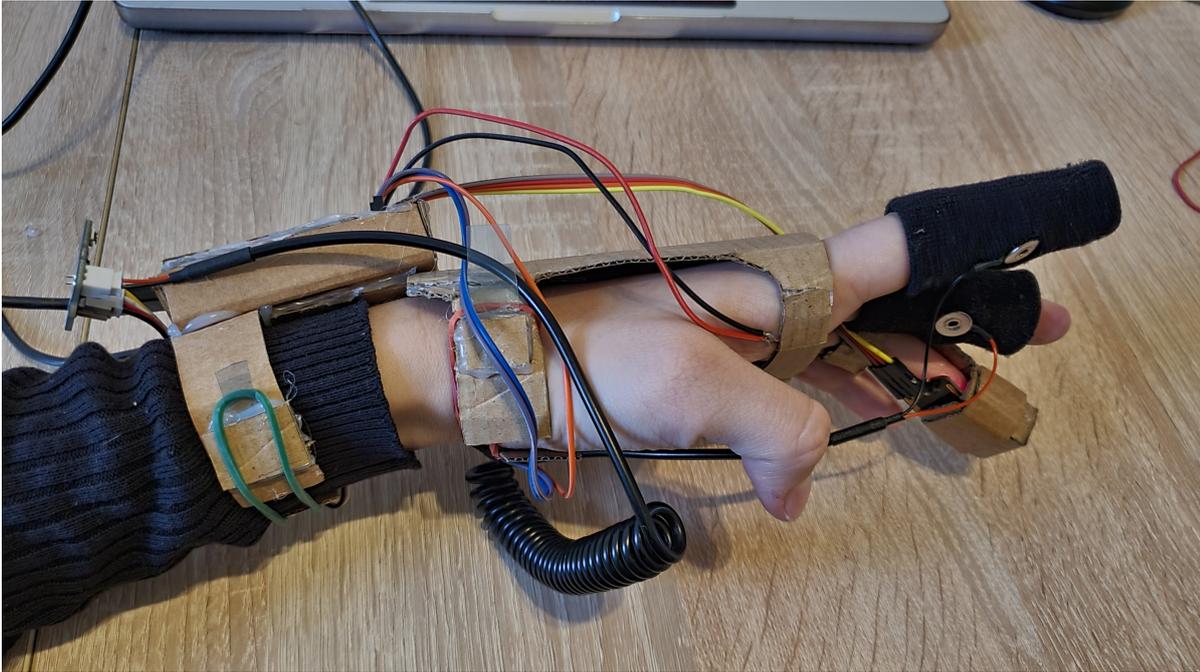


Figure 7.4.: full view of the cardboard Prototype 1, with ESP32 in its housing and sensors, fitted accordingly

Prototype 1 Feedback

Feedback and critique are vital after each stage of prototyping, as they provide a clear evaluation of the quality of execution. This stage was more complicated to evaluate, as it involved users wearing the product. Since cardboard is a stiff material, it required me to build the prototype in the exact measurements of my hand. This significantly decreased my pool of participants. From the initial 20 I gathered, only 4 could put the glove on, with only one having some experience in music production. I could not ask these participants too specific questions about music production. To combat this issue, my workaround was to create two different questionnaires- one for live testers and one for users just watching video documentation of the prototype.

According to the first feedback group, the cardboard execution was fairly successful. This data is somewhat biased due to the small pool of participants. The answers are listed in the table below for an easier overview:

Question	Results
What is your age?	75% 25-29, 25% 18-24
How interesting did you find the whole idea?	25% - 8, 50% - 9, 25% - 10
How strong is the wow factor?	50% - 8, 25% - 9 & 10
How effective is the prototype execution overall?	50% 8 & 9
How easy to use is it?	50% 9 & 10

Question	Results
How responsive is it?	100% - 10
How intuitive is the user interface of the software?	25% for 7, 8, 9 & 10
How effective is the translation of emotion controls into music?	50% 8 & 9
Does the prototype feel bulky?	100% no
Does the placement of the microcontroller make sense?	75% yes, 25% no
Does the placement of the sensors make sense?	75% yes, 25% no
Is the prototype bendable enough?	75% yes, 25% no
Do you see how this product could be useful for creativity?	75% yes, 25% not sure
Could you see yourself using it once the final product has been developed (bracelet with sensors)?	50% yes, 25% not sure & no
What would you add or subtract from the prototype, if anything?	More sensors, smaller heartbeat sensor, less straps
Do you see many tech-loving musicians purchasing this product in the future?	50% yes & not sure

Out of the original group of testers who could not wear the prototype, I got 7 responses with feedback based on them watching a video of me wearing and using the prototype. I have received some fascinating responses giving suggestions on how to expand the utility of my product. One of the answers is as follows:

“What I would have in my mind is something that uses augmented reality glasses or a cell phone and some sort of a VR helmet. These sensors would likely be on a band that goes over the forearm or bicep... If I wanted to go with optimal connectivity I would use a sticky sensor or a set of sticky sensors on the side or back of the neck every time the helmet is connected.

I would then utilise an AI software that was in recent development to use your measurements in order to create scenery during running whether I'm inside on a treadmill or outside, I can combine the terrain with the scenery that I would like to view outside or just completely use the VR while on the treadmill...

I would have different beats per minute and different temperatures set to different sceneries as things progress images might not be as clear to Make the experiences real as possible... Perhaps one of the sensors chooses which type of background setting I will be in, or perhaps it's programmable by itself.” (Tester 1, 2022)

Another suggestion is quoted below:

“I think its success will depend on the reliability and warranty/shelf life, and price. Overall, something that's worth having tho and may help musicians with disabilities.” (Tester 2, 2022)

The following table is extracted from the second feedback group consisting of 7 online participants who reviewed a prototype explanation video before.

Question	Results
What is your age?	57% 18-24, 14.3% 25-29 & 35-39 & 40+
How interesting did you find the whole idea?	57% 10, 28.7% 8, 14.3% 9
How well did you understand what is going on from the video?	43% 10, 28.6% 9, 14.3% 8 & 7
How strong is the wow factor?	43% 9, 28.6% 10, 14.3% 8 & 7
How effective is the prototype execution overall?	43% 8, 28.6% 10, 14.3% 9 & 7
How intuitive is the user interface of the software?	43% 10, 14.3% 9 & 8 & 7 & 5
Does the prototype feel bulky?	100% no
Does the placement of the microcontroller make sense?	100% yes
Does the placement of the sensors make sense?	100% yes
Do you see how this product could be useful for creativity?	85.7% yes, 14.3% not sure
Could this product help you generate new ideas when you're stuck (e.g. melodies- generating arp sequences and harmonies from your body)?	85.7% yes, 14.3% not sure
Could you see yourself using it once the final product has been developed (bracelet with sensors)?	85.7% yes, 14.3% not sure
Do you see many tech-loving musicians purchasing this product in the future?	85.7% yes, 14.3% not sure

Overall, ratings were high on this prototype, with only one outlier giving an answer of 5 in the question about the software's user interface. Most users found the placement of each component entirely appropriate, which they have also listed in the comment box, in addition to answering the required questions. The ratings were definitely better with the tester group, as having and wearing the physical prototype definitely made the concept clearer to them. The most obvious thing I foresaw is that one tester suggested fewer straps. This solidifies my choice to use a glove for the final product, as it will involve only one strap (for the PCB board housing). Since the device only has three sensor controls right now, I expected people to ask for more sensors. As mentioned in section 6.2.1, additional controls will be created from different GSR patterns in the future. An important portion of feedback is that testers found the emotion-to-music connection to be substantial enough to give it a high rating. I explained how the sensors are not reading our emotions directly but rather our body's response to them, and most have agreed

that this is a good solution, having in mind my limited prototyping experience and the availability of technology needed for this project. After these results, I can compare the current state and outcomes to the initial aims and objectives presented in 2.4. - Methodology.

