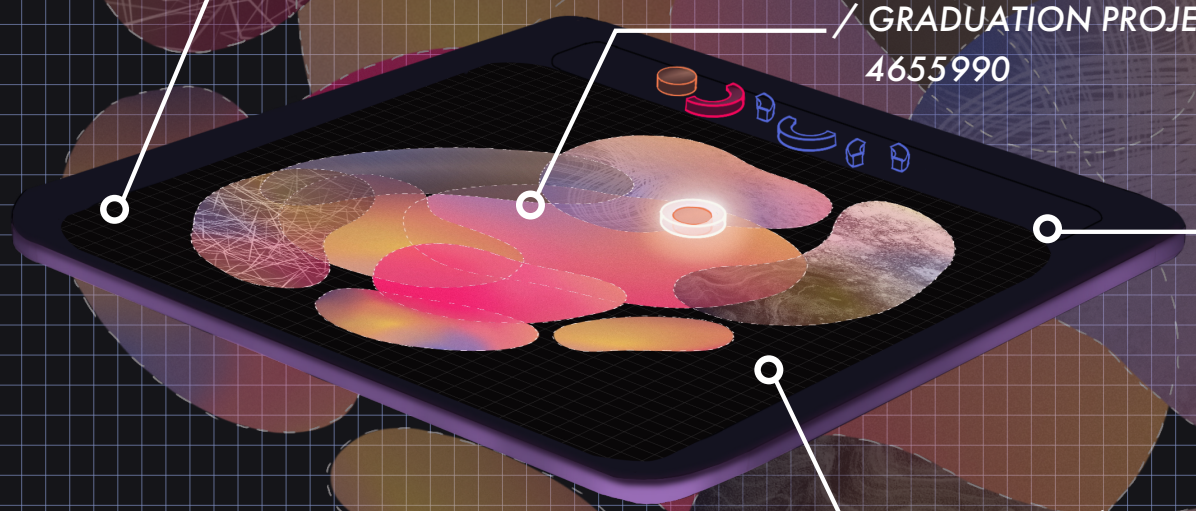
/ PROTOTYPING TANGIBLE TOOLS FOR SONIC SKETCHING IN THE UX DESIGN /



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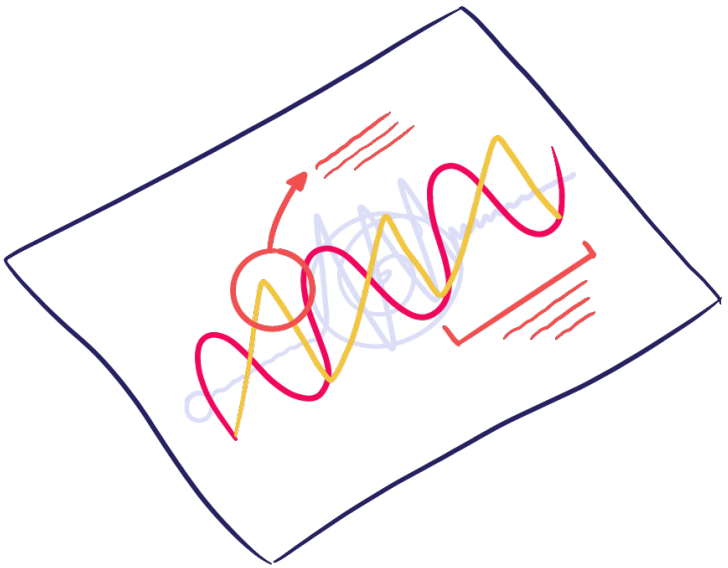

MASTER THESIS

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May 2023
MSc. Design for Interaction
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Summary

Sound in UX design can be used in a variety of ways; to navigate the interaction, for branding, to set the ambience etc. The importance of sound for the user experience of a product is undeniable; however, this is not represented in the practices of UX designers.

UX designers lack the tools and knowledge needed to integrate sound design into their prototyping activities. As a result, the sound is often considered last-moment, limiting the creative potential and added value of sound in the interaction. This report explores the possibilities of integrating sound design activities into the practices of UX designers. This is done through design research activities such as interviews, co-creation sessions, creating (interactive) prototypes and user testing. The aim of the project is to provide UX designers with prototyping tools for sound design.

Common sound design tools are difficult to integrate in prototyping activities as UX designers often lack the skills and knowledge needed to operate these tools in a quick-paced and iterative way; which is needed in order to facilitate prototyping. Furthermore ways of bridging the semantic gap between the stakeholders is explored as well as the potential of tangible interfaces in making sound design more intuitive and engaging for UX designers.

Finally, a concept is introduced: The Timbreworld, parts of which are embodied in an interactive prototype. The Timbreworld is a (tangible) interface for sonic sketching, it enables its users to create quick and iterative sound prototypes. The interactive prototype has been tested with participants and evaluated based on the design guidelines provided in the report

“Once you free your mind about the concept of harmony and of music being correct, you can do whatever you want.”

-Giorgio Moroder

Preface

Dear reader,

The report in front of you is the result my love for (digital) musical instruments and my complete inability to play any of them.

For the past half year, I explored many of my hobbies and interests and had the privilege to position it all as a graduation project. I wanted to create something that would make sound more accessible to people. Of course, back then I used to think that sound and music were the same but through my project, I have realised the depth, potential and value of sound design (and its separate existence from music).

Before diving into the background topics, literary reviews, design research activities, and numerous quotes from user tests, I want to take a moment to express my appreciation and gratitude to the people who have supported me throughout this project.

First and foremost, I would like to thank my supervisors: Gijs Huisman, Stefano Delle Monache and Dave Murray-Rust. Throughout this project, I had the chance to learn a lot from you and broaden my understanding of sound, design and research. I am eager to continue exploring these topics and apply all the skills you have taught me. I would also like to thank you for helping me apply for my first-ever conference, which I am very much looking forward to. And lastly thank you for taking your time and helping me out with prototyping, and understanding the complexities of sound and tangible interfaces.

Furthermore, I would like to thank my graduation support group 'Koffieleutjes': Dana, Noortje, Clint, Maaike, Sanne, Sylvia and Nina. For their mental support, wisdom and friendship. I have enjoyed our time together immensely over the past six months and I will miss it every day (at least from 12:30 till 13:30).

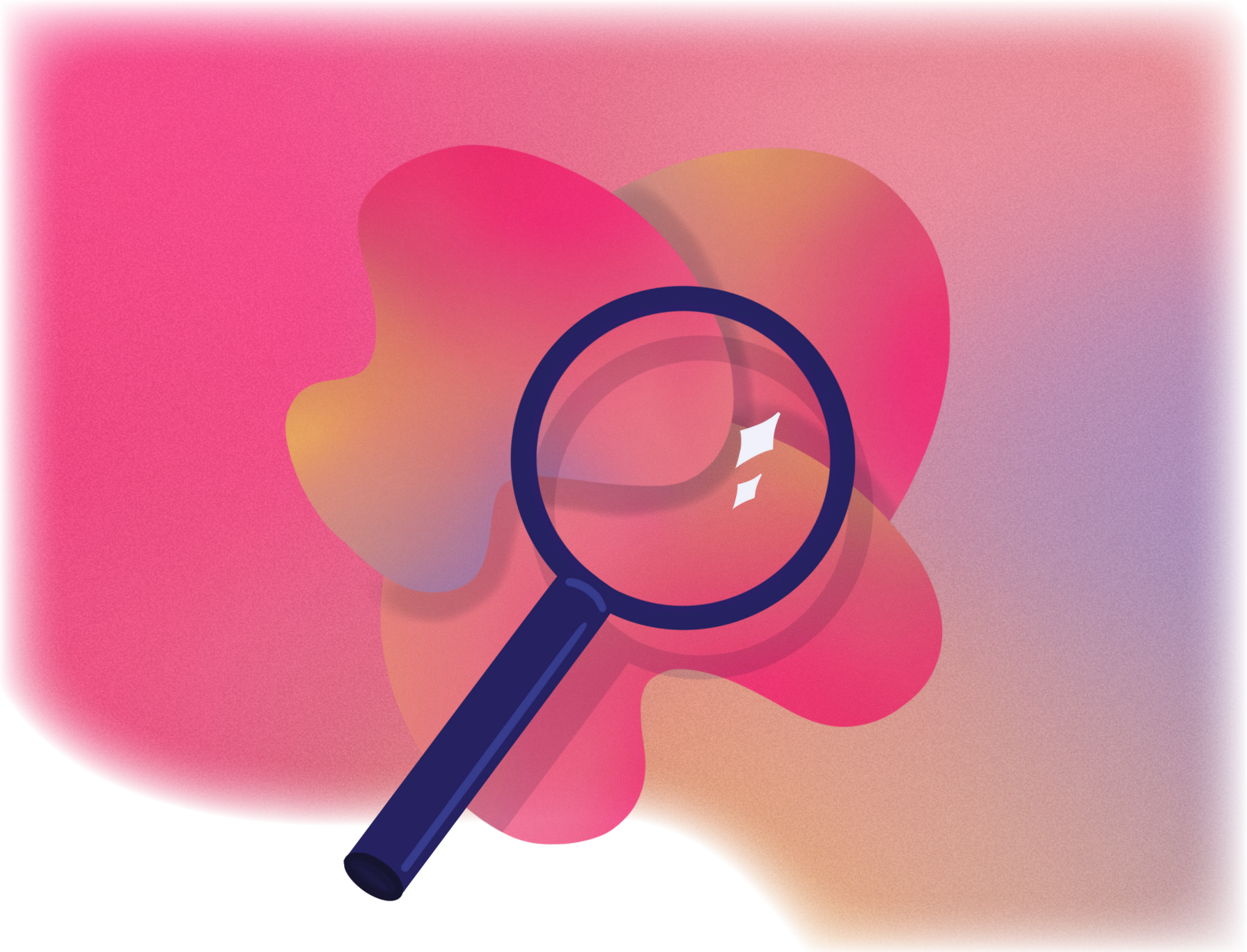
I would also like to acknowledge Aadjan van der Helm and Ianus Keller from StudioLab for granting me a space in the studio Dream, which has been immensely helpful.

Lastly, I would like to thank Nivard Koenis, for too many things to list here.

Thank you all for your time, assistance, and contributions to this project.

Sincerely,

Diana



Glossary

Auditory icons / Earcones: Distinctive sounds or audio signals that convey specific meanings or information.

Co-creation session: Collaborative sessions involving participants and designers to generate ideas and solutions.

Context mapping: Understanding and mapping the context and needs of the users or target group.

Cross-modal mapping: The association or mapping between different sensory modalities, such as sound and visuals.

DAW: Abbreviation for Digital Audio Workstation, software used for creating, editing, and producing audio.

Design research: A systematic approach to investigate and understand design-related problems and develop solutions. element in the design process.

Embodied experience: The holistic experience that encompasses sensory, physical, and contextual aspects.

Feedback: Information or signals provided by a system or product in response to user actions or events.

Foley box: A device used in sound production that contains various objects to create sound effects for films or other media.

Interaction design: Designing the ways in which users interact with a product or system.

Interaction qualities: Descriptive attributes or characteristics that define the way a user interacts with a product or system.

Interface: The point of interaction between a user and a system

Intuitive (adj) - Easy to understand or use without explicit instructions.

Lofi: Short for "low fidelity," referring to a prototype or representation that is simplified or not highly detailed.

MIDI: Abbreviation for Musical Instrument Digital Interface, a protocol used for communicating musical information between devices.

Onomatopoeias: Words that imitate or suggest the source of the sound they describe.

Prototyping: The process of creating a preliminary version or mock-up of a product or system to test and evaluate its design and functionality.

Sample library: A collection of pre-recorded audio samples that can be used for sound design and music production.

Semantic analysis: An analysis that focuses on the meaning and interpretation of language or communication.

Semantic gap: A disconnect or difference in understanding and communication between individuals with different levels of expertise or using different terminology.

Sensitizing: Making someone aware or knowledgeable about a particular topic.
Sonic sketching: A method of prototyping sounds using low-fidelity tools such as voice, body, or objects found in the environment.

Sound synthesis: The electronic or digital generation of sounds using various techniques and algorithms.

Sound-driven design: Design approaches that prioritize the use of sound as a central

Stakeholders: Individuals or groups who have an interest or involvement in a project or activity, such as UX designers, sound designers, clients, users, and engineers in the context of sound-design activities.

Synthesizers: Electronic musical instruments that generate sound signals.
Tangible interactions (n) - Interactions with a tangible interface using physical objects.

Thematic Analysis: A method of analyzing qualitative data to identify common themes or patterns.

Timbre-like qualities: Characteristics or attributes related to the tone or quality of a sound.

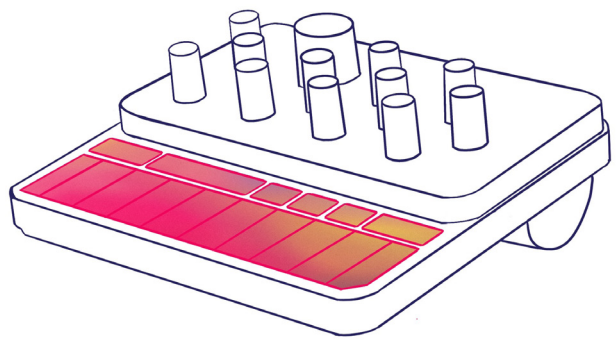
User Experience (UX) Design: The discipline of designing products or systems that provide meaningful and satisfying experiences to users.

User Experience (UX): The overall experience and perception a user has while interacting with a product or system.

User tests: Evaluation and testing of design concepts or prototypes with end users to gather feedback and insights.
Vocal scribbling: A sound prototyping technique where designers vocalize or make vocal sounds to convey and explore sound design concepts.

This glossary has been made using ChatGPT. The output was reviewed by the writer to ensure reliability of the content.

Table of contents



A. Introduction

Sound & Product Design

Introduction

You can not see it, you can not touch it and yet it's always there: sound. The role that sound plays in our lives is immense. From the way we communicate to the way we experience the world around us; we are surrounded by sound. Nowadays most (electronic) products emit some sort of sound, exposing us to various soundscapes throughout the day.

This section explores the application of sound in product design; its purpose and importance for the user experience of a product. Furthermore, the field of User Experience Design is briefly introduced to illustrate the area of design responsible for the user experience. Lastly, a short overview is given of the integration of sound design in the UX design and the challenges that can arise during that process.

A.1 Sound in Design

A.1.1 Importance of sound in product design

Even though sound is invisible to the human eye, its value in product design should not be overlooked. Good sound design can elevate a product or experience, making it more pleasant to use. On the other hand, when ignored or badly designed, sound (or lack thereof) can have an adverse effect, resulting in irritations, frustrations and confusion [2], [7], [20].

Why is sound so important? First it is one of our main senses, we rely on sound to experience our environments next to the visual and kinetic stimuli. It also has a big emotional and cultural value to us: when thinking about sound we may often think of linguistics or its musical applications.

In product design, sound can be used to embody a countless variety of information. Think of your daily activities: the alarm that wakes you up, the microwave that zooms while rotating and beeps when it's done heating your breakfast, and the elevator that whooshes and happily chimes when it reaches your floor. Sound is the type of feedback that can be experienced without seeing or touching the product, which makes it useful in interaction design, an example is the notifications of our phones [Image 3, p. 3].