Question/Result	Aims	Identify	Assess
How can I make my product portable and reasonably light?	Define a product design standard for portable/wearable music tools	component size, flexibility, comfort	Test product on myself, testers, passive observers
How was the question answered with the prototype?	Created highly responsive sensors/code and intuitive software IU. Adapted prototype with better sensors.	Determined how flexible the product needs to be and how much to adjust this factor before the final prototype. Currently not a lot of flexibility. Not adaptable to different hand sizes (cardboard shell needs to be an exact fit	Succeeded in creating melodies. Users wore and analyzed the prototype. Online participants watched demo video.
How could this product inspire other musicians to expand their interests into the technical side of music?	Define a simple and fun way which demistifies technology/programming and makes it less intimidating for non-technical musicians.	People are more likely to try and learn a new skill if it is presented in a novel and fun way. It wakes up the competitive and inquisitive spirit naturally present in people	Play testing, demos, final performance
How was the question answered with the prototype?	A guide on how to get started was given throughout the thesis, especially in the future research part	The simplified presentation of the prototype (plug-and-play), enabled users to focus on enjoying the results instead of trying to figure out how to set everything up. Participants were more likely to exhibit interest in the product in this scenario.	Participants were given a short introduction and encouraged to independently use the prototype. At this stage, my final performance has not yet been made

Question/Result	Aims	Identify	Assess
How can I bring value to the market with this product	Assure that the thesis product can help alleviate a target user's painpoint	Every creative struggles with creative block from time to time. Musicians and producers are always looking for cool new ways to interact with their music and speed up their workflow or make it more intuitive and more efficient	Alpha testers, Self-testing, questionnaires, interviews with testers
How was the question answered with the prototype?	Testers rated the product highly on being helpful for creativity	Testers confirmed product could help with creative block and that they could make music faster with it	All assessments except interviews have been conducted. Interviews were replaced by the feedback form

7.3. Prototype 2

In the previous section, I built a cardboard version of the prototype to establish the sizing, proportions and placement of individual components. Based on feedback from testers, I established that I could proceed with building the final prototype with a few improvements in mind. The next version has to be appropriate for more hand sizes. This will allow me to test it with more people and come one step closer to what I envision Sensim Artis could be in its future forms, developed beyond the scope of this thesis. I used a stretchy textile glove for Prototype 2, making it more durable than a cardboard prototype.

The Glove

For the glove, I decided to use a larger safety glove that will further stretch out if worn by users with big hands. I cut off all the fingers, as they were not needed. An open-finger design makes using other controllers or instruments easier while wearing the glove.

The Casing

I ordered a plastic case that had to be cut down to size so that it does not feel too bulky on the hand. Part of the lid was cut off to accommodate the cabling on the microcontroller.

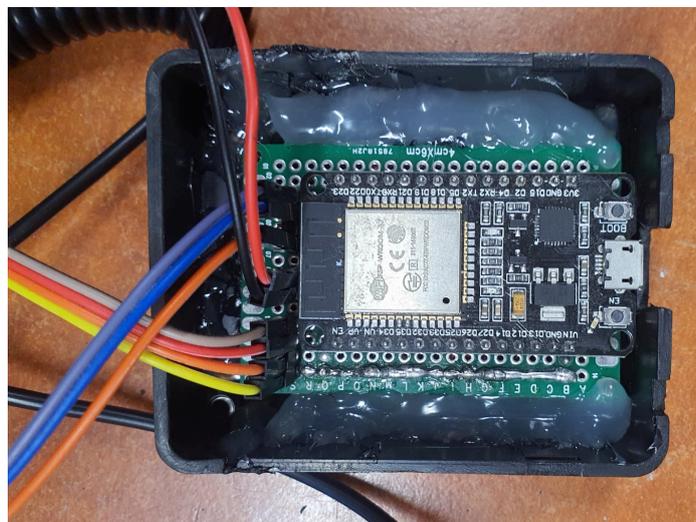


Figure 8.1.: Plastic casing cut to size, with a cutout for the micro USB port. ESP32 and the PCB were hot glued down to the case.

The Heart-Rate Finger Design

To ensure proper placement and pressure on the heart rate sensor, I sewed it onto the top of one of the fingers that were cut off. I tested the finger piece on multiple hand sizes.

Those with larger fingers needed to place it on lightly, and those with smaller ones pushed the finger in. The trick worked in both cases, and the heart rate reading was successful due to the finger piece's flexibility.

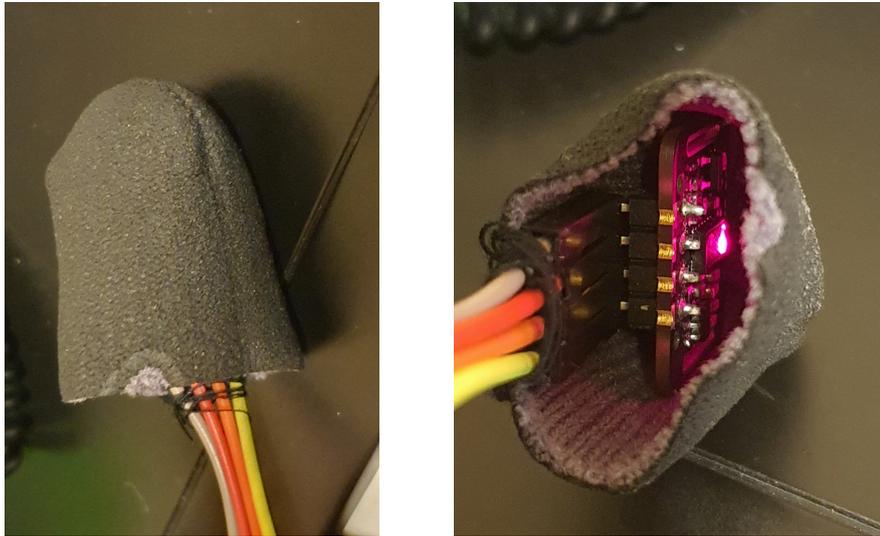


Figure 8.2. and 8.3 and Figure: Custom-made finger enclosure to house the heart-rate sensor. The sensor's wires were sewn down to ensure a secure fit.

Aesthetic Improvements

To make the final prototype more polished-looking, I had to find ways to hide the box and extra cabling tastefully. I sewed on a piece of a compression glove onto the end of the Sensim Artis glove. I cut two slits- one for the cables and one for the USB port. The sock piece was slid over the plastic casing, hiding and tucking away everything nicely. The GSR sensor was partially wrapped around the wrist (black curly cable), and the rest of the colourful wiring and the GSR sensor board were hidden in the pocket of the sock on the bottom side of the prototype. A piece of flexible black fabric was sewn on top of the main glove to hide the previous branding and make the glove more coherent with the colour of the black sock. A vinyl sticker will be hot-pressed onto the top of the glove to give the glove its recognisable branding in line with the start-up side of my project.

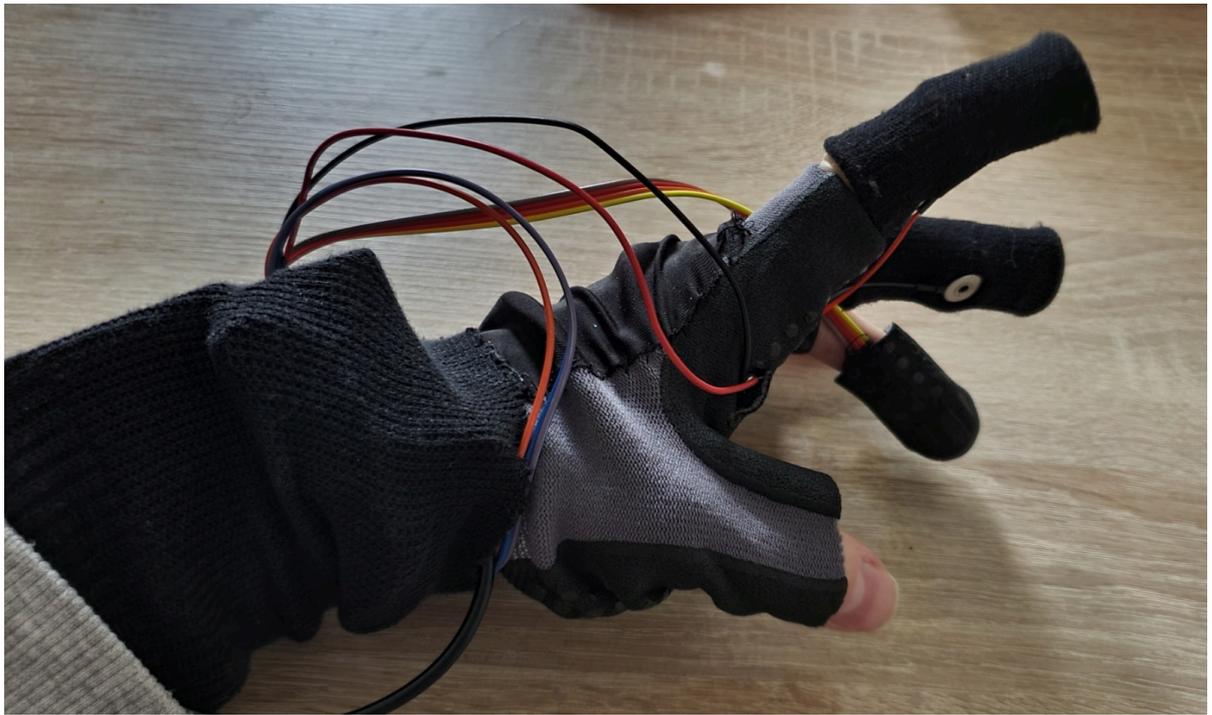


Figure 8.4.: Finished Sensim Artis Glove, side-view.



Figure 8.5.: Finished Sensim Artis Glove, side-view.

Prototype 2 Feedback

The same feedback principle was taken for this phase as for prototype 1. This time, a much wider range of hand sizes fit into the glove- from big male hands to small female hands. The first test portion had five live participants. The second portion was performed by 15 online participants, with a final prototype video explanation, as well as the cardboard prototype video for reference. This allowed me to ask users to rate the improvements made between the two prototyping stages. The live tester group gave higher ratings on average, especially on the wow factor question. Live testing versus video testing showed to have an impact on the rating in all stages of testing. It was unfortunate to see that a large percentage of testers stated they would pay up to 200 EUR for the product, as I have calculated that the final version would have to cost 500-50 EUR to sustain continued production. Some outliers gave a rating of 4 or 5/10 on questions regarding emotion-to-music translation and how intuitive the user interface is. This tells me I need to make the interface even more straightforward in the future and the emotion pick-up by sensors needs to be better. Many participants are not musicians, hence not in the music industry. This may have resulted in them not seeing a value high enough to pay the actual price. Nonetheless, I again got some fascinating suggestions and viewpoints that are quite promising. There were mentions of wireless controls, different glove sizing options (S, M, L) and getting polished. Some notable answers are listed below:

“I would use it for music conduction with a lot of musicians. I would use it for my meditations to experience myself and my feelings. I would use it to vibe with myself. And with my closed eyes. I see it as a soundtrack of my personal life, through which I can experience myself, adjust my feelings and my responses, to program myself to a better path that I follow.” (Anonymous tester 20, 2022)

“I would add more sensors, including the mechanics of movement, Bluetooth technology and share technology, so I can share my music, my feelings and emotions. Listen to them on my own and record.” (Anonymous tester 21, 2022)

Some testers left additional comments as follows:

“Keep up the good work! I would love to be a tester in the future. And I can consult you on the marketing of your product when you feel like it's ready. Anyways, amazing experience, thank you for this self-portrait of my feelings.”

“Wanna have the techno party -- silence party with those gloves in near future. All the love and luck to this!”

The two tables with a full response breakdown are listed below, starting with the live testers and ending with the online participants. The first table was created from live tester results.

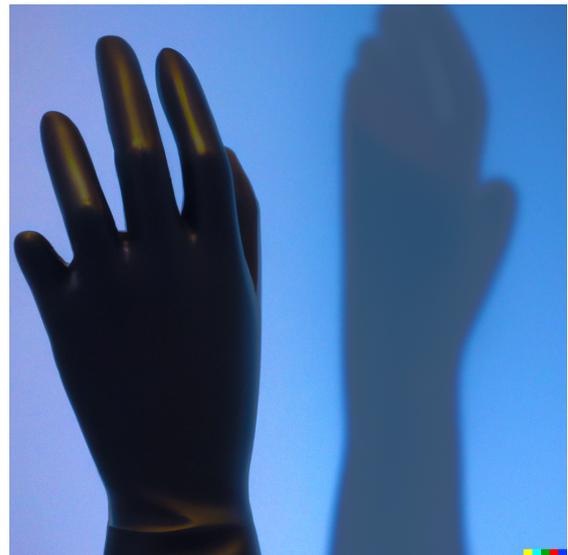
Question	Results
What is your age?	40% 25-29, 20% 18-24 & 30-34 & 35-39
What is your gender identity?	40% male & female, 20% non-binary
Are you part of a minority group in your country?	40% yes & no, 20% prefer not to say
How interesting did you find the whole idea?	40% 10 & 8, 20% 9
Is the prototype stretchy enough?	100% yes
How would you rate the quality improvement between Prototype 1 and Prototype 2?	40% 8, 20% 10 & 9 & 5
How would you rate the aesthetics of the prototype?	40% 8 & 7, 20% 9
How strong is the wow factor?	40% 10 & 9, 20% 7
How effective is the prototype execution overall?	40% 8, 20% 10 & 7 & 6
How easy to use is it?	40% 7, 20% 10 & 9 & 8
How responsive is it?	40% 9 & 8, 20% 5
How intuitive is the user interface of the software?	20% 10 & 9 & 8 & 5 & 4
How effective is the translation of emotion controls into music?	60% 9, 20% 8 & 4
Does the prototype feel bulky?	80% no, 20% yes
Does the placement of the microcontroller make sense?	100% yes
How much would you pay for such a product?	40% 50-200 & 200-400 EUR, 20% 400-600 EUR
Is the prototype comfortable to wear?	100% yes
Do you see how this product could be useful for creativity?	100% yes
How fun is it to work with Sensim Artis?	60% 9, 20% 10 & 6
Could this product help you generate new ideas when you're stuck (e.g. melodies- generating arp sequences and harmonies from your body)?	100% yes
Could you see yourself using Sensim Artis to create music on a regular basis?	100% yes
Do you see many tech-loving musicians purchasing this product in the future?	100% yes