A.1.2 Sound for communication

Sound is also used as a tool in branding. Companies invest vast amounts into sound logos, which are specific sounds that are associated with the product. An example is the tweet sound of twitter, the intro theme of Netflix or even the "I'm lovin it" jingle of McDonalds [Images 1-3].

The message that a sound conveys differs per product. However, the function of a sound is usually to communicate something to the user.

Whether it is communicating a brand identity, interaction progress or a specific message such as 'error' or 'reminder' [Image 3]. Through associations, sound can also communicate how the product is intended to be experienced, e.g. luxurious.

All in all, we tend to agree that product sounds affect the product-experience of the user [36] and are an important element of interaction design.

Image 1: The sonic logo of Netflix
Image 2: The jingle of McDonalds
Image 3: Phone notification of Twitter

A.2 UX Design

A.2.1 What is UX Design?

In the previous chapter, we have established the importance of product sounds in the user experience of a product. However, who is responsible for the design choices that result in said product sounds?

The area of design that focuses on the way a product is experienced and interacted with is called User Experience Design or more commonly, UX Design [35]. Throughout this report, the focus will be on the UX designers and the ways they could integrate sound design activities into their practices. Therefore it is important to define who exactly is considered a UX designer and what kind of activities are part of their practice.

A.2.2 What are the competences of UX designers?

In 2004, UX Designer Peter Boersma created a model of skills necessary in the UX Design process: The T-Model [iii] [figure 1]. This model of skills has spread through the design world and was often used by the media to define the activities of a UX designer [6]. In 2023, Boersma expanded the model and updated it to include the developments of the field in the last 19 years.

As you can see, the model proposed by Boersma presents a wide-ranging definition of the competencies of a UX designer. However, sound design may not be equally relevant within all of these competencies.

Later in the report, an overview will be made of relevant UX design practices and a specific part of the design process will be highlighted: prototyping [FX]. Throughout the report the terms UX designer and Interaction design may be used interchangeably, however, both refer to the same area of design.

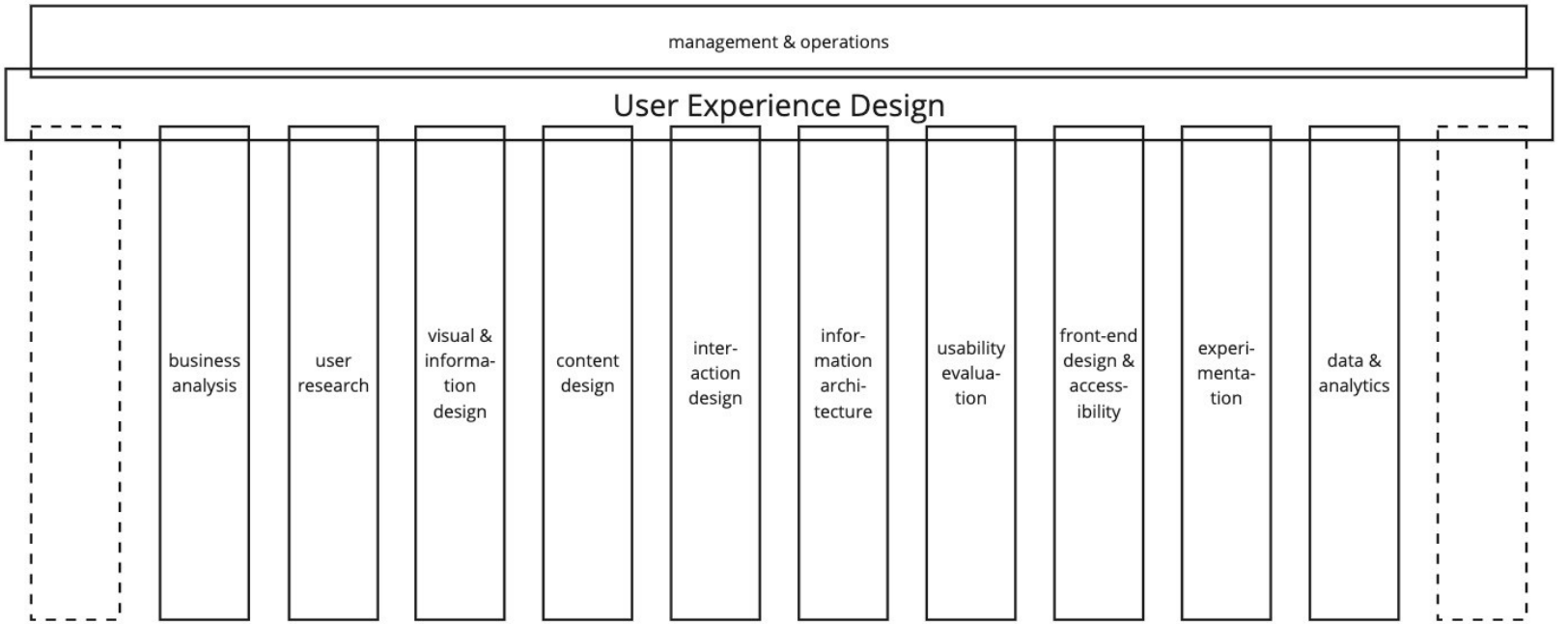


Figure1: The updated T-model for UX by Peter Boersma (2023) [iii]

A.3 Challenges of integrating sound design in the UX design process

In Semantic Models of Sound-Driven Design: Designing with listening in mind, Delle Monache et al. (2022) present a semantic analysis of interviews conducted with 20 participants representing design researchers, sound designers, engineers and expert users. The focus of this study was on uncovering the problems that arise during sound integration such as the semantic gap and the challenges of reframing sound design as an embodied and situated listening experience [33].

A.3.1 The semantic gap

UX designers often collaborate with professional sound designers. However, the difference in the expertise levels may create a semantic gap between the collaborators: UX designers often use metaphors and analogies to communicate their sonic visions, while professional sound designers may use more specific and technical jargon. This problem grows with the involvement of other stakeholders such as the target group or the clients.

The presence of this semantic gap may affect communication and collaboration, resulting in misunderstandings and delays in the design process [7].

A.3.2 Sound-driven design orientations

The Semantic Models of Sound Driven Design positions four perspectives on sound design: designing the sound, designing with sound, designing against the sound and designing sound for (something).

The first one, designing the sound is very similar to the traditional approach to sound design where the goal is to create a specific sound fitting an interaction and/or part of the product. However, it is also possible to use sound as a design tool itself and inform the design process through an iterative approach by designing with sound.

This approach of designing with sound is not yet widely spread in the design practices of designers, but offers an interesting perspective on the integration of sound. The main principle of designing with sound is to approach the process with a focus on the listening experience rather than the sound itself.

A way of understanding this differentiation is to view sound as part of an embodied, multisensory experience. At all times, sound is embodied and experienced in a context that should be taken into account when designing with sound. The way the sound interacts with the context and what role it plays in it shapes the listening experience. This provides the designers, and other stakeholders, with a fresh perspective on the role of sound in their project.

The reason why sound design is often outsourced to professional sound designers could be due to the lack of appropriate sound prototyping tools for UX designers and the lack of insight into the value of integrating sound into the design process.

The challenges of integrating sound design activities are:

1. There is a lack of appropriate tools and resources to effectively incorporate sound design in the UX design process.
This could perhaps be related to the history of sound in product design. In the past, the embodiment of sound in the product often was restricted by electronic components such as speakers. There was less creative freedom in the sound design process of the UX designers and the professional sound designers and engineers would determine which sounds were feasible in the product [33]. Therefore, designing the sound would often become an afterthought, as the physical embodiment of the product would determine the possible placement and size of the speakers.

2. Lack of appreciation for sound in interaction design.
Sound is often overlooked in the traditional design process in comparison with visual and kinetic elements [20]. Due to a lack of awareness, UX designers may not realize the importance of sound in their products. As a result, sound design has often been limited to auditory icons and earcons [21] leaving little space for creative exploration.

Nowadays, we can integrate small, high-quality speakers into our products and technology is less restricting than it used to be. Therefore, there is more space for input from UX designers into the sound of their products. This is also reflected by emerging approaches to sound design integration such as the Sonic Interaction Design.

Sonic Interaction Design is the integration of sound in interaction design, specifically in the context of designing interactive systems and experiences [20]. This approach recognises the impact sound can have on the user experience and uses sound to elevate the user interactions, conveyed information and overall experience of the product/system.

A.4 Conclusion

Sound has proven to be an integral part of the user experience [2, 20, 41]. It embodies information and provides one more dimension of communication with the user which can create a specific brand identity and in general guide the interaction between the user and the product [41].

UX Design is an area of design that focuses on the experience of the user. Although the aforementioned literature states the importance of integrating sound in the design process it is not yet reflected in the practice of UX designers [20].

Sound design is often outsourced to sound design professionals as UX designers may not have the tools or knowledge needed to integrate sound into their projects [20].

When collaborating with professionals, communication issues can arise such as the semantic gap and different perspectives on the integration of sound.

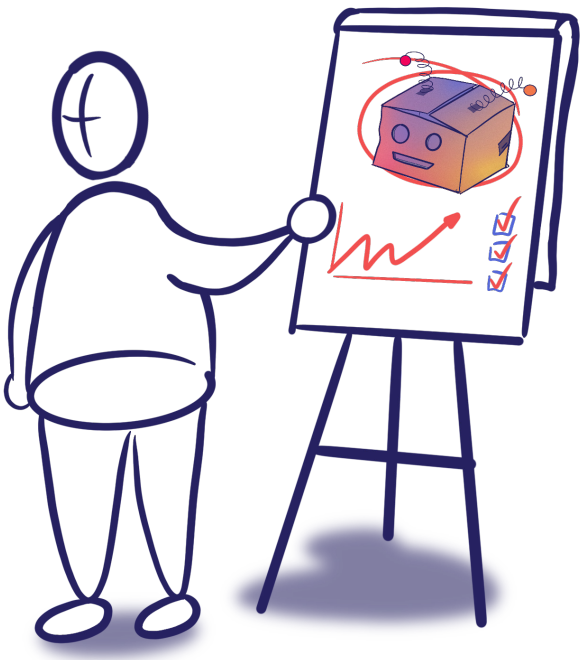
B. Project Definition

B.1 Problem Statement

Sound is an integral part of the user experience of a product, however, this is not represented in the design activities of UX designers (see: Introduction). Lack of sound expertise, appropriate tools and semantic gaps are some of the difficulties that UX designers may experience when trying to incorporate sound into their projects.

To improve the integration of sound in the design process, one needs to be aware of the current practices of the UX designers as well as their potential needs.
To facilitate the design process of such a solution the following research question was formulated:

How can we design a tool that integrates sound design activities in the current practices of the UX designers?



B.2 Scope of the project

Due to the time limitations of a graduation project (100 days), it is important to establish some (pre-determined) focus points.

B.2.1 Focus on the synthesized / intentional sounds

In Product Sounds: Basic Concepts and Categories (2014), Özcan et al. [36] distinguish two kinds of sounds in product design: consequential sounds and intentional sounds. Consequential sounds are the result of the embodiment, choice of material and the internal workings of the product: e.g. the grinding sounds of a coffee machine. The latter, intentional sounds are different, they exist separate from the physical qualities of the products and can be composed and synthesized. A similar differentiation is made by Carron et al. [7] in the words4sounds lexicon (ch. 3. FX) where sounds can be described as natural (consequential) or artificial (intentional).

In this project, the focus is on the design of intentional, or artificial, sounds in UX design. In contrast to the traditional industrial design, the products created through UX design can often have a digital nature and may not even have a physical embodiment (e.g. apps as a product are designed as software applications to be used on a physical product such as a smartphone). This is also reflected by the interviews with the UX design experts (ch. 1. FX) as the types of sounds integrated into their products were all intentional/artificial sounds.

B.2.2 Design of a (tangible) tool

The term tool can be confusing; within design, 'tool' can be used to describe a variety of elements that are used in the process: toolkits, toolboxes, methodologies, and activities. As a result, we can find many different explanations of what a tool is. To establish a shared understanding, within this project, the following definition is used: a tool is a physical thing that is used as a means to an end [41 p. 65].

The choice for a physical tool is a result of a combination of personal interest in (physical) interface design, electronics and topics such as embodied cognition. Note: Although the project aimed to design a tangible tool, in the end, the tangibility of the interface remained on the conceptual level and a digital interface was tested with the participants (ch. FX).

B.2.3 Target group

The target group for the project is the UX designers, the tool designed during the project is intended to be used by them during e.g. the prototyping stage of their projects.

B.3 Design Research Approach

Based on the scope and the knowledge from the research activities conducted in the introduction (p. 1) a set of supporting research questions were formulated.

The table on the next page (table 1) presents the supporting research questions in combination with the design research activities that were conducted to answer them. The figure below (figure 2) explaining the legend in the table.

When choosing the design research activities the focus was on directly involving the target group and learning from their first-hand experiences. Since the user is the ultimate expert of their context [41] this is a helpful approach to learn about the needs of the target group.

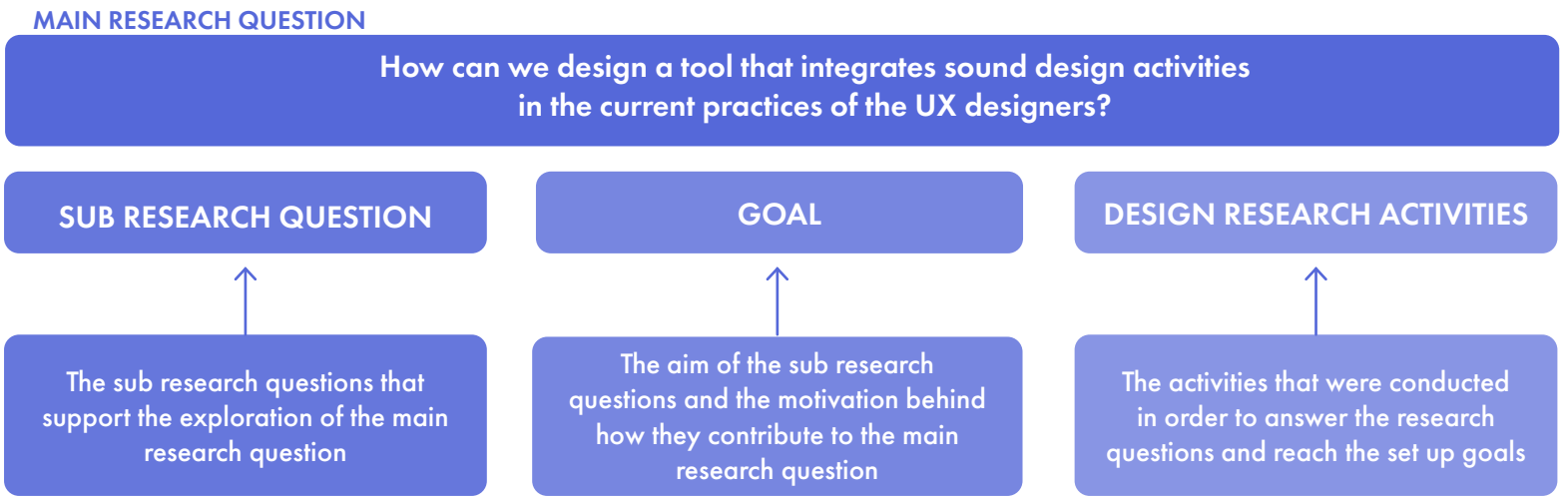


Figure 2: Legend of the design research approach shown in table 1

How can we design a tool that integrates sound design activities in the current practices of the UX designers?		
1. In what ways do designers want to integrate sound design activities in their practices?	1A. Understanding the current practice of the UX designers when it comes to sound design 1B. Exploring the needs of UX designers when it comes to sound design prototyping tools	Interviews with the design experts (1A, 1B) [ch. FIXME] User tests (1B) [ch. FIXME] Co-creation session (1B) [ch. FIXME]
2. What kind of sound design tools do UX designers need?	2A. Learning about approaches to sound design within the context of UX design 2B. Learning about the existing tools for sound design; their benefits and shortcomings 2C. Understanding to what extent UX designers want to work with sounds	Literary review (2A, 2B) [ch. FIXME] Interviews with design experts (2B) [ch. FIXME] User tests (2B) [ch. FIXME]
3. How do we make sound design comprehensible to UX designers?	3A. Exploring possible representations of sound design recognisable to UX designers 3B. Exploring ways of creating intuitive sound design tools 3C. Learning about how the UX designers want to interact with a sound design tool	Literary review (3A) [ch. FIXME] Co-creation session (3A, 3B) [ch. FIXME] User tests (3A, 3B) [ch. FIXME]
4. How do we bridge the semantic gap between the participants of a sound design activity?	4A. Understanding the current level of knowledge of UX designers 4C. Learning about tools and methods available for the bridging of the semantic gap	Literary research (4A, 4C) [ch. FIXME] Context mapping (4A, 4B, 4C) [ch. FIXME] Interviews with the design experts (4A) [ch. FIXME] User tests (4A, 4C) [ch. FIXME]

Table 1: Research questions, goals and the design activities conducted to answer the questions.