Question	Results
What is your age?	25% 18-24 & 25-29 & 40+, 12.5% 30-34 & 35-39
What is your gender identity?	50% female, 37.5% male, 12.5% non-binary
Are you part of a minority group in your country?	75% np, 25% yes,
How interesting did you find the whole idea?	62.5% 9, 25% 8, 12.5% 10
How well did you understand what is going on from the video?	37.5% 10 & 8, 25% 9
How would you rate the quality improvement between Prototype 1 and Prototype 2?	82.5% 9, 25% 10, 12.5% 10
How would you rate the aesthetics of the prototype	37.5% 8, 25% 9, 12.5% 10 & 7 & 6
How strong is the wow factor?	37.5% 10 & 8, 25% 9
How effective is the prototype execution overall?	50% 8, 25% 10 & 7
How intuitive is the user interface of the software?	50% 9, 25% 10 & 8
How effective is the translation of emotion controls into music?	37.5% 10 & 8, 25% 9
Does the prototype feel bulky?	87.5% no, 12.5% yes
Does the placement of the microcontroller make sense?	100% yes
Does the placement of the sensors make sense?	100% yes
Is the prototype bendable enough?	100% yes
Do you see how this product could be useful for creativity?	100% yes
Could this product help you generate new ideas when you're stuck (e.g. melodies- generating arp sequences and harmonies from your body)?	87.5% yes, 12.5% no
Could you see yourself using it once the final product has been developed (bracelet with sensors)?	100% yes
Do you see many tech-loving musicians purchasing this product in the future?	87.5% yes, 12.5% no

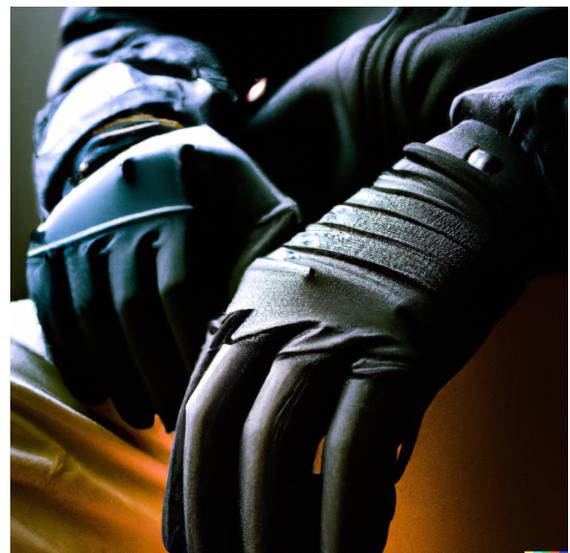
7.4. Final Product Video

After finalising feedback and reviews, I created a short commercial-style video to showcase the prototype's capabilities in a short content form. Firstly, I made a short storyline with imagery to establish precisely how the story will progress and which frames I will be using approximately. The storyboard can be seen below. All the imagery was created either through prompts using MindJourney AI and DALL - E 2 or by using screenshots from my personal project. My account on these platforms retains the copyrights for the provided imagery.

1. Sculpture of a hand on a glass table with the glove



2. Putting on the glove, torso shot macro. Low directional light



3. Slow pan to half of the laptop screen with Ableton opened



4. Sitting on a chair in the middle of a dark room with a chair, directional light



5. macro shot of music controls



6. Silhouette in front of the TV (playing videos e.g. colourful liquids or anything smooth and generative). TV dims, leaving an underexposed silhouette and dark background



The final product video with a live performance recording and additional filler shots for dynamics demonstrates how a song can be created live with this device and follows the previously given storyboard. The link, along with all other testing stages and live sound tests can be found in *Appendix 3*.

In the previous chapter, I created a final product through three prototyping stages, each being tested with a group of participants to evaluate success at each stage. The final outcome of the feedback is that the prototype is good for the current stage at which the product is but that there are many possibilities to enhance it in the future. This also includes a lot of different opportunities for expanding the business model. Currently, the product is intended for the music production hardware market, but the possibilities in the future include stress management, sound therapy, AI, gaming, and many more. The next chapter explores these possible roads and describes how the prototype will be adjusted for each of these in the future.

8

Where To Go From Here?



After completing the development of the prototype for academic purposes, the following question was left- what next? The project itself is definitely far from being polished. It is normal for tech projects to take a long time to develop- it could take anywhere from a year to even 10 years, depending on the complexity of a chosen project and the availability of raw resources. And even then, products must be constantly upgraded to keep up with new trends and developments in the tech world. The best example of this are phones. iPhone releases a new flagship phone once every 1 to 2 years, while Samsung releases so many new versions within just the span of a year. Even just releasing the first model of something takes a tedious amount of iterations to get rid of all the bugs, structural shortcomings, etc. The following chapter analyses the plans, as well as other possibilities of ways in which this project could continue.

8.1. The 3 Roads of Music Tech Products

Based on the experience I gained during this research, I have established there are 3 roads every music technology developer could take after successfully creating a prototype. The project could either continue being developed as a private “passion-project”, only intended for use by the original developer and maybe a small group of people online, if the author decided to publish the step-by-step development process. The second road is to bootstrap a small home business (*bootstrapping* - starting a business with only one’s personal capital), which produces a limited quantity of products and sells it online. The third road that could be taken is to go commercial and turn the idea into a start-up, just like I decided to turn *Sensim Artis* into one. Each and every one of these roads is completely valid; one cannot go wrong by taking either of them. The only thing important is what the author desires to do with the project. In some cases, financial circumstances could lead a music technology creator to take the commercial road and gather external funding, thus achieving financial stability without having to work a “regular job”. These are just some examples that may not always be true, but they serve the purpose of demonstrating why someone would choose a specific road.

8.2. Future Plans

After deciding which road I wanted to take with my project, I would like to lay out the future plans of *Sensim Artis*, to demonstrate how a commercial music tech product could develop in the future. This section may be used as a guide for anyone else who might want to embark on a similar journey. The graphic below with different nodes demonstrates some of the possible roads of expansion for this start-up idea.