Chapter 1

Practices of UX designers and spaces for the integration of sound design activities

Introduction

This chapter presents the design research activities exploring the ways sound is currently integrated into the practices of UX designers.

In order to get a general sense of the context an online testimony of a UX designer was analysed (1.1). The insights from the testimony, along with previous research insights have inspired the setup of interviews, conducted with four UX design experts: a serious game designer, a digital interfaces designer, an interaction designer and a design researcher.

The results of the interviews are presented in the form of visualised overviews and concluded in section 1.2.

Furthermore, the concept of prototyping is introduced from the theoretical perspective as the research goal is to design a prototyping tool (1.3).

Lastly, the findings are concluded in the final section (1.4).

1.1 What do the current practices of UX designers look like?

1.1.1 Online testimony

To prepare for the interviews with UX experts, a quick study of online testimonies was conducted. Experiences shared by UX designers online, in the form of informative blogs, are understood as online testimonies in this context. Creating a preliminary overview of the sound design activities in the UX helped to formulate the interview questions and get sensitised to the context of the UX design.

The following testimony was found to be most contextually relevant and insightful for the formulation of the interview questions: A story-telling type of blog post on the process of designing with sounds from an inexperienced perspective: *"Sound Design: Composing Sounds in the World of UX: How the Zeta design team took its first steps towards dabbling in the art of sound design."* by Lavanya Gopalaswamy [17].

The design approach as described in the blog post by Lavanya Gopalaswamy, along with some of the obstacles and solutions they have encountered (figure 3):

Competitor Research
Creating libraries of sounds used by the competitors and analyzing them

Setting interaction goals
Analyzing how the sounds can contribute to the brand identity and enhancement of the user experience

Creating sound prototypes
Using tools such as GarageBand to explore sound design and create different variants of sound samples

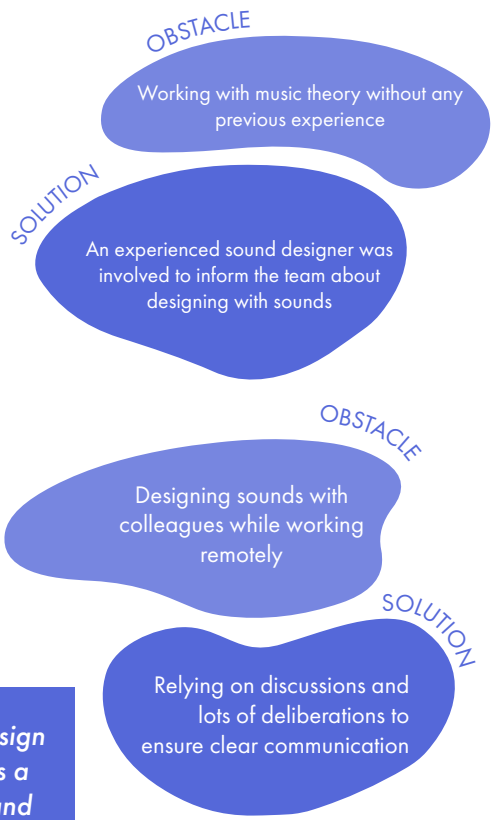


Figure 3: Obstacles and solutions that Lavanya encountered in the design process

> *"The biggest learning for me was that sound design cannot be looked at as a standalone entity; it's a vital part of the user experience of a product and should undergo the same level of focus and scrutiny as any other design element. Sounds can never take the centre stage, they must harmoniously blend in with the interface, helping the user make sense of the activity at hand."*
> *-Lavanya Gopalaswamy, [17]*

1.2 Interviews with the design experts

To understand how sound design is currently integrated into design practices I have interviewed four experts from the following fields: serious gaming design (AR/VR), digital interfaces design, interaction design and design research. All these design professions, with the exception of design research, are focused on user experience design even though their official functions may not carry that name. Design research in itself is a much wider expertise that can be concentrated on a variety of topics. The design researcher that I have interviewed specializes in sonic interaction design; therefore he has extensive knowledge of interaction design and the applications of sound in (product) design.

1.2.1 Method

Participants: Four participants, 35-45 years old , three male, one female all with 10+ years of experience.

The interviews were conducted in a semi-structured way, individually, online or offline depending on the preferences of the participants. The interviews were audio-recorded for note-taking. Thematic analysis, 'on the wall' [41] was applied to extract generalized results from the interviews. This method of data processing is recommended for smaller research populations (<10 participants).

It consists of summarizing the data and creating immersive visual displays of it. The aim is to gain inspiration and design insights by translating qualitative data into information and knowledge.

1.2.2 Results

The results of the interviews are presented on the next pages in a visual form [Figures 4, 5, 6 & 7].

This designer works for a company that develops **serious games.** They work for diverse clients and have a wide level of expertise.
Their games are used for educational and informative purposes.

They always work in small teams, **the participant is the main designer and is responsible for the interaction, the over-all game lay-out and the user experience.**

They make **new sounds for each of their games** because they're always contextual, and they want the sounds to fit the context and the ambiance of the game.

"In a team brainstorm session the starting point for the sound is the desired ambiance / vibe."

"It does not happen often but sometimes you have to make sounds you never heard before or that don't exist"

What role do sounds play in your projects?

Sounds are for example signaling sounds (UI) and ambient music sounds that help to create the right ambiance

Serious Games Designer

Usually the participant and his team make a sound moodboard to communicate their desired ambiance. The moodboards consist of samples they have found online.

"It takes time to find the right sounds, when we don't agree in the team we try to understand what does not work. Then we take a step back and try to find samples that do work."

The team comes up with a sound vision which they then share with a sound designer, the sound designer is not part of the company but is hired for the project.

They use recognizable sounds, metaphors and analogies to communicate. Something they all recognize. Usually there are no misunderstandings within the team, according to Niels it's because they are all from similar fields and know each other quite well so it is not difficult to find common language.

Could you see yourself using vocal scribbling in a project?

Yes absolutely, you get to the point much quicker that way. Often, it happens when it is not completely clear what somebody means yet, and then you can see that people naturally tend to imitate sounds and verbalize them and that helps us to get to a conclusion

What does this game designer need?
-A way to come up with ambiance mood-boards without having to listen to samples.
-Something that can help communicating with the sound designer.
-A tool that could help to quickly iterate during the brainstorming sessions.

Interesting points
-How does one find samples for fantasy sounds, which don't exist yet?
-Iterating with sounds can take a lot of time if you have to look up samples.
-A lot of inspiration for sounds in their games comes from skeuomorphisms

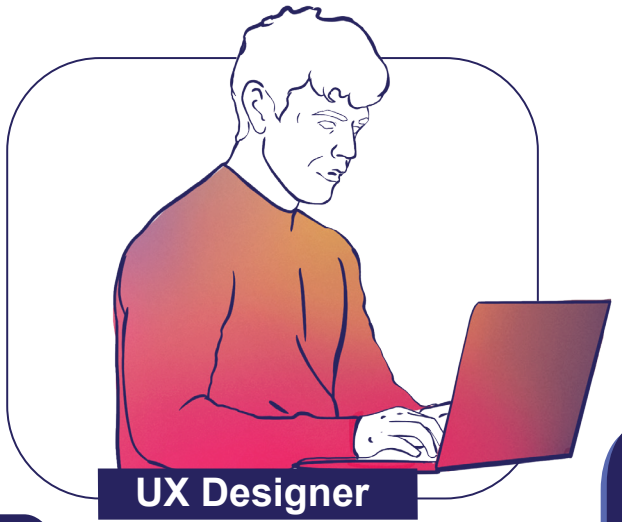
Figure 4: Results from the interview with the serious games designer

This UX designer works in a multidisciplinary company where he does the **majority of the design tasks**. He **taught himself to design with sounds so he was able to integrate it in his projects himself.** He also enjoys playing on his synthesizers. The company is working on a robot that can be piloted remotely through a VR headset.

The designer works on the digital interfaces for the company such as the website and is currently developing a **VR experience** through which users can interact with the robot.
The responsibility for user-friendliness lies on the shoulders of the user experience designer.

Sound design plays a big role in his project, especially the VR experience since the goal is to provide an immersive experience.

"I put the sound in at the very beginning, the moment I have a button I add sound to it."



There are few opportunities to user test the robot and usually the designer ends up testing the usability himself or with coworkers.

He picks the sounds based on the **context (ambiance) and on the functions of the interface.**

"I want the sounds to fit together. The sounds in user experience almost always exist in pairs. Every 'win' sound should also have a 'lose' sound that exists in the same sonic universe "

What role do sounds play in your projects?

All my sounds are for the user experience, they tell about the interaction, the affordances or set the ambiance.

What does your sound design process look like?

Usually to find the right sound I go through my sample libraries. I have around 50GB of libraries, all with different properties. Samples are usually not named or tagged so I spend a lot of time going through all of them to find the right one.

"Sound is incredibly important for the user experience, it should be almost unnoticeable but you will miss it if it is not there"

What does this UX designer need?
-He wants to browse and try out different sounds to find the perfect sound sample.
-He wants to be able to filter sounds based on a specific function e.g. 'button sounds'.
-He wants something he can easily integrate with his VR experience.

Interesting points
-Sounds for different functions should still fit together since they exist in the same sonic universe
-You start quite broad with the sound vision & then zoom into specifics
-Sounds also depend on material properties of the object (in AR/VR experiences)

Figure 5: Results from the interview with the Interaction Designer

This interaction designer has worked on the design of a ticket machine for public transportation. Her studio has asked for help from a **professional sound design studio**. Sound was an important way of providing feedback in this project therefore the **sound designers had a big role in the collaboration**.

How did you communicate about sounds with the sound designers?

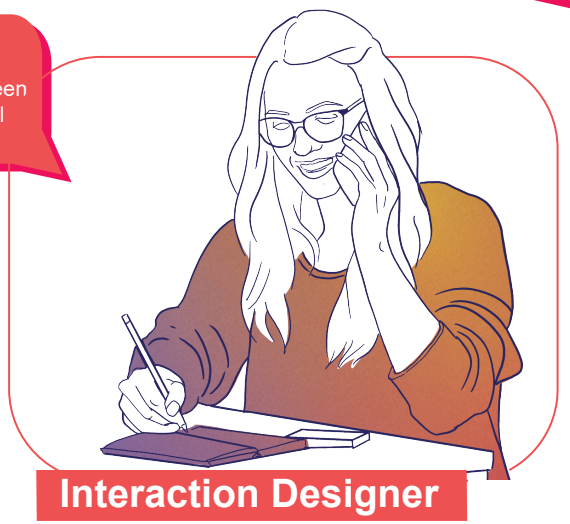
"When talking to the sound designers we tried to communicate through analogies and describe experiences we wanted to evoke. **The technical terms that they used flew over our heads.**"

What role do sounds play in your projects?

"In interface design sound is important for feedback. When interacting with the screen through clicking it feels natural to also hear a click."

The interface designers provided the sound designers with insights into the target group and the context.

"The **client would have been fine with us designing the sounds ourselves or using generic sounds**. But during the project, we have learned how important sound is in this interface and I wanted to take this [sound design] more seriously."



Interaction Designer

The sound designers were involved in the process later on, when the interaction designers **already had a cardboard prototype and an interaction vsion**.

The sound designers came up with three **sonic visions**, which they presented to other stakeholders.

"What we wanted to know is whether sounds would support the interaction and which sounds would be most helpful. It should not startle the user, we were looking for sounds that would support a comforting and guiding interaction."

Through user research, the interaction designer tested the sonic visions to select the perfect sonic vision for the interface.

"We never work with sounds so it was very **helpful to collaborate** with sound designers. It opened my eyes to the possibilities, they [sound designers] did not only think about the interface but also the clients' brand as a whole."

What does this Interaction designer need?
-Multiple sound design visions that get user tested & iterated
-*"We need a palette to try different things out & experiment"*
-A certain amount of expertise to make the communication with sound designers easier

Interesting points
-Designers used a type of sonic sketching to fuel the research: which sounds support the interaction?
-Starting point is the design brief, desired interactions & how sound can help achieve that
-The client may need some convincing when it comes to the imporatance of sound in the project.

"I wonder if the sound designers will appreciate it if you come to them with a predetermined sonic vision. Every designer wants to feel a bit of autonomy in the creative process and this **could maybe take autonomy away from the sound designer.**"

Figure 6: Results from the interview with the Digital Interfaces Designer.

This design researcher has a background in **music, sound design and soundscapes.**

His current research centers around design theory and methodology in sound, particularly using **representations of sound-based concepts and design communication of sound.**

Sound is integrated in his research in various ways, for example he participated in **workshops on sonification** of astronomical data;

He employs methods like turning data into audible ranges, exploring associations between dimensions and sound, and using metaphors to convey meaning.

"You're not designing for sound, you're designing for listening. Listening is the interaction which is mediated by sound. It's not something passive, It's always something that happens while we do something else, so listening is what the listener does"

"How do you communicate about sounds with others?"

"It is always a mix of verbal description with examples that I usually do with my body or my voice. Over the years I found this to be the most effective way."

Design Researcher

When organizing workshops for students he notices a lot of **miscommunications when discussing sounds or experiences.**

"Usually students have long discussions about the emotion of the sound. But they are not really able to embody these ideas of emotions into something that we could listen to. Instead they start browsing archives of samples and so on, again without having the possibility to work on these samples. So in the end, the results were always a bit disappointing. The sound output is very poor compared to the complexity of the design process."

There is a challenge in **moving from conceptual ideas to practical implementation in workshops focused on sound design.**
Students often focus on designing systems and tools rather than intuitively creating sounds.

Where do you think these miscommunications on sound are possibly coming from?

"Sometimes people think that they understand sound because they listen to a lot of music. There is the assumption that you can be an expert listener just because you know lots of artists. But to me, sound and music are different. Music is a kind of a subcategory of sound, and sound is a subcategory of the audible and vibrations. Not all audible experiences are sound, because some vibrations are so low we feel them better than hear them. "

What does this Design Researcher need?
-A way of prototyping with sound that empowers the students to create sonic prototypes that represent the complexity of their explorations
-"Focus on how you can help people understand what they are talking about"

Interesting points
-Sounds are designed for listening
-Anything can be used for sonic sketching, it's a skill that people can develop
-Sound and music are not necessarily the same thing

Figure 7: Results from the interview with the Design Researcher

1.2.3 Insights from the interviews

Based on the data analysis, a set of research insights was formulated, in this section some of the most prominent insights are mentioned.

Sound was a relevant design element in the practices of all interviewed designers. The starting point of all sound design activities would be the design brief with the desired interaction qualities.
The final sound design is usually outsourced to professional sound designers.

"When talking to the sound designers we tried to communicate through analogies and describe experiences we wanted to evoke. The technical terms that they used flew over our heads." - P3

The communication about sound within the group and with stakeholders, e.g. sound designers, is often through metaphors, analogies and experiential examples.

"Usually to find the right sound I go through my sample libraries. I have around 50GB of libraries,...samples are usually not named or tagged so I spend a lot of time going through all of them to find the right one." - P2

However, some of the designers first brainstorm on possible sounds and make samples to share. The prototyping with sounds would start with looking up samples and discussing them with a team to achieve a shared view of the desired ambience.

Both, browsing the libraries and iterating in between the discussions take time.
The decision-making is often done in a group setting. In a brainstorming session, designers would like to have a way of quickly iterating through multiple options and adjusting them dynamically.

"It takes time to find the right sounds, when we don't agree in the team we try to understand what does not work. Then we take a step back and try to find samples that do work." - P1

"We need a palette [like a painting palette], to try different things out and experiment"

- P3

1.3 Focus on the prototyping activities

According to the interviewed UX designers, the final sound design of a project is most often outsourced to professional sound designers/producers. Even if UX designers were able to integrate sound design into their process, the goal is not to replace the participation of sound designers. Instead, the goal should be to improve the communication between UX designers and sound designers by bridging the semantic gap between them. To achieve that, UX designers need to become acquainted with (some type of) sound design within the context of their practice.

Furthermore, UX designers want to be able to work with sound iteratively; they want to use it for discussions, decision making and user testing rather than creating finalized sound productions. Within the context of UX design, such iterative activities are often supported by the creation of (testable) prototypes.

> *"We define a prototype as a concrete representation of part or all of an interactive system. A prototype is a tangible artifact, not an abstract description that requires interpretation. Designers, as well as managers, developers, customers, and end users, can use these artifacts to envision and to reflect upon the final system."*
>
> *-Beaudouin-Lafon and Mackay (2009). [3]*

Therefore it would be appropriate to focus on how sound design could be integrated into such iterative, fast-paced prototyping sessions.

1.3.1 What is prototyping?

Prototypes are early representations of ideas or concepts. Their shape, goal and application vary within different design fields. Designers use prototyping tools as artefacts with which they can generate ideas, gather feedback, make design choices and evaluate their decisions [3]. To make an analogy with visual representations, if a painting is a final work a prototype is like a sketch or a mock-up that helps the artist decide how to proceed with the painting.

1.3.2 Guidelines for successful prototyping tools

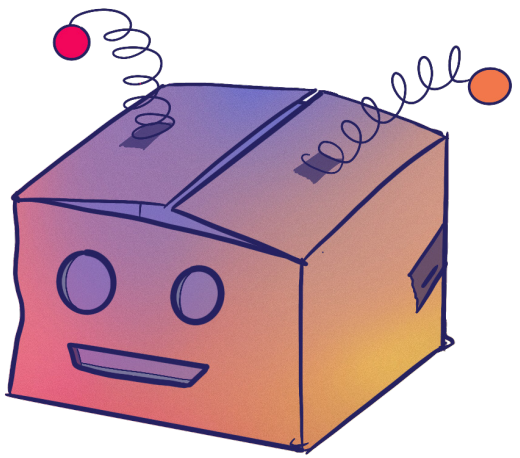
Prototypes can be viewed as concrete artefacts or as components of the design process. Beaudouin-Lafon and Mackay (2009) [3] have set up the following guidelines for a successful (artefact) prototype:

1. The prototype supports creativity
2. The prototype helps the developer to capture and generate ideas
3. The prototype facilitates the explorative process of design
4. The prototype uncovers relevant information about the users, contexts and their work practices.

Within the context of UX design, prototyping activities can consist of making paper-based mock-ups, acting out the interactions, using rapid prototyping materials to create 3d mock-ups, pretending to facilitate interaction (wizard of Ozz-ing), creating various levels of interactive prototypes using electronics and many more.

The efficiency of a prototype can be an important factor when selecting prototyping methods. The efficiency here can be defined as the amount of time it takes to create the prototype versus the number of insights one can gain from it. The stage of the project often determines the fidelity level of the prototype.

In the beginning, designers like space to explore and do not yet want to fixate on a specific implementation. Later in the project evaluation of the design choices becomes more prominent. The higher the quality of the prototype the closer the designer can get to a realistic representation of use.



1.4 Conclusion

The current design process

Insights from the interviews were combined with the literary findings to pinpoint some of the challenges UX designers may face when working with sound: the semantic gap between the stakeholders, loss of time to big sound libraries and iterative sessions, not knowing what the possibilities of sound design are and lack of appropriate tools for prototyping with sound.

Designers have tools and methodologies to facilitate the prototyping of physical, visual and interactive design aspects. When it comes to sound design, however, designers often only consider sound at the last moments of the design process and then often opt for pre-existing sound libraries rather than generating their audio. The design experts noted that they would like to work with sound and make quick sound prototypes during brainstorming sessions.

The way the designers approach sound design in their projects is by first setting the preferred interaction criteria and finding sounds that represent said criteria. These are distilled from the design briefs and project requirements.

The design of the sounds themselves is often outsourced to professional sound designers. UX designers use metaphors and analogies to communicate with sound designers, they may also try to evoke specific experiences to describe their sonic visions.

Need for prototyping tools for sound design

The process of audio design is detached from the design process while the research shows the importance of integrated audio prototyping in product design [33]. Preferably designers should be able to integrate audio design within their projects and prototype with it just like they prototype the visual and haptic feedback of a product.

Criteria for successful prototyping tools are noted on p. 24 Generally, tools for prototyping should facilitate creativity and exploration. The prototypes themselves serve to uncover information about the user, context and product.

Chapter 2

Sound design practices

Introduction

The goal of this chapter is to gather the information needed to answer research question 2: What kind of sound design tools do UX designers need? by looking at the practices of sound designers and the existing tools for sound design; their benefits and shortcomings and understanding how sound design can be facilitated through a tool.

An overview of existing tools for sound design is presented. The tools are divided into two categories: common sound design tools and design-specific sound design tools

Examples of each of the categories are presented and analyzed in the form of an overview (p. 30 - 39). A set of benefits and shortcomings is listed for each of the tools, supported by the analysis.

Furthermore, we take a look at sound prototyping methods: sonic sketching and vocal scribbling (2.3). These methods are tried out through sonic sketching exercises, prototyping activities and user tests with participants (2.5). The insights from the literary research, the analysis of the tools, prototyping and user tests are concluded in the final section of this chapter (2.6).

2.1 The sound design process

Due to the scope of this research, there were few opportunities to explore the professional sound design process in depth. However, to create a sound design prototyping tool it is necessary to have a certain understanding of the sound design process, sound design functions and sound synthesis. To fill the knowledge gaps within this area the following activities were conducted:

1. Research into sound synthesis, sound processing and music theory (appendix FX).

2. Research into the applications of sound design within the context of UX applications resulted in the following overview [31]:
a. Feedback sounds (earcones)
b. Decorative sounds (emotional state, expressive and playful moments)
c. Hero sounds (highlight an important moment, express celebration)
d. Notifications (requests for attention)
e. The system sounds (provide feedback)
f. Ambient sounds (decorative layer that communicates identity, emotional state)

Furthermore, two types of sounds are distinguished in the UX applications [31]:

aa. Skeuomorphic sounds - literal imitations of sounds in the real-world

ab. Abstract sounds - tones that are not imitating real-world sounds

3. An informal interview with sound design students from the HKU

A short and informal interview was conducted with sound design students from the Utrecht College of Arts (Hogeschool voor de Kunsten Utrecht).

The two students told about their process of sound design and their experience of a collaboration with an artist. In their recent project, they were contacted by an artist to create ambient and feedback sounds for a multi-sensory installation.

The students noted that the artist provided them with descriptions of desired interaction qualities rather than examples of specific sounds; this resulted in difficulties in communication throughout the collaboration. The result of this miscommunication was a large amount of discussion and iteration to achieve the sounds the artist required.

Furthermore, the sound design students noted that when they are asked to design a specific type of sound (e.g. warm and friendly) they apply an experimental approach; because there are no set rules for sounds based on specific interaction qualities such as ‘warm and friendly’. Each time the sound designers have to evaluate whether the sound is perceived as ‘warm and friendly’ and adjust it accordingly.

2.2 Tools for sound design in the UX

2.2.1 Common sound design tools

The tools used for audio design, both professionally and recreationally, are often digital music instruments such as synthesizers. These can be interacted with digitally (through software) or physically (through hardware) but the input and output are always a form of a digital signal. The way we are used to interacting with sound, as noted above, is through DAWs and common sound-modulation elements.
Examples:

- Digital Audio Workstations (p. 30 - 31)
- Common Physical Tools (p. 32 - 33)

2.2.2 Design specific sound design tools

There are few commercially available tools specifically designed for the use of sound design in UX design. However, there are academic tools available that can be analysed within the context of this research. Examples:

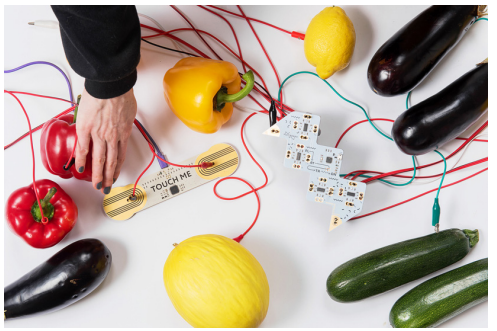
- words4sounds.speak lexicon (p. 38 - 39)
- PSST! (p. 34 - 35)
- SDT (p. 36 - 37)

2.2.3 MIDI's

Another type of commonly used tools are MIDI's or Musical Instrument Digital Interface (image 4). MIDI's do not generate sound but rather trigger MIDI notes. They are intended to be used together with a sound producing tool and mediate the interaction between the user and another interface, such as a synthesizer or a DAW see 2.2.1.
MIDI's come in all shapes and sizes, they can be used in professional settings as well as for individual use.

The flexibility in the design of MIDI's allowed for creation of explorative and educational tools that are relatively cheap and accessible to the mainstream user.
Commercially available MIDI's such as TouchMe and Playtron (image 5) make it possible to create quick tangible representations of sound. These tools are great for exploration of the physical translations of sonic spaces, and sequencing simple compostions. Such tools are popular in performative settings because of their visual and interactive qualities.

Images 4 & 5: Examples of MIDI interfaces, MiniLab by Arturia (i), TouchMe and Playtron by Playtronica (v)



COMMON SOUND DESIGN TOOL: DAW'S

Image 6: Screenshot Ableton 1 [xi]

TYPE OF TOOL
DAW (Digital Audio Workstation)

EXAMPLE
Ableton

GOAL & CONTEXT OF USE : DAWs or digital audio workstations are used to create and edit audio files. They are often computer screen based, such as Adobe Audition, Audacity or Ableton.
You can synthesize your sounds in these interfaces or edit a recorded sample. Ableton can be considered an industry standard [1], [44] in the context of sound design.

It is used in professional productions and live performances. However, it can be applied within many possible contexts and is not limited to professional use. Many hobbyists also turn to Ableton, and other DAW's, to try out sound design and music production.

TYPES OF INTERACTIONS: Ableton is a digital interface, it is shown on a (computer) screen (image 6). One can interact with Ableton through their computer, with the use of a keyboard and a mouse. Or through a MIDI, which can take many different shapes.

The user can navigate through an accordion type (image 7) of the menu by clicking on the categories in the sidebar. Through a converging selection process, the user can find the specific function that they need.

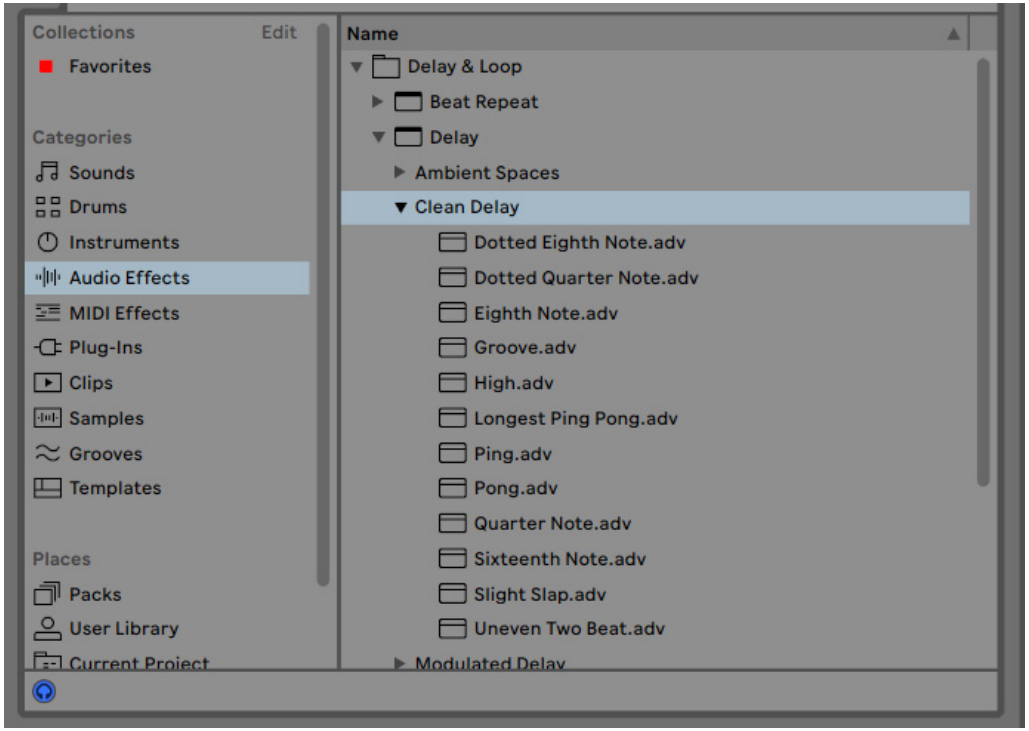


Image 7: The menu of Ableton through which the user can access the functions of the interface.