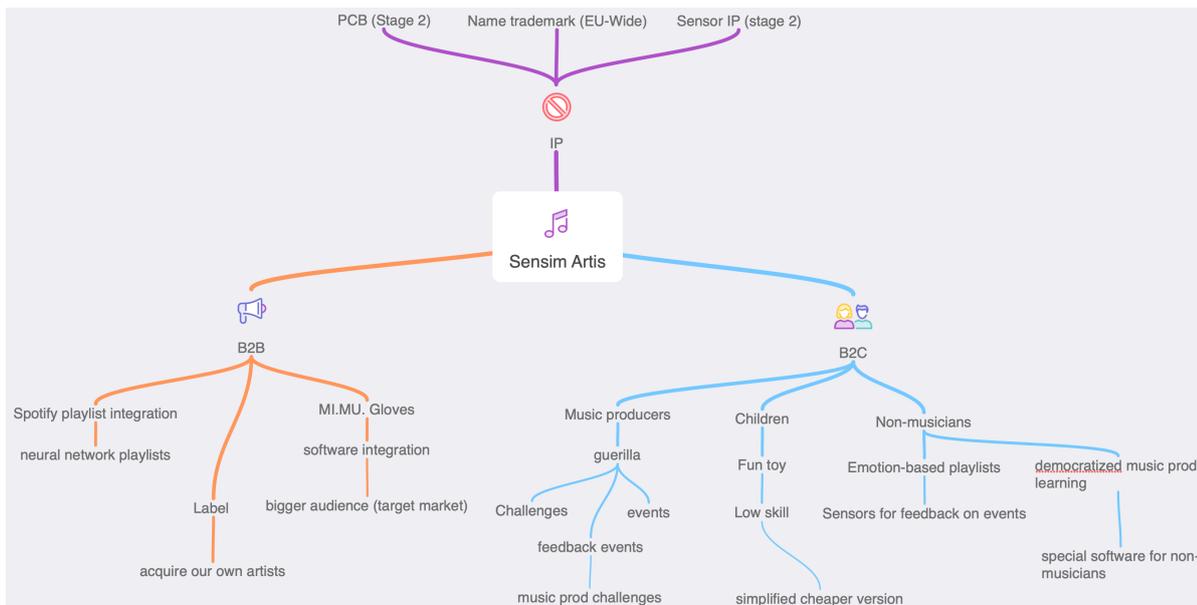


Figure 9: Mindmap of possible future roads of Sensim Artis

8.2.1. Fourth prototype and sales-ready model

The project in its current state (as of the finalisation of this thesis) has had 3 different prototypes. Neither of these are polished enough to be used for commercial purposes. Before any sales happen, Sensim Artis as a team will have to create a sturdy and polished-looking product that will appeal to the target audience and match the production quality of other sensor-based music industry products. In order to reach the sales-ready model stage, a drastic development in the start-up's production capabilities must be made. We plan to apply for pre-seed funding intended to cover the production costs of the first sales models in order to meet the demand. Funding will allow us to rent or even buy the machinery and production space needed to serialise our product. There need to be enough models produced to make sales that would cover the initial business costs and show investors that the business can become profitable in the near future. After that, another expansion needs to happen through seed funding. After that, the ideal scenario is that the business is profitable on its own. My future teammate is working on our own proprietary sensors, and PCBs optimised to pick up health signals in a way that is beyond the current state of the art.

8.2.2. Gamified Learning

The next step in the development journey of Sensim Artis is to develop ways to gamify this product's use. The experience needs to be fun and engaging, as this boosts the speed at which a user can learn new information. We want to adapt the product to be approachable to a broader audience and make music production more accessible through gamification. This could mean that the product would be adapted to work with a simplified music production interface that behaves like a video game and, for example, teaches the user about music theory basics on the go. These are just ideas, as we do not currently have a set decision on what we would like to do with gamification. This will come at a later stage of business development. A great example of a gamified learning music tech product is

MusicGlove by FlintRehab. The glove has finger sensors and can be used with games like guitar hero to train the user's hand reflexes. This is a great combination of fun and training.¹¹²

8.2.3. Multi-practical use (Health monitoring + music production)

Once the first series of Sensim Artis have been tested, sold and reviewed, the next step will be to expand the utility of our device. As the controller works on the principle of health-tracking sensors, it would make sense to add an additional layer of wellness monitoring. The future Sensim Artis team could explore the medical feasibility of the product by creating an app that follows the trends and fluctuations of stress levels and health indicators of the user, giving them advice on how to improve their well-being or warning them of prolonged periods of high stress. Sensim Artis could also be used to open new fields of understanding in medicine by expanding into well-being wearables that incorporate both fashion and utility. For example, through testing, I have discovered that the heart rate monitor could also work on the earlobe, meaning that I could create fashionable earrings that track our heart rate and oxygen saturation. I have also thought about improving the emotional feedback of text-to-speech programs that were designed for speech-impaired patients. Stephen Hawking is a famous example of a person with amyotrophic lateral sclerosis (ALS), a degenerative disease that progressively leads to full-body paralysis and, ultimately, death due to the lungs' inability to expand and contract anymore. Hawking's robotic speech computer was his signature later in his life. With Sensim Artis technology, speech computers for patients will be made much more expressive and able to convey real-time emotions of paralysed subjects through their physiological responses.

Sensim Artis will incorporate machine learning to recognise basic emotions in real-time to create an excellent emotion-tracking model. The way inputs are taken from sensors would change in this case. Instead of using direct data from each sensor, the ML algorithm will output a mix of emotions that are being picked up at a specific point in time and provide a connect option for each of them. I have spoken to my start-up team member, and according to him, each individual emotion present at a specific point in time will be rated with a percentage (e.g. anger - 18%, sadness - 34%, etc.).

8.2.4. More funding plans

Sensim Artis has requested funding in the amount of 37,000 EUR from Austrawirtschaftsservice in the framework of their AWS First Incubator. After we complete our first round, we plan to incorporate our Start-Up and proceed with pre-seed and seed funding. We will first attempt to proceed with AWS Pre-Seed/Seed - Deep Tech. If we are not accepted, we will apply for FFG FEMTech and funding from the Vienna Wirtschaftsagentur, intended for start-ups for women in different areas of the music industry. We require around 97,000 EUR of pre-seed funding for serialised pre-production, employee salaries, production facilities, components, and incorporation costs. Once we are in our second year of production, we will

¹¹² "MusicGlove Handtherapie Für PC/Mac." *Flint Rehab*, 8 Mar. 2017, <https://www.flintrehab.com/de/product/musicglove-handtherapie/>.

need additional seed funding to expand our operations. We would have to be capable of producing a larger amount of models, as well as expanding the marketing budget to reach new customers.

8.2.5. Teamwork

As Sensim Artis grows and hopefully obtains the required funding, we plan to expand our team, to delegate tasks in a more efficient manner and have specialists dedicated to specific aspects of the business. Firstly, we will need an industrial designer with 3D printing knowledge who will be responsible for re-designing the look and feel of our music controller, making the product look more polished, professional, sturdy, and stylish. Afterwards, we will need a dedicated sound engineer who is experienced in building music software with JUCE, a C++ application framework often used for creating music software and effect plug-ins. In the future, I will be focusing more on ideating new features and taking care of branding and marketing, as during this project, I realised my biggest strengths lie in obtaining funding, branding, and spreading the word about our start-up.

8.2.6. Addressing gender-related problems in the industry

This project started with a significant portion of the research done on non-cis-white-male creators in the industry, and I would like to keep gender/sexual identity/race equality as one of my central values in the project's future as well. This means that Sensim Artis, as a start-up, will aim to contribute to equality in every way I can think of in the future. The first and obvious choice would be to prioritise minorities in the community for future work positions that might open in the start-up, which will undoubtedly happen if and when the start-up starts growing and expanding. The next possibility is that our team chooses minority musicians and music influencers for promotional campaigns and collaborations. This way, their voices will hopefully be amplified. It is important to continually raise awareness through the topic by participating in conferences and presentations. I have started putting a lot more effort into presenting my passion for women and LGBT people in music technology. I am actively trying to get myself on the list of keynote speakers on conferences and platforms with a large following. Many conferences are mainly a tool for building prestige and reputation, but I believe they are the best and easiest way to spread awareness. As the first step towards raising awareness, I am scheduled as a keynote speaker for the TEDxYouth conference on February 10th, 2023. My proposal has been accepted, and a lot of research from this thesis will be used as a reference in building my keynote presentation. Additionally, I hope that Sensim Artis will have enough resources in the future to organise our own events meant to promote minorities in the industry and foster an open learning atmosphere where knowledge would be easily accessible to anyone. This could include knowledge of aspects like music production and product design.

8.2.7. Addressing Statistical Inadequacies

Throughout the thesis research, many questions have been presented, and many of them couldn't be answered in an academically satisfactory way due to the lack of specific data/statistics. For example, the British study from Helpmusicians conflated non-binary and LGBT groups together. It was impossible to make a

quantifiable distinction in mental health cases. Moreover, data related to other countries was not possible to find. The only conclusive statistical reports that were of interest were issued by the US and UK. A good step in the future developments of this project would be to inspire the production of more conclusive studies and improve my own research conclusions based on new statistical data, as it appears. In short, it would be really helpful to have more statistics and segment the research participants more clearly.