BENEFITS

+ Ableton has a wide variety of functions and options and provides the user with limitless potential for creativity.
+ Ableton can be used with practically any computer, no external hardware is needed
+ Ableton is an industry standard, the user is able to achieve high quality sound productions using this tool.

SHORTCOMINGS

-The complexity and hierarchy of the interface make DAWs such as Ableton difficult to operate for novice users.
-Someone unfamiliar with sound design may now know which functions are used for what and how to access them.
-It can be overwhelming to see all the options without knowing what the results will sound like after applying them.
- In order to master tools such as Ableton one needs to invest lots of time. Furthermore, use of such tools often requires a subscription which can be costly.

COMMON SOUND DESIGN TOOL: HARDWARE

Image 8 (top left): OP-1 by Teenage Engineering [viii]

Image 9 (top right): SKULPT synthesizer by Modal Electronics [xii]

Image 10 (bottom left): OPSIX by Korg [vii]

Image 11 (bottom middle): DrumBrute by Arturia [vi]

Image 12 (bottom right): The Moog System 55 at the NAMM show in 2015 [xiv]

TYPE OF TOOL

Hardware interface: Physical synthesizer (images 8 - 12).

EXAMPLE

SKULPT by Modal Electronics (image 9). The synthesizer analysed here has similar types of interactions as many common synthesizers, it is not as recognisable as e.g. the OP's by Teenage Engineering (image 8), but it was more accessible to physically explore within the context of this project.

GOAL & CONTEXT OF USE : There are many synthesizers available on the market. They can be used by novice users as well as by professionals. This is usually reflected by the complexity and price of the interface.
Synthesizers are used to synthesize a digital signal into an audio output. They can be used standalone or modularly with other tools.

TYPES OF INTERACTIONS: If we look at the typical interface of a synthesizer we see lots of knobs, buttons and sliders. Usually part of a keyboard is integrated for easier sequencing.

Each of the sliders, buttons and knobs corresponds to a specific function of audio design (image fixme).
The same type of input is used for different outputs and functions.

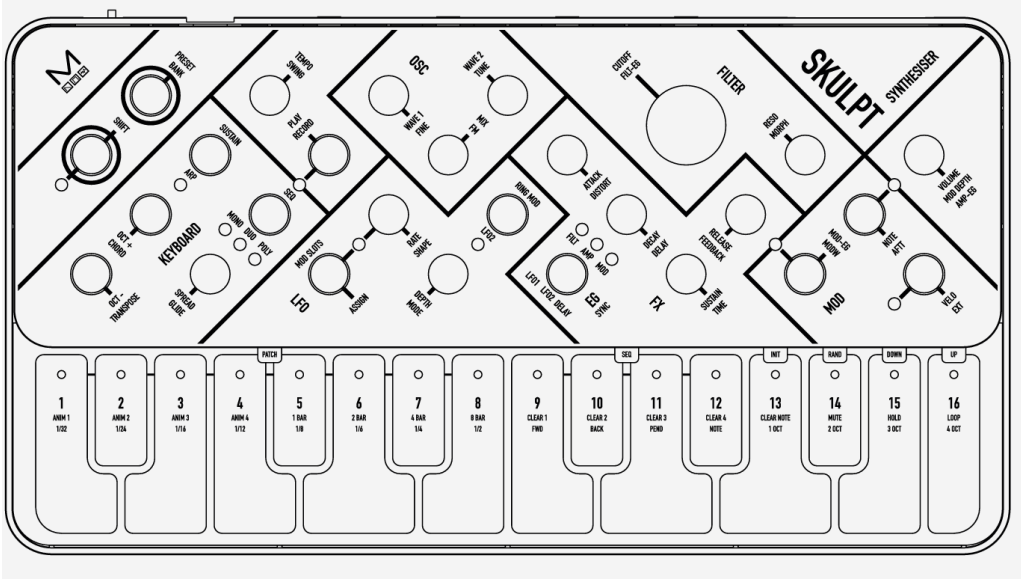


Image 13 (top): Synthesis engine interface of the SKULPT synthesizer [xiv]

Image 14 (left): DATO, a synthesizer designed specifically to be used with children [xiii]

BENEFITS

+Physical synthesizers provide a tangible interface for digital signal modulation which can be more user friendly
+Just like with Ableton, synthesizers provide the user with a wide variety of functions and limitless potential for creativity.
+The synthesizer market is very diverse, making it possible to find synthesizers for specific target groups e.g. children (image fixme).

SHORTCOMINGS

-Most hardware synthesizers consist of the same interface elements that have not evolved much since their first appearance [40].
-Synthesizers are difficult to use for novice users [13] in a way that is required for UX design.
-Synthesizers often have inconsistent ways of interaction. Consistency refers to the use of similar elements to achieve similar tasks. According to the theory of affordances, by Don Norman, consistency is important to ensure the user-friendliness of a product/interface [37].
-Most synthesizers require need to be combined with an audio interface in order to be able to record the sound.

Image 15: Images from the PSST! report [23]

TYPE OF TOOL
A tangible interface that connects physical input with digital audio synthesis

EXAMPLE
PSST!

GOAL & CONTEXT OF USE : PSST is an academic example, developed during a MSc graduation project [23] at the faculty of Industrial Design Engineering, Delft.

It is a product sound sketching tool that has been designed specifically to integrate sound in a design process [23].

The tangible interface of PSST! aims to make sound design more accessible to product designers by translating sound descriptions into physical representations.

TYPES OF INTERACTIONS: PSST! allowed its users to experiment and explore sounds based on the categories from Product Sounds: Basic Concepts and Categories [36].
Through a tangible interface, participants are able to generate sounds in the following categories: mechanical, impact, alarm, liquid, air and cyclic.

The tangibility consists of the ability to physically manipulate sound representations (tangible elements). The users can also create their own tangible elements by putting the sticker tags on objects they would like to be part of the interface.

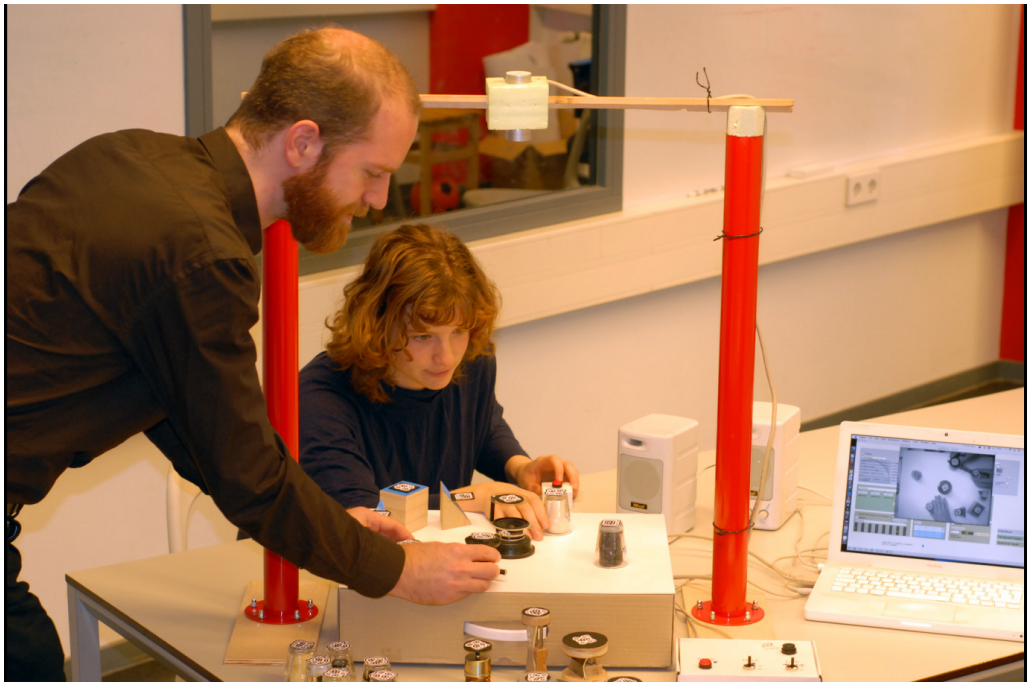


Image 16: PSST! in use, the webcam positioned above the tabletop is used to recognise the presence of the tags. The tags and their relative position trigger sound samples andtheir adjustmenets [23]

BENEFITS

+The interface proved to be quite intuitive and PSST! succeeded at supporting the sound design process [23]

+PSST! proposes an interesting, tangible way of interacting with sounds and makes sound design accessible to product designers.

SHORTCOMINGS

-The tool was not developed further, meaning that it is not available for use.
-PSST! is based on the product sound categories [36]: mechanical, impact, alarm, liquid, air and cyclic. As a consequence the use of PSST! is more suited for consequential sound prototypes rather than intentional
-One of the supervisors of the project noted that the prototype ended up being rather bulky, making it impractical for use in real context.

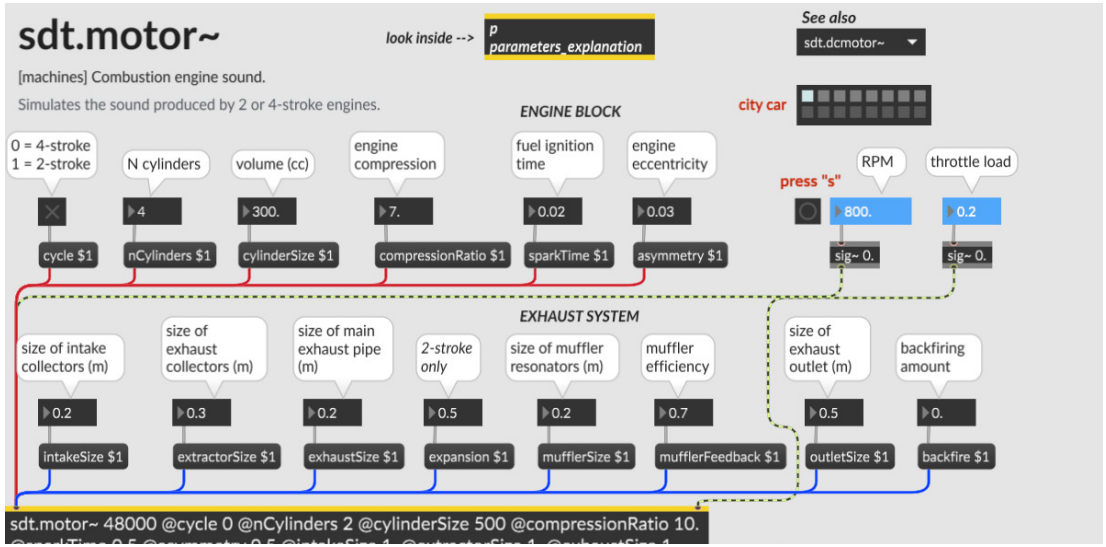


Image 17: Screenshot SDT tool in MAX MSP

TYPE OF TOOL
Digital interface for sound synthesis informed by physics

EXAMPLE
SDT: Sound Design Toolkit [51]

GOAL & CONTEXT OF USE : This digital interface is targeted specifically at product design.
The SDT allows the user to synthesize sounds using physically informed algorithms. Designers can use this toolkit to model the sounds based on the physical properties and their interaction with the environment.

This toolkit can be very useful for the exploration and modeling of possible user scenarios. Furthermore the tool can be used for exploration of the context and possible environmental interactions with the product.

TYPES OF INTERACTIONS: The SDT is a digital interface, users can interact with it through their computer using the keyboard & the mouse.
The type of sounds that can be generated, for example, are sounds of friction, impact, rolling, and crumpling but also sounds of motors and windshields.

The user can vary different elements of the model, adjusting textures, processes and physical forces.

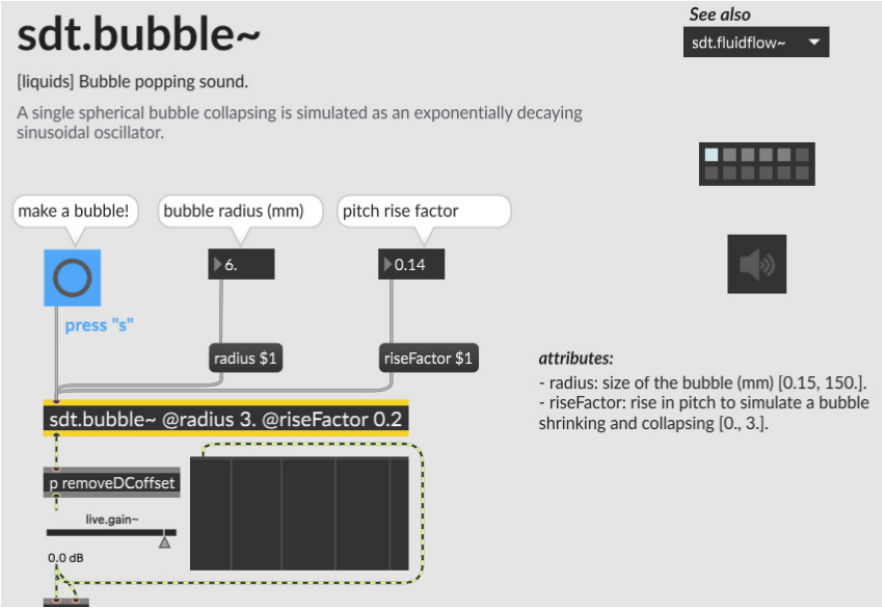


Image 18: Screenshot SDT tool in MAX MSP, example 'sdt. bubble'

BENEFITS

+This toolkit can be very useful for the exploration and modeling of possible user scenarios
+SDT makes it possible to model and simulate consequential sounds at all stages of the design project

SHORTCOMINGS

-There is a limited amount of models available which can be constricting in a design process, especially because the provided sounds are rather consequential than artificial (intentional).
-The tool is only available to the users of the MAX MSP software.

TYPE OF TOOL

Digital Interface of a lexicon for sounds

EXAMPLE

words4sound SpeaKweb

GOAL & CONTEXT OF USE : The words4sounds lexicon is a set of descriptors for sounds based on the research by Carron et al. [7]. The lexicon consists of 35 words, frequently used to describe sounds. It is specifically designed to improve the communication between designers, engineers and other stakeholders.

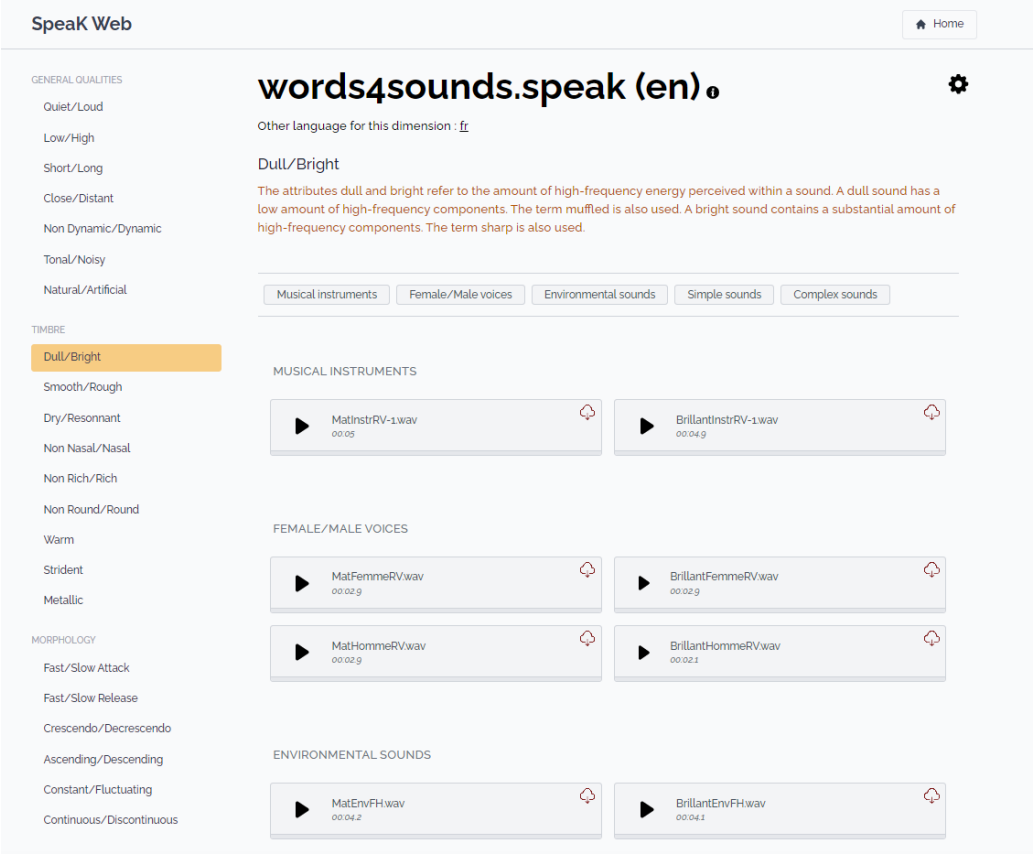


Image 19: Screenshot of the wordsforsounds.SPEAK webpage

TYPES OF INTERACTIONS: The digital interface of the words for sounds lexicon, SpeaKweb [7], divides the lexicon into three categories: General Qualities (e.g. 'Quiet/Loud'), Timbre (e.g. 'Dull/Bright') and Morphology (e.g. 'Fast/Slow Attack'). Within the three categories each of the word pairs is supported by audio samples and experiential descriptions. Furthermore, the samples for each of the word pairs are driven from multiple sources: musical instruments, female/male voices, environmental sounds, simple sounds and complex sounds (image 19).

Within the Timbre category each of the descriptions mentions one or multiple of the following acoustic qualities: Frequency (high/medium/low), Temporal Asperities (absent/present), Prolongation of Energy (present/absent), Cover of the Audible Range (high/low) and Attack (slow/fast).

The user can interact with the interface online where they can play the sound samples. Furthermore it is possible to save the sounds offline.

BENEFITS

+The descriptions provided in the SpeaKweb tool help to understand and communicate nuanced sonic visions and allow for the user to develop their own sonic vocabulary.
+Different examples of the sounds help to understand the appearance of similar sounding sounds in different contexts
+Using this lexicon, during a sound prototyping session can ensure a mutual understanding of intended sounds between the participants.

SHORTCOMINGS

-The tool is rather positioned as educational material and lacks in interactivity layers for more creative applications. As it is not possible to synthesize or sequence sounds using this tool. Only to playback the samples.

2.3 Sound prototyping method: Sonic Sketching

This section presents some methodologies for prototyping with sound. Sonic sketching (2.3) and vocal scribbling (2.4). Both of these methodologies can be a very accessible way of getting familiar with sound design through lofi (low fidelity) activities. In the context of UX design, these methods can be used to create quick, iterative sonic visions.

2.3.1 What is Sonic Sketching

A way for designers to prototype with sound is to engage in sound sketching [32]. The word 'sketching' is associated with an activity evolving pencil and paper, or any other visualization tool, however, the definition of 'sketching' is much broader than that.
Sketching, hereby, is an activity that can be applied to visualization as well as to prototyping physically or in this case: sonically, meaning with sound.

The emphasis on 'with' is intentional, as described previously conventional product-design practice leaves the design of sound until the very end of the project. However, designing with sound means considering the role and application of sound from the very beginning of the project [32].

The benefit of such an approach is that it allows us to explore the interplay between the interaction, embodiment and functioning of the product early on and use sound as one more tool to prototype with. This is essential for well-designed interactions as it helps you to design with more elaborate associations rather than adding some generic sound to your finished embodiment.

> *"Sketching is not about drawing, but about designing, that is, considering multiple ideas and solutions first, reflecting and distilling a subset worth being further elaborated and iteratively transformed and refined."*
> *-Delle Monache, 2020, p.80.*

2.3.2 Lack of tools for sonic sketching

When it comes to visualization we have plenty of sketching tools at hand, we have pens, papers, and tablets. Same with fast and rapid prototyping where any tinkering material can be applied to simulate a variation of the embodiment. However, when it comes to sonic sketching it becomes a bit more difficult to find suitable tools or tinkering materials.

Most of the common tools for sound design, such as DAW's (2.2) consist of a diversity of functions and are aimed at (professional) level of sound design. A side effect of such an interface is that it itself becomes complex to grasp and difficult to integrate into prototyping sessions.

A certain level of expertise is needed to be able to use these interfaces in a dynamic, reflective and responsive manner that is expected from a sketching activity.
Therefore conventional sound design tools do not apply to sonic sketching. However, existing tools can be (mis)used and lofi tools can be created (fixme foley box).

2.3.3 **Practicing sonic sketching**

The value of a sketch can perhaps be measured by how clearly and efficiently the message is communicated. Visualization skills are perhaps easier to understand as a level of expertise, one can be a very experienced (and perhaps talented) visualiser which can allow them to make quick and clear sketches.

But how does one measure or develop this expertise when it comes to sonic sketching? Just as with any tool, one needs to practice and build a certain base of knowledge to flexibly use their skills in sonic sketching.
In 'Sketching Sonic Interactions' (2020) [32] Delle Monache describes a set of exercises one can practice to develop a deeper understanding of sonic qualities.

The exercises consist of collecting and analyzing sonic objects and events. As a result, you end up with a library/archive of sounds at your disposal that you can use for sketching.

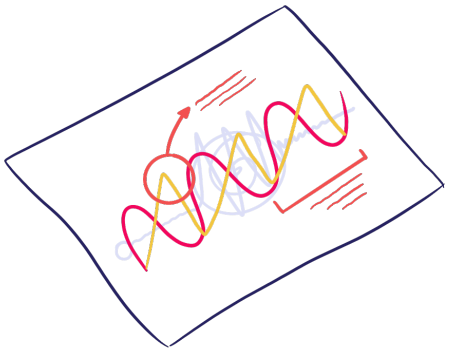


Image 20: 'Sketching' in sonic sketching does not necessarily mean using a pen and paper

The reflective sessions allow you to deepen your understanding of the sonic events, the exact ways the sound interacts with your perception and how you may want to adjust it for a more pleasurable (or not) experience.
In a way this enables you to develop your sonic vocabulary, as you may not be familiar with the official jargon of sonic design, you may want to describe the sonic events in ways that feel familiar and clear to you.
This sonic vocabulary may be personal and subjective, however, it is a good starting point for discussions and can be used to share knowledge and perspectives during sonic sketching sessions.

2.4 Sound prototyping method: Vocal Scribbling

A very natural way of sketching with sound is through vocal scribbling, which is an activity when one mimics the sound they would like to communicate with their voice.

One may confuse this with onomatopoeia, however, onomatopoeia is a tame imitation, tame in the sense that it is tamed by the language used by the person. While vocal scribbling uses non-verbal vocalizations, which are free from cultural or linguistic influence and focus on representing the intended sound as recognisable as possible.

Vocal scribbling is something we do intuitively as presented in 'Non-Verbal Imitations as a Sketching Tool for Sound Design' [30], researchers have found out that people use descriptive and imitative vocalizations in more than half of the conversations when asked to communicate a sonic experience.

Furthermore, the same research has shown that the quality of such imitations is often surprisingly high, considering that the recognition level was overall high for imitations, even for more abstract sounds that were otherwise difficult to verbally communicate.

This means that not only do we already possess a possible sonic sketching tool, but we also have proof that communicating using imitations (vocal scribbling) can be an efficient and effective way of conveying one's idea.

2.5 Application of the sound prototyping methods

To gain a deeper understanding of the design process of sonic sketching & vocal scribbling in the context of UX design the following research activities were conducted:

Individual activities
- Assembly of a foley box (image 21) (p. 44)
- Practice of the sonic sketching exercises (p. 46)
-Prototyping a paper based tool for sonic sketch prompts generation (p. 47)

Activities with participants
- User testing sessions with master students (p. 48)

This section describes the activities, the methodologies and the results from the activities. The insights are concluded at the end of this section.

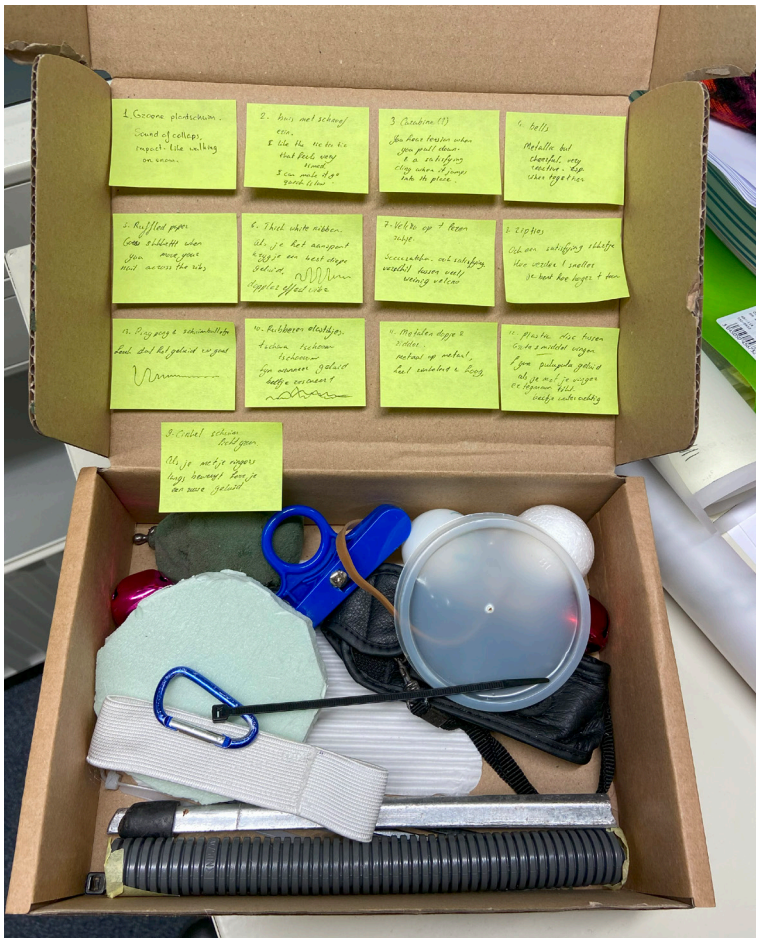


Image 21: First iteration of the Foley box, containing found sonic objects.

2.5.1 Sonic Sketching: Individual Practice

ACTIVITY

As described previously sonic sketching is a way of prototyping sounds with lofi tools which can range from your voice and body to objects found in the environment. In order to gain a deeper understanding of the sonic sketching method a series of exercises were performed based on the nine exercises noted in 'Sketching Sonic Interactions'[14].

STEPS

1. Collection of sonic objects

The first step of the sonic sketching exercises is to collect objects that generate sounds and note down what distinguished these objects for you. This resulted in a foley box with sounding objects differing in their material properties, type of sound emitted and ways of activating said sounds (image 22).

Later I expanded this collection with a variety of shakers, which I made to understand the connection between elements within the shaker and the sounds generated as a result of it.

I also added a Kalimba as I noticed that more soft, musical sounds were missing from the collection.

2. Analyze the sonic collection audibly and label the emerging associations

For the second part, I made a video recording of myself listening to each sound and describing how I experienced them. Afterwards I have analyzed the recordings and reflected on my ability to imitate the sounds and perform the exercises.

3. Vocally scribble the sonic collection

This exercise is meant to understand how sounds can be vocally scribbled using sound imitations with your vocal cords.

Image 22 (next page): Final iteration of the Foley box, enriched with more diverse sonic objects and explorations on similar sounds.


Seffe
HandCaster

RESULTS

During the exercise, I noticed that some sounds were more challenging (or impossible for me) to imitate. When I felt frustrated with my ability to imitate I would end up using onomatopoeias and descriptions of the sound. I would also often need a couple of tries before I was able to imitate the sound, there was a certain need to first explore the range and my ability to generate different variations of a specific sound.

CONCLUSIONS

Some sounds feel more natural to imitate than others, to imitate musical sounds one can use vocal cords, for sounds of shuffling and shaking one can use their tongue and the movement of the air in the mouth.
I believe that to imitate a big variety of sounds one needs to be aware of how their body can be used as an instrument.

Some imitations feel more natural as they may have more straightforward connections to our daily vocalizations, while some are very specific and difficult to imagine without exploration.
Since vocal scribbling is an important part of sonic sketching I would suggest that it could be important to immerse users into vocal scribbling so they grow more comfortable with the use of their voice and learn to navigate and expand the boundaries of their sound.

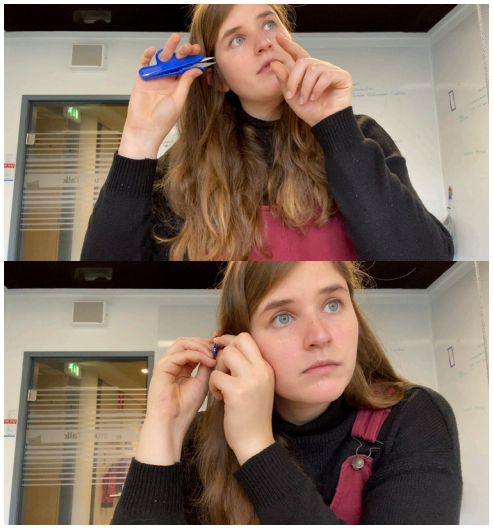


Image 23: Snapshots from the video recordings of the sonic sketching exercises

2.5.2 Sonic Prompt Generator

ACTIVITY

To explore the process of sonic sketching I have created a paper-based design prompt generator meant to facilitate quick brainstorms on possible sonic experiences around specific products and functions. The generator consists of three static elements and three dynamic ones (see image 24, figure 7).

INDIVIDUAL FINDINGS

When using the sonic prompt generator I found it useful to place the prompt within an imagined context that would provide me with more background information. This also connects with the notion that listening is an embodied experience that can not be separated from the context.

When playing around with the prompt elements I noticed that the type of product and the interaction quality were more important to me than the specific function of the product.
I found that e.g. alarming sounds would not differ much between the products, but I also noticed that the sounds I generated would often be based on my previous experiences and I did not manage to go out of the box with my sonic sketches.