9

Research Recommendations



The previous section explores possibilities for the future developments of this project. I concluded that there are many ways this project could be improved and talked about the current limitations of the research. The following chapter serves as a guide for those who want to learn how to prototype and program music technology projects. It also provides information on implementing a start-up idea in the music industry. Resources are listed in the footnotes and inside the Resources chapter of the thesis.

9.1. Start-Ups in Music

From my experience, it is slightly harder to run a successful music tech start-up, as the global music market (\$26 billion)¹¹³ does not look as big to investors when compared to the field of personalised healthcare (\$514 billion)¹¹⁴ or even the AI market (\$50 billion).¹¹⁵ Product-based start-up ideas need a large sum of capital to cover R&D costs, as well as alpha testing, test model production and pre-sale production. This was determined during consultations in different accelerator and incubator programs I attended. Music tech start-ups get chosen for funding less often than other projects, mainly due to the market mentioned above share. However, it is still possible, and there are two ways of doing it. The first way is to apply for incubation and funding specifically for creative projects. Wirtschaftsagentur Wien offers multiple funds for creative projects, for example, the “creative_project” grant¹¹⁶. There is also funding specifically targeted at women (and other non-cis white male counterparts). For example, there is the “Female Creatives” grant.¹¹⁷ As previously mentioned in the Chapter regarding the start-up perspective, almost every Austrian funding agency offers a “female bonus” in the amount of 10- 20% of the maximum allocated funding amount. However, it is important to note that most larger funding programs only cover 60% of the R&D and production costs, meaning that the start-up has to rely on multiple grants, a bank loan or personal funds. The least risky option with the lowest capital offer is an incubator programme. The most significant one I could find in Europe tailored entirely toward music and technology is the Music Worx Incubator in Hamburg. The program offers coaching and networking, as well as up to 5,000 Euro funding for each team and 1500 Euro per month to assist with living costs in Hamburg throughout the duration of the programme. The second option is considering how a music tech product could be extended to different markets through business plan adaptation. For example, while Sensim Artis is an emotion-to-music controller,

¹¹³ Savage, Mark. “The Global Music Market Was Worth \$26bn in 2021.” *BBC News*, BBC, 22 Mar. 2022, <https://www.bbc.com/news/entertainment-arts-60837880>.

¹¹⁴ “Personalized Medicine Market Size & Growth Report.” *Personalized Medicine Market Size & Growth Report, 2030*, Grand View Research, <https://www.grandviewresearch.com/industry-analysis/personalized-medicine-market>.

¹¹⁵ Marin, Enrique Cadena. “AI-Driven Data Could Be the Music Industry's Best Marketing Instrument.” *VentureBeat*, VentureBeat, 26 Mar. 2018, <https://venturebeat.com/ai/ai-driven-data-could-be-the-music-industrys-best-marketing-instrument/>.

¹¹⁶ “Creative_project.” n.d. *Wirtschaftsagentur Wien*, Wirtschaftsagentur Wien, <https://wirtschaftsagentur.at/foerderungen/aktuelle-programme/creative-project-69/>.

¹¹⁷ “Female_creatives.” n.d. *Wirtschaftsagentur Wien*, Wirtschaftsagentur Wien, <https://wirtschaftsagentur.at/foerderungen/aktuelle-programme/female-creatives-178/>

there is also a potential to expand into stress management (mental health sector) through sensor tracking. There could even be a possibility of implementing Sensim Artis as a medical sonification device. This means that the start-up could target three different markets in the future. This way, it is much easier to get funded by traditional programs and incubators catering to generalised start-up ideas. Typically, these programs offer some R&D funding (paid out in full) to get a team started. However, reputable incubators will also help start-ups find appropriate investors for the specific business idea. The most obvious and well-known option in Austria would be the AWS First Incubator. This program offers 50.000 Euro for development, as well as coaching. My rejection from the final round of AWS and the feedback is what gave me the idea to expand the business model of Sensim Artis. The second incubator I talked about is Science Park Graz. This is the oldest and one of the most reputable programmes in Austria, with many very successful start-ups in their alumni network. Acceptance into this incubator almost guarantees the future success of a start-up. The team is incredibly good at recognising true human potential and helping each project take its shape through tailor-made coaching. SPG also offers 50.000 Euro for R&D.

9.2. Female-Led Initiatives

There are a lot of great organisations out there that are helping create a safe space for women and all other non-cis male individuals alike. The following list describes some of the most prominent organisations covering Europe/Austria. as my country of residence is Austria. Most on this list cover most of Europe, and some are global, so they are relevant for anyone from Austria as well. She is The Music is a global non-profit focusing on helping women in every sector of the music industry. They aim to provide education, support and promotion to women in the industry. They also offer mentorship programs and workshops meant to connect different female experts in the field with studios, labs and production companies for free. Applications are open to any woman in the industry directly on their website.¹¹⁸ The International Alliance for Women in music is a global initiative accepting both novice and successful women in the music industry. They highlight and help women get heard by connecting them with the previously mentioned successful women across the entire industry. This organisation also publishes opportunities, resources and grants from their program.¹¹⁹ Keychange is a Europe-centric organisation funded by Creative Europe. It is aimed at anyone considered a gender minority (female, non-binary). It allows individuals to nominate other gender-marginalized individuals or themselves to the program. Those who get accepted are given the tools, resources, connections and mentorships to propel their career in the music industry.¹²⁰ Lastly, the Omni Sound Project provides all the resources and mentorships to help with both the technical and creative aspects of the music industry. Membership applications can be made online easily, and their workshops and feedback sessions are held online.¹²¹

¹¹⁸ "She Is the Music." *She Is The Music*, <https://sheisthemusic.org/>. n.d.

¹¹⁹ "The International Alliance for Women in Music (IAWM)" *International Alliance for Women in Music*, <https://iawm.org/>.

¹²⁰ "Keychange". *Keychange*, <https://www.keychange.eu/>. n.d.

¹²¹ Machac, Lisa et al. "Home." *Omni Sound Project*, <https://www.omnisoundproject.com/>. n.d.

9.3. Resources for Programming (MAX, Arduino, C#)

During the practical implementation of this thesis, I had to acquire a lot of knowledge in coding/programming through different sources. My previous prototyping/programming experience was minimal. This section acts as a “starter pack” for anyone who wants to go down a similar path to this thesis but doesn’t know where to start. I started with sensor programming; hence the first part I will talk about is Arduino programming. I used Arduino IDE (2.0) to create code for sensors. Arduino IDE uses C/C++, and the company has provided official documentation for many important programming commands. Their resources can be found on the Arduino Docs page under IDE 2 software. Besides the software, there are various resources for different Arduino boards. When a problem requires a specific solution, one can refer to Arduino forums to look for a solution or even ask for answers in a new post. Another great and very active forum is StackOverflow, which is used by almost every developer, data scientist, admin, and so on. From my experience, there are already many posts with answers regarding unusual problems and glitches. I used a lot of the posts as guidance for my own project. Sometimes, these resources won’t be enough. In that case, one can refer to Reddit communities like *r/Arduino*, *r/Csharp*, or *r/MAX*, the latter being the programming environment I used for sound programming. MAX and MAX4Live have a lot of resources available on the official Cycling ’74 website, Ableton Live’s website, and even documentation directly inside MAX. Cycling ’74 also has a forum where I’ve gotten answers to my questions within two days and found a lot of valuable tips in other people’s posts. Sometimes video tutorials are more helpful for users who are not accustomed to the user interface of these programs. For those interested in connecting DIY Arduino projects to music production (i.e. to create controllers), the user *mo_thunderz* has great detailed tutorials on his YouTube channel. He works with Arduino, but the same code can be used with ESP32 and other boards as well, with minor changes. The user has also created alternate documentation on GitHub for non-Arduino boards, as viewers requested his help in the comments.