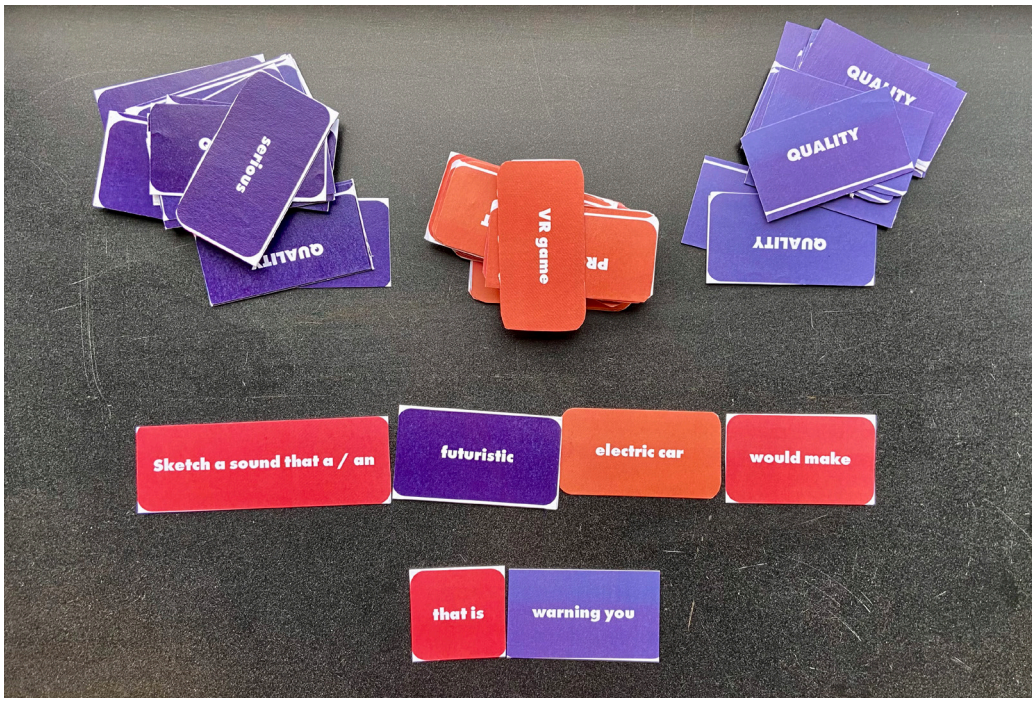
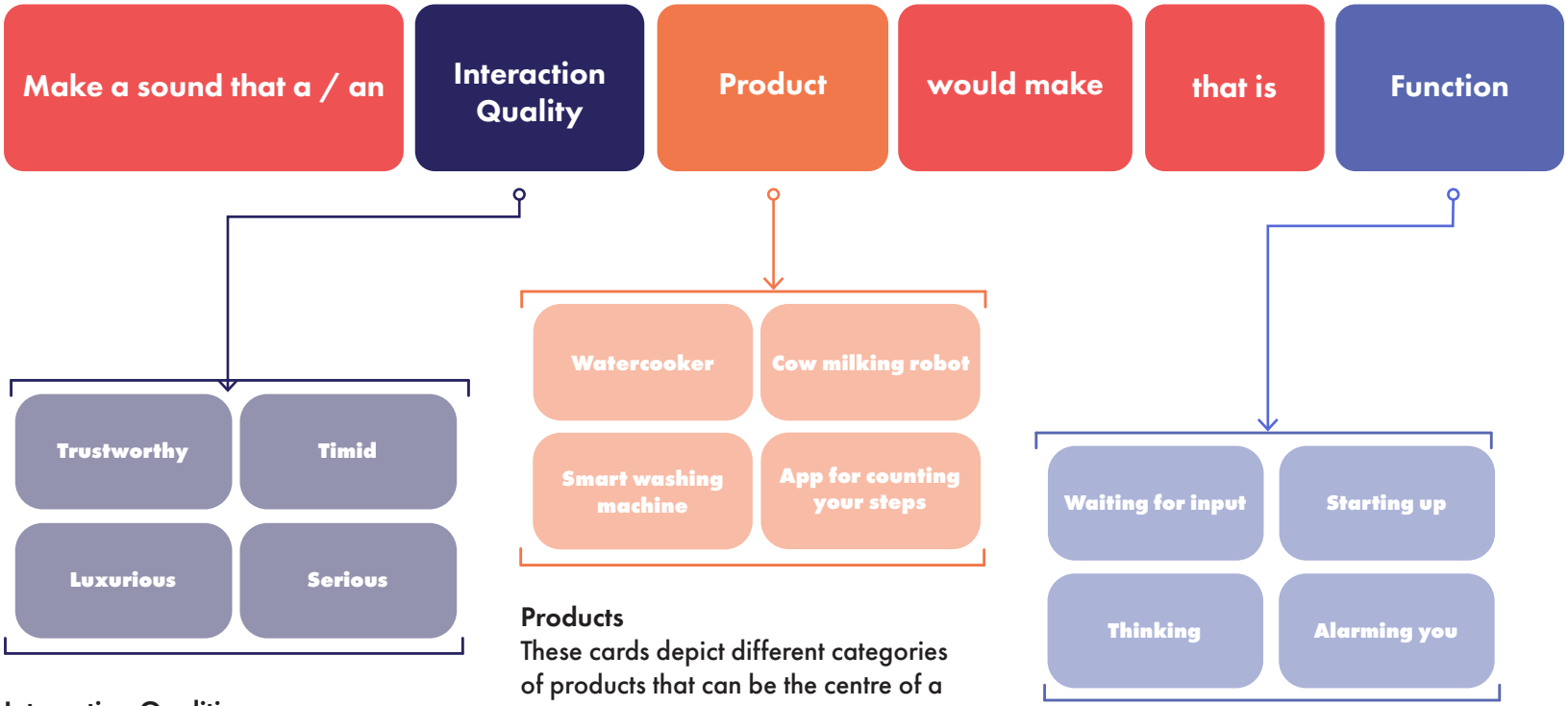


Image 24: The sonic prompt generator made with cardboard.

I was stuck on what sounds I considered to be recognisable for a specific product. However, when I later did the same exercise with my participants I found a lot of inspiration in their ability to use the sonic prompts.
The most unique and interesting outcomes were discovered when the participants based the sounds on the context and tried to embody the context through the product, rather than just finding a recognisable sound for the product.



Interaction Qualities
These cards depict various descriptives, symbolizing the interaction visions designers often use in their projects. Interaction visions are used to ensure a specific type of user experience. They help to guide the choices in different aspects of the design process towards a cohesive and consistent output.

Figure 7: The contents of the sonic prompt generator with explanations

Products
These cards depict different categories of products that can be the centre of a design brief.The categories are:
1. 'Conventional' consumer products
2. 'Unconventional' products
3. 'Smart' products (to nudge the participants to think about intentional sounds rather than secondary sounds)
4. Digital interfaces such as app

Based on the previous experience with product design, this selection should provide participants with anchor points, for their sonic sketching activity.

Functions
These cards describe the possible functions of a product. They are meant to symbolize general functions such as 'waiting for input' rather than 'pressing the continue button'. This is to ensure the coherency of the exercise.
This also allows designers to generate their own contexts of use and possible user scenarios within which their sonic sketch is experienced.

2.5.3 Sonic Prompt Generator

ACTIVITY

The sonic prompt generator was used in user testing sessions with participants. The aim of these sessions was to:

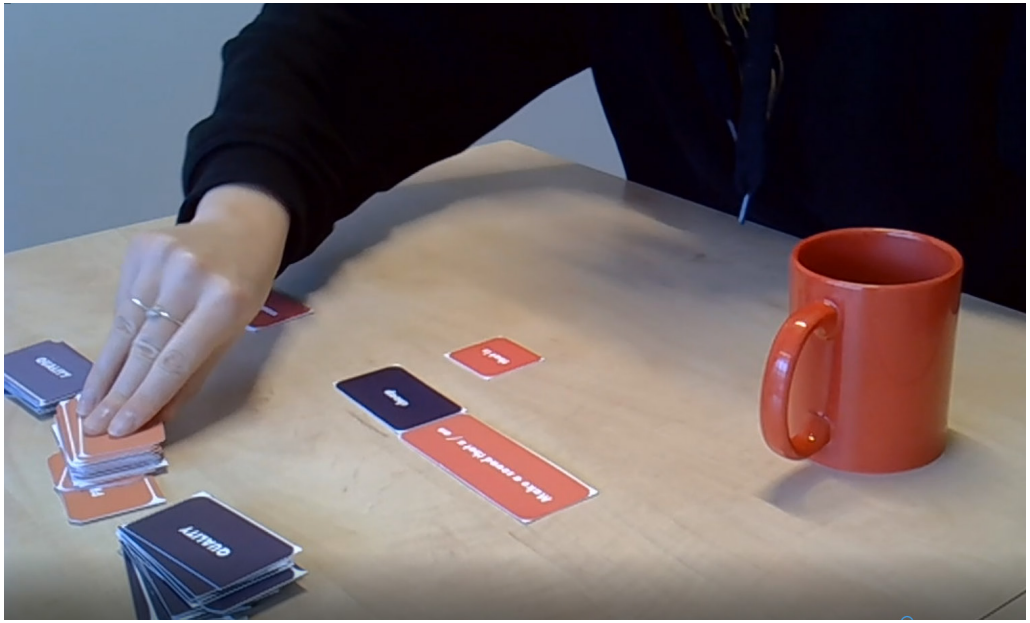
1. Learn how designers approach sonic sketching briefs
2. Learn how comfortable designers are with vocal scribbling
3. Learn whether designers can use sonic sketching and vocal scribbling to convey their ideas

METHOD

The sessions were conducted with 6 master students and 3 design experts. Participants were shown how the sonic prompt generator works and were then encouraged to explore it for themselves. Since not all combinations work well for sonic sketching, participants were allowed to remove and change cards if they felt like they were getting stuck.

During the activity, I observed how the designers approached each design prompt, whether their focus was rather on the interaction qualities, product or its functions. I was wondering which kind of input was more inspiring to participants when it came to sonic sketching.
The activity was video recorded and later analyzed using the 'on the wall' method of analysis [44].

Images 25 - 26: Photographs from the user tests with participants.



OBSERVATIONS

Participants got to choose which action aligned best with what was expected of them in the exercise. Most participants found the command 'sketch' to be confusing in the context of the sonic realm, while 'compose' made them feel less adequate about their sonic skills and forced them into a more musical mindset. Action 'Make' was preferred by most.

Participants had different approaches to sonic sketching, some were more focused on the product and imitated sounds that they associated with the product. Some would use the context and the interaction quality as inspiration for more original sounds. This connects well with the different approaches of sonic sketching: designing the sound vs. designing with sound.
Designing with sound results in more creative and out-of-the-box sketches, which can be an interesting kind of output in a design project. Especially when your goal is to differentiate your product and deepen the way of interacting with it.

REACTIONS TO THE ACTIVITY

Most participants felt comfortable with the idea of vocal scribbling and noted that they would feel the same way in a team environment. Especially the design experts were able to imagine themselves applying vocal scribbling in brainstorming.
However, there were also a couple of participants who did not feel comfortable using their voices. The reasons behind it were that they felt like they lacked the skills to control their vocal expressions. They also noted that the unpredictability of their voice held them back from fully expressing themselves through vocal scribbling. This shows an interesting design challenge for vocal scribbling.

ABILITY TO EXPRESS IDEAS

When it came to participants' ability to convey their ideas, vocal scribbling was often used in combination with other tools. All participants used descriptions and associations to convey their idea, next to wild and tame imitations. Often participants would describe a specific context in which they have heard familiar sounds or imitate said contexts. Furthermore, sometimes participants also used surrounding objects, their bodies (stomping on the floor, scratching the table) and the contents of the foley box. These were used to complement their vocal scribbles and provide context rather than substitute them.

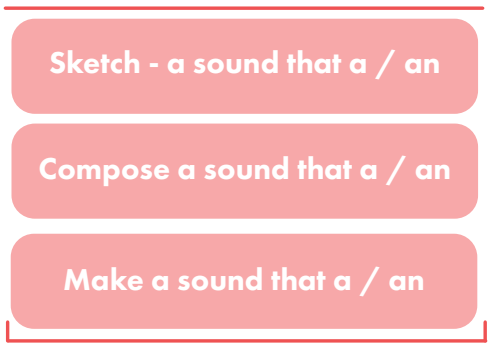


Figure 8: Different variations of the prompt

CONCLUSIONS

During the sessions it was prominent that all participants had no trouble varying the tone of their imitations, they also were able to come up with tunes and play with the attack and release of their sound. Most participants only used their vocal cords for sound imitations, they did not explore the possibilities of e.g. clicking with their tongue or creating more throat-sourced sounds. They also had trouble applying timbre-like qualities to their sketches, often they would imitate a sound and verbally describe how the sound should be perceived (e.g. warm, ringing, scratching).

Most sonic sketches ranged in duration between two to six seconds, given the context of product design it makes sense since the sounds in UX are meant to convey a message quickly.

2.6 Conclusion on the tools & methods for sound design

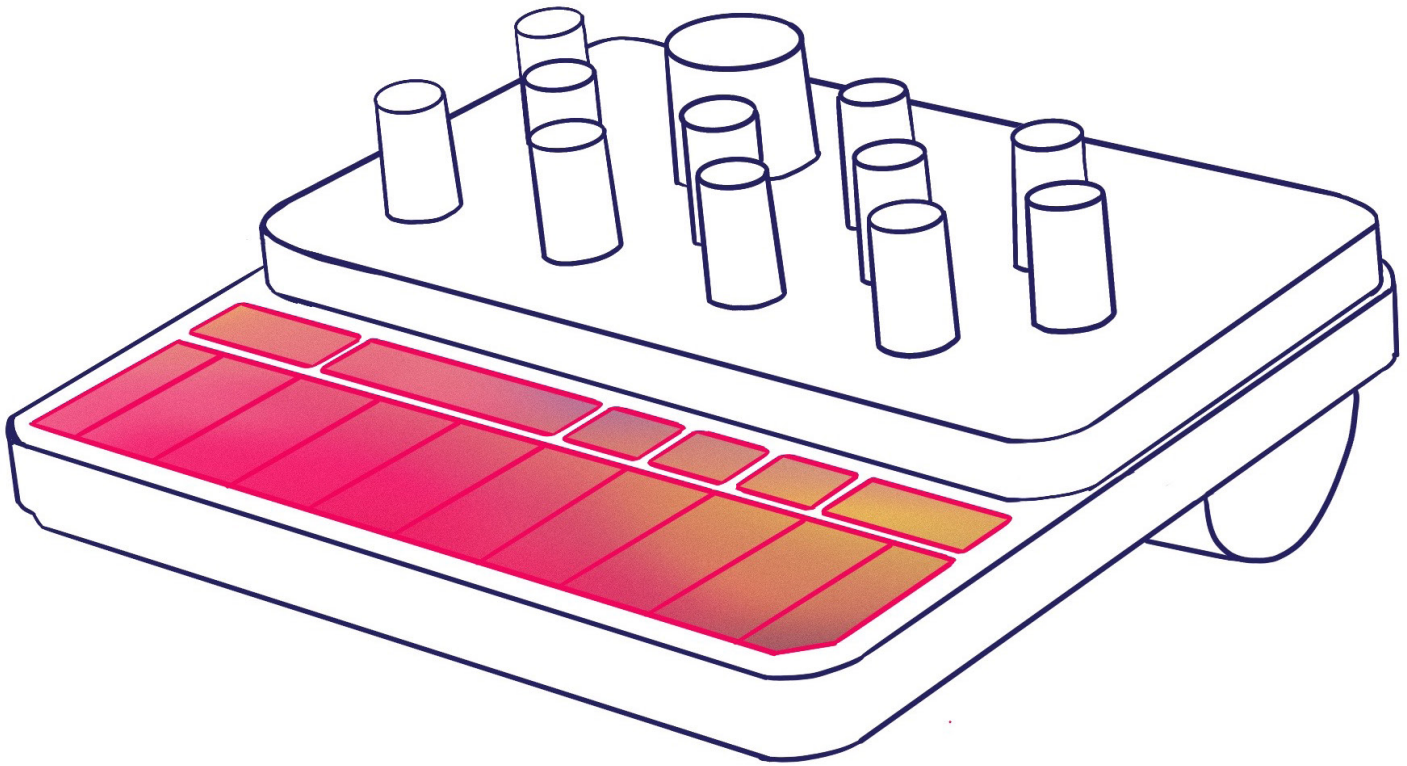
To conclude, this chapter aimed at learning about the approaches to sound design within the context of UX design and learning about the existing tools for sound design (their benefits and shortcomings).
This chapter explored various sound design tools, categorized into common sound design tools (DAWs and synthesizers) and prototyping tools for sound design (PSST! and SDT).