9.4. Resources for Electronics & Soldering

Physical prototyping with electronics requires soldering components together so they can be moved around and retain a stable connection. Breadboards are only used for testing purposes, which is a step needed before assembling the final prototype. Hence, this section gives a list of valuable resources that are easy to understand for beginners. The Arduino forum is yet again one of the most valuable resources for this scenario, as there are explanations created explicitly for electronic projects that involve ready-made components, like the ones used in this thesis. There are a few great channels on youtube explaining the basics of different soldering techniques. Video formats are always easier to follow due to the visual breakdown of techniques and the process. The first YouTube channel I recommend beginners to explore is “wermymy”. This channel contains everything from an introductory soldering crash course to more advanced tutorials.¹²² The following relevant channel is called “How Do You? DIY”. One of the videos on the channel

¹²² “Soldering Crash Course: Basic Techniques, Tips and Advice!” *YouTube*, Wermymy, 18 July 2020, <https://www.youtube.com/watch?v=6rmErwU5E-k>.

explains why flux is helpful for soldering, but there are many other videos with different tools needed for DIY electronic projects.¹²³

9.5. The Future in a Nutshell

This chapter demonstrated how many roads could be taken to transform Sensim Artis in the future. Combining both health-tracking sensors and machine learning could result in an exciting product that would extend beyond the current state of the art. As music is already recognised for its healing potential, I would like to extend the functionality of Sensim Artis to mental health/stress management. This could be done through sound healing from melodies created with our bodies or by using the future machine learning algorithm to make users more mindful of their mental state. Lastly, the chapter closed with resources for non-cis white male funding and a guide collection to help anyone wanting to create a similar product start quickly.

¹²³ "Using Flux | Soldering Basics." *YouTube*, How Do You? DIY, 4 Oct. 2020, <https://www.youtube.com/watch?v=OWNAjwhwzro>.

10 Conclusion

This thesis has been an exploration of music technology development from a non-cis white male perspective. In the beginning, I established that the achievements of non-cis white male individuals were not treated the same as cis-males. A great example of this can be taken from the infancy days of computer technology. Back when this was considered low-value work, it was given to women. But as soon as computers became an essential part of life, the same women were “kicked out”, and men stepped in. Consequently, it required digging deeper into source material to find the true scope of achievements made by women in music technology.

I then compared this data to the current situation, establishing that the situation is getting better, but sexism and gender/cultural stigma are still present. Some musicians and music tech producers explained how it had a mild to moderate impact on them or their careers and reputation. Others, like the anonymous interviewee, stated that homophobia and stigma had such a devastating effect on them that it led to death threats and this person completely removing themselves from the internet and closing their well-known music tech company. I also explored the difference between men and women in the start-up environment, both from my own experience and the experience of people like Imogen Heap. It was shocking to realise I couldn't find any female-led music technology companies that have even reached the product launch stage. Because of this, only mi.mu Gloves were given as an example. I created an action plan for my start-up to ensure Sensim Artis will highlight non-cis white males in the industry, including equal-rights employment, minority-led and centred events, and public speaking.

Lastly, I started my own prototyping process by reflecting on the experiences and expertise of all the non-cis white male individuals explored in this thesis. I built on top of previous inventions by using an array of already explored sensors but using them in combinations that were not done the same in the past. After three stages of prototyping, I am now able to give a succinct answer to the research question, repeated once more below:

“How can sensor-based immersive music production tools be designed by centering the experience of LGBT/Genderqueer & Female performers/creators?”

As already described in the abstract: “with a safer learning environment and mutual acceptance, there would be many more individuals actively participating in developing technology”. A safer environment could include having learning spaces dedicated only to women or LGBT people, to avoid potentially mixing with problematic cis-white male members of the community. We need more female/LGBT-centric workshops, where judgement on skills is not passed. These solutions can be designed to highlight the mentioned individuals in two ways. The first one is to explore the non-cis white male history in detail and use the listed advancements as a basis for development. The second way involves designing a system that supports and highlights non-cis white male creators through employment, events, collaboration, or public speaking to raise awareness.

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Appendices

Appendix 1 - Interview III-Esha (Zoom)

Name (can be anonymous): Elysha Zaide
Age (if comfortable answering): 39
Gender identity (if comfortable answering): Female
Sexual identity (if comfortable answering): Pansexual

3. *How did you end up in your career path?*

It was a little bit of an accident. My family is very musical and I was lucky enough to be encouraged in my passions. I started playing piano as a kid and I was in a choir and bands. I've always been kind of a creator, my parents encouraged me to take art classes, film and I was very much encouraged to make stuff. I've never been super-content just watching and I have to be a participant. And when I discover something good, I have to be a part of it! When I discovered raves, I quickly realized "OK, I wanna do something to contribute, and started singing and kind of just got into DJing and finding other ways that I could contribute from there. When I was in my early 20s, I started making music for fun with my friends and it started to take off. Then I thought "Hey, I could do this for a living, you know!" So, the whole thing kind of happened naturally on its own, and then, it just snowballed.

4. *Is there anyone you look up to (i.e. an idol)? Who and why?*

Absolutely- Imogen Head and Björk, because they're multidimensional, they're really strong women that are constantly pushing the boundaries of music and technical ability. So I really think they inspired me so much because of that.

5. *Have you ever felt discriminated against based on your gender/sexuality? For E.g. Have you seen a difference in treatment, behaviour, opportunities, professional demands, funding, etc?*

I mean sure! I know that women generally get paid less, their offers are smaller and you know, it hasn't really stopped. To be honest, I guess I'm 2-3 years behind, but so is everyone else, obviously, because of COVID, stuff has been on hold. But up until that time, I still had encounters of being asked who I was with, being asked if I'm lost, being asked if I need help setting up when I have 200 hundred pounds of complex equipment with me. At this point, I think that sexism has definitely stopped years ago. But many people don't even realize how much it's embedded in them. You know- guys that are not bad guys, but actually just half-ignore me, thinking I'm somebody's girlfriend. I hate to say it, but that is still the prevalent dynamic. Part of the reason it still hasn't changed is that only 2% of women *are still* in the industry. So I think it's kind of a circular thing we all need to work together to fix.

6. *Have you ever felt unsafe in your field of work (e.g. aggression, sexism, transphobia, sexualization, etc.)?*

Sure I definitely can say that I had some encounters (I would say that this is in the old days). Nowadays, there's the upside to things being mainstream where there are often lots of people around, as well as regulations. In the underground parties, I've definitely had advances, but I mean as recently as 2018, I was on stage and I was sexually assaulted by an artist hospitality manager who was on drugs and nobody stopped him because everybody had a sense of submission to his (as the authority). And for some reason, it was guessed that he was my boyfriend. I told them later "If any boyfriend of mine did that to me, they wouldn't be my boyfriend

anymore!" The person in question was later like: "Oh, sorry, I got dosed." I mean my thinking is that lots of people have done drugs lots of times across all time and space and you know, they didn't do those things!

In the intermission before the following questions I stated that we aren't seeing any women assault other women when they're "dosed", which Ill-Esha said was true, but however, that in the rare cases it happens, women use the excuse that they "also have boobs" and "it's totally fine".

7. *Do you think that there are enough female/non-binary/LGBT people in the field of music and technology? Do some changes need to be made?*

Yeah! I mean we definitely do have a lot more DJs now. The world has opened up greatly. But in the field of production, there still is a huge gap, and unfortunately, even though there are a lot of these women producers being put forth in EDM in America (because you know, that's still my main point of reference, as I haven't been long enough in Europe). I think in Europe though, there are some positive differences, including- it is more underground and more people I've met in the industry have "day jobs". Because of that, but there's also like a wider age group- you know, people in their 40s and even 50s who are sort of experimental artists. And in America, it's very much like "18-year-olds, EDM". So in America, there are a lot of women being put forward who are, unfortunately (I know for a fact) being ghost-produced and manufactured and groomed. Again, we should not judge women by the way they look. Because if a woman looks commercial and hot, it should not be expected that she is not making her own music. Unfortunately, the entities and the labels are perpetuating this exact type of woman and doing this exact type of thing to her. And it sucks, but as a woman, I definitely would like to collaborate more with women and non-binary people. I have met maybe 2 women in my entire life who are truly as technically nerdy as I am. And if I'm being honest, part of that drive to be technical was the feeling of inadequacy I was presented with, as that I should feel. That I wasn't capable, that I didn't know much so because of that, I studied twice as hard. I learned 4 times as much. I read the manual, unlike even many of the men! I think that a lot of women feel held back by this, they don't feel like they can learn from anybody. So, you have this really unfortunate cycle that shouldn't be this way, but it is.

8. *Do you have any ideas on how to tackle the issues in the industry present for the groups mentioned above (if anything)?*

I think that education and modelling are huge things and more programs that perpetuate the new cycle of having more women to look up to. She Knows Tech is a very good example- it's an organization I've been working with a lot. It's revolving around summits and conferences and lots of programs. And they hire women to release these programs. I recently lead one with Kilohearts as a partner where I spent a few weeks teaching women sound design and also a little bit about how to make tutorials. In the end, they all have to make a tutorial themselves. So they didn't only have to learn the material, but they also needed to explain it, which I think is a great way to learn. In the end, Kilohearts was so happy that they actually contracted several of these women- pay them to make a series with them. It was something that had such a dramatic result for something that was just a small program. I think those are the things we need because those are the seeds that we can sow into the world. Now, some girl goes and looks it up and says "Oh, hey! There's a tutorial that happens to be run by a woman. This is making me wanna learn this synth a little bit more." This makes it less intimidating.

9. *How much has inclusivity in the field changed for the better or worse since you started your career?*

I have skipped this question, as some of Elysha's previous answers already addressed it. To restate, she already said that it was much worse before and mentions how electronic music becoming mainstream has brought so much more acceptance. She also mentioned that she feels a positive difference in Europe as opposed to America in the underground music scene.

10. *What is one piece of advice you would give to young girls/non-binary/LGBT people who are trying to break into the industry right now?*

The music industry is saturated, period. Whatever gender you are. There are 60,000 tracks being released every day on Spotify. Everybody knows we're in this weird era where social media and the story are more important than the music. In the last week alone, there have been a lot of these artists coming out on TikTok, saying their labels are forcing them to make TikToks. I personally hate it and suffer a lot from it, because I wanna be making art. But at the same time, the way that you can look at it is that- ok, your story and your unique journey are important. And sadly, I think that being a super-techy, knowledgeable girl is a rare thing, but also that's why it's a unique story. I would like to see more of those stories. It has been tough for me, but it has also given me a lot of rewards in my career, where I get asked to do a lot of tutorials, panels, and workshops because there aren't that many women. So I would say, if you're looking to break in, it wouldn't hurt to be the best at what you do, anyways. So, even if you don't plan on making tutorials or teaching, having that knowledge gives you more stories you can make out of it, and puts you in a position of better confidence to express yourself more. Just in general, there isn't really a downside to knowing your shit!

11. *Who do you think would also be of importance to interview regarding this subject?*

Honestly, definitely with the She Knows Tech groups. Also women from the female-led initiatives, especially technical women.

Appendix 2 - Interview Anonymous

Name: Anonymous (Email correspondence)

How did you end up in your career path?

- 1993-1997 Demoscene
- 1997-2001 Music
- 2003-2007 Music software development
- 2003-2010 Signal processing and machine learning research (academia + > R&D in the tech industry)

Is there anyone you look up to (i.e. an idol)? Who and why?

At various stages of my life: Eric Wenger, Pascal Lévy, Dan Ellis, Bret Victor.

Have you ever felt discriminated against based on your gender/sexuality? For E.g. Have you seen a difference in treatment, behaviour, opportunities, professional demands, funding, etc?

Yes. This includes:

- Not being taken seriously by suppliers / technical partners
- In customer support, people assuming I am incompetent or not qualified to solve technical problems and requesting to talk to "the guy in charge"

Have you ever felt unsafe in your field of work (e.g. aggression, sexism, transphobia, sexualization, etc.)?

I feel extremely unsafe and targeted, especially on social media (twitter, instagram, music forums, comments on youtube videos)

Various issues:

- Transphobia
- Extremely negative and hateful remarks about my appearance, voice, etc (to the extent that since 2018 I have made sure that my face and voice would remain hidden from the entire synth community – no video, no interview, no participation to any event, disappearance from social media accounts, disappearance from forums, culminating to the shutting down of my business)
- Several cases of sustained online harassment, extending to targeting friends
- It should also be noted that a significant number of negative experiences online come from people who would identify as "allies" or LGBT+ people. This includes fetishization, sexual advances, or disturbing discussions about my identity (unnecessary "outing" in contexts where it is not relevant at all)

Do you think that there are enough female/non-binary/LGBT people in the field of music and technology? Do some changes need to be made?

I think barriers to entry – and anything that make people feel unsafe should be removed, but I don't believe that a certain "quota" or "ratio" should be established

Do you have any ideas on how to tackle the issues in the industry present for the groups mentioned above (if any)?

1. A standardized code of conduct and set of moderation guidelines that online spaces (forums, blogs in their comment section) would adhere to. With rules such as no outing, no deadnaming, clear criteria as to what qualifies as hate speech, strict enforcement of those rules, and right to privacy (eg: easy deletion of content)
2. A video sharing platform that doesn't have the limitations of > youtube in terms of moderation / code of conduct.
3. Festivals/meetups with safe spaces and/or non-mixity

How much has inclusivity in the field changed for the better or worse since you started your career?

For the worse, since these issues are now heavily politicized, and since social media now offers a much larger "attack surface" than one or two forums/ mailing lists in the 2000s. I also find that many people display a hateful attitude just for the sake of showing allegiance to their party's dominant line of thought.

What is one piece of advice you would give to young girls/non-binary/LGBT people who are trying to break into the industry right now?

HIDE.

Appendix 3 – Product Photo/Video Documentation

Prototype 0 testing with sound: youtu.be/3YK1m71QXRM

Prototype 1 explanation for online questionnaire: youtu.be/1x_yoYt6zC4

Prototype 2 explanation for online questionnaire: youtu.be/U6wXJAKizpY

Tester wearing prototype 1:



Video and sound output generated during testing: youtube.com/shorts/wneqEy51v3M

Final product video: youtu.be/IYv3xABJVEE

Social media video summarizing start-up road: <http://tiktok.com/@enoltralive/video/7184401704220183814>

Social media video summarizing experience at AWS Camp (start-ups): <http://tiktok.com/@enoltralive/video/7185533615567113477>