Furthermore, a literary study was done on sound prototyping methodologies such as sonic sketching and vocal scribbling.

Both methods can be highly effective in the context of UX design, however, the results of the user tests indicated that designers might be uncomfortable with practising vocal scribbling within groups. Furthermore, common sound design tools such as DAWs are not suitable for sonic sketching because of the complexity of these interfaces.

Overall, the insights gathered from the literary research, tool analysis, prototyping activities, and user tests contribute to a deeper understanding of the sound design process and the tools and methodologies suitable for UX designers.

The chapter highlights the importance of considering the sound design from the early stages of a project and emphasizes the need for more accessible tools and resources for sonic sketching in the field of UX design. By integrating sound design tools that facilitate sonic sketching and vocal scribbling, UX designers can enhance their ability to create well-designed interactions and communicate sonic experiences effectively.



Chapter 3

Intuitive interfaces & tangible interactions

Introduction

What does it mean for the tool to be accessible to UX designers?

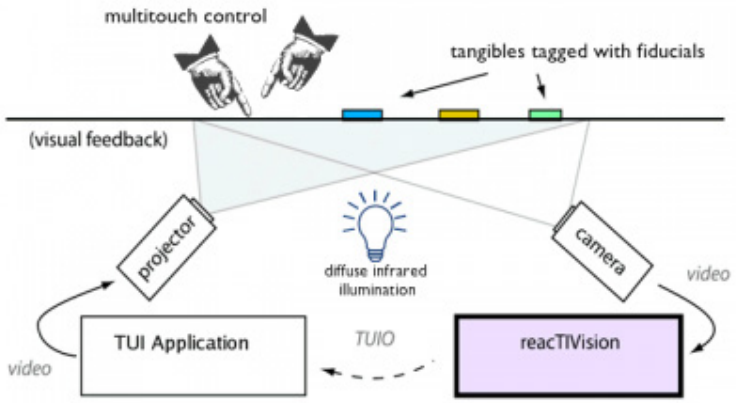
UX designers may not have the time to learn how to operate a novel interface next to their project activities. Therefore, the key to a successful tool is to ensure that UX designers can interact with sounds in an intuitive and easy-to-understand way, lowering the threshold of implementing the tool in the project. This could be achieved through intuitive interactions as well as creating recognisable to UX designers representations of sound design functions.

To facilitate the intuitive use of the interface an analysis has been made of several tangible interfaces. Tangible interfaces are user interfaces that allow the user to interact with the digital world through physical objects.

Compared to digital interfaces, the use of tangible interfaces can result in a more intuitive and engaging user experience [45]. The following examples of tangible interfaces are analyzed on the next pages: Reactable, soundFORM and Audiopad.

The world of tangible interfaces for sound is much larger than these three examples. Conferences such as the International Conference on New Interfaces for Musical Expression (NIME) [34] are a good source of the actual developments in this area and can serve as a source of inspiration as well.

This chapter also presents supporting literature for the choice of a tangible interface and explores possible tangible interactions. Furthermore, prototypes for tangible interactions are made and tested with participants to explore how tangible interactions could be used to facilitate sound design activities for inexperienced users.



Images 27 - 28: ReacTable full size (left) [iv], ReacTable technical set up (right) [ix]

INTERFACE
Reactable
(2009) [23]

GOAL & CONTEXT OF USE
Reactable is a famous tangible interface for sound synthesis often used in public spaces such as at museums and exhibitions.

The interface consists of multiple tangible elements, each representing a sound synthesis function. The users can move the objects around on top of the reactable Table while underneath the reacTIVision analyzes the positions of the blocks using computer vision [23].

The data is sent to a computer where the sound synthesis is executed.

The tangibility of the interface makes it possible to explore sound synthesis within many diverse contexts. The translations of the sound synthesis functions into visual representations create an accessible way of conveying this complex information to the users.

Image 29: ReacTable in use [xv]

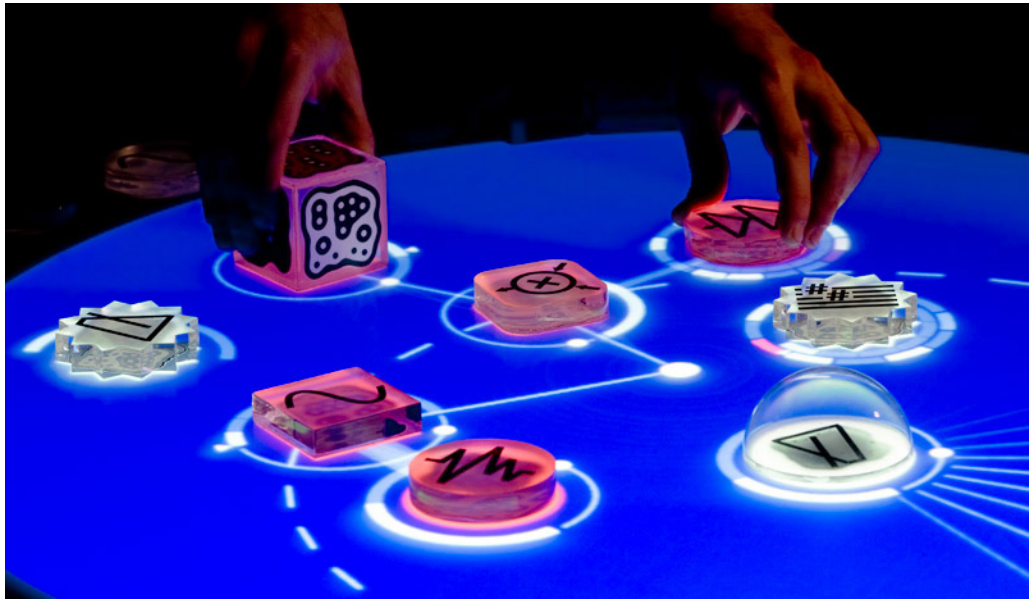


Image 30: Different tangible elements of ReacTable [iv]

TYPES OF INTERACTIONS

There are six tangible objects that the users can move, add or remove from the table

General interactions: Moving your hand through a line that connects objects 'cuts' them apart from each other. Touching the animated circle around the object results in reactivation of the connection.

OBJECTS [14] (image 30):

1. Square objects - sound generators

Rotating a generator changes the frequency, and dragging your finger around an animated circle can increase or decrease its amplitude.

2. Squares with rounded edges - sound filters

Adding a square to the connection of a sound generator results in filtering of said sounds. Filtering means adjusting certain frequencies to achieve a different sound.

3. Circular objects - controllers

Send control data to objects closest to it. The data can change the frequency of the soundwave.

4. Octagonal, or eight-sided - Control filters & pentagonal, or five-sided- audio mixers

Allow to create more complex sounds by changing shape and key of the signal

5. Hemispheric - Global objects

Create a field that affects all of the objects within the field. They can be used as a metronome, keep the time, act as a tonalizer or correct notes.

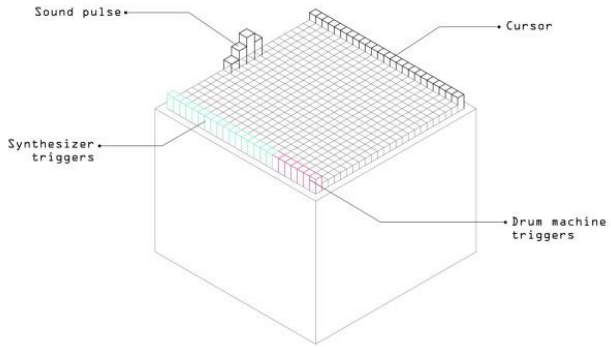
INTERFACE
SoundForms
(2016) [49] [50]

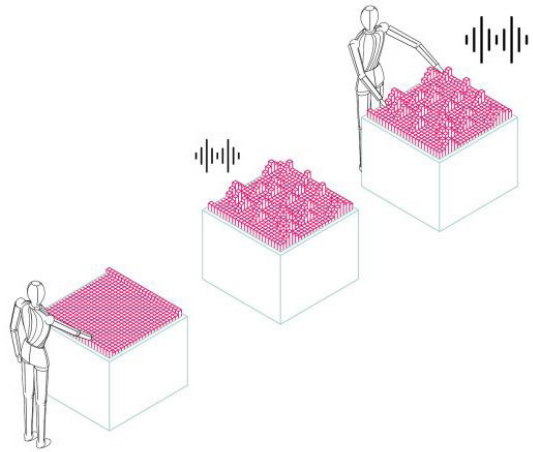
GOAL & CONTEXT OF USE
SoundForms is a pin-based shape-shifting display, designed to visualize the sound synthesis in the 3d space.

The intended use is to allow composers of electronic music (DJ's) to experience and manipulate their compositions through physical interactions.

The shape-shifting aspects of the interface are created using the shapeShift elements which are frequently used in the interfaces of the Tangible Media Group [49]. These programmable elements allow to map out a variety of data onto the dynamic surface. In this case sound signals are used as an input and through different interactions with the surface the user can modulate the sound signals.

Image 31: The SoundForms interface in use [49]





TYPES OF INTERACTIONS

This type of a tangible interface provides the user with the possibility to not only manipulate the sounds through the interface but also to experience it through a physical input.

Through the interface the user can sequence the visualized sounds and adjust them. The interface has synthesizer triggers as well as drum machine triggers. Pressing a pin at the edge of the interface (button type of interaction) plays a corresponding note.
The pins in between the cursor row and the drum/synthesizer rows serve to visualize the sound through movement. These do not work as buttons but the user can still interact with them through gestures. User can for example change the shape of the synthesizer waves through different gestures (image 32).

Lastly, pushing the pins down into the table terminates the sounds (image 33).

On top of the interface another layer of information is added through light projection. Different colours are used to highlight the current functions of the pins and their state (active/inactive).

Image 32: The technical set up of the SoundForm (left) [50]

Image 33: The interaction with the SoundForm (right) [50]

INTERFACE
Audiopad
(2002) [48]

GOAL & CONTEXT OF USE
Audiopad is a tangible interface developed by Ishii, Patten and Recht [48]. The interface is designed to facilitate musical performances and combines knob based controllers with trackable elements that can be moved multidimensionally.

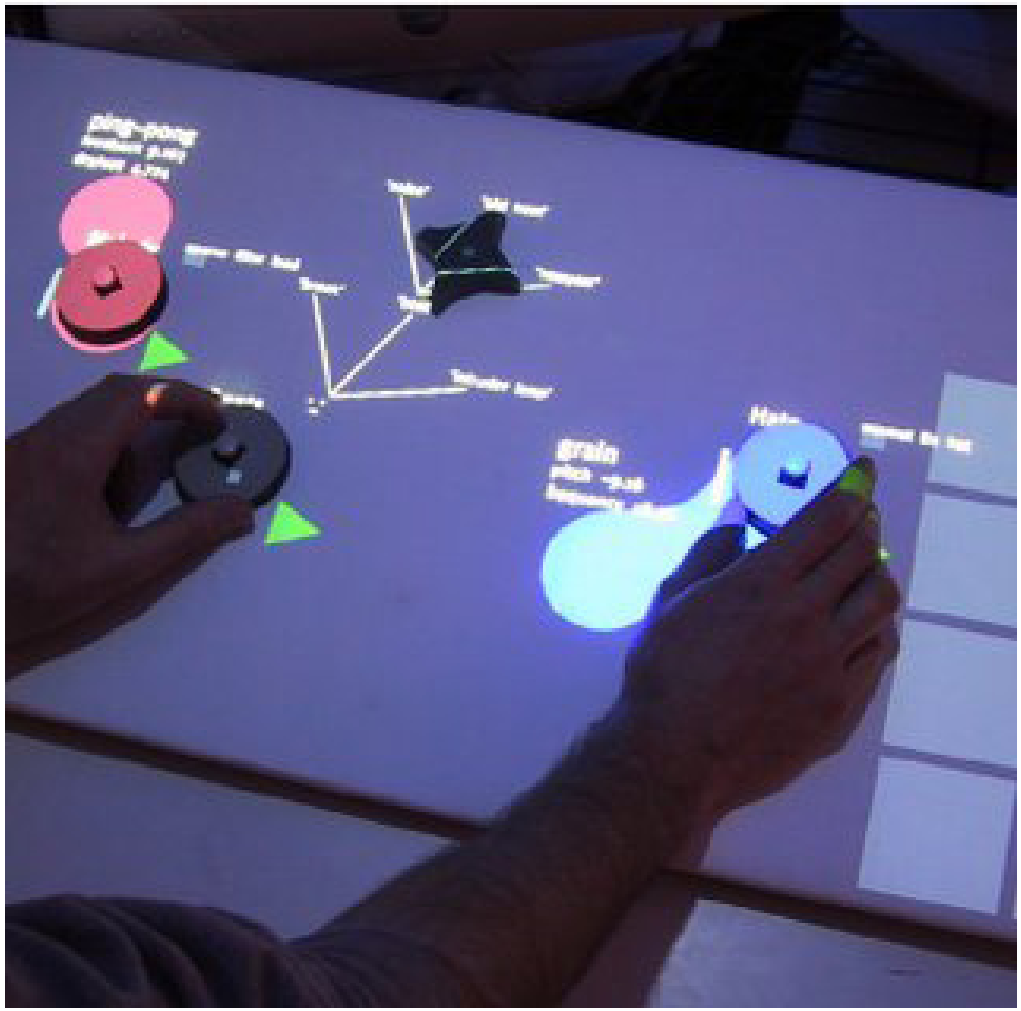


Image 34: The use of the pucks with the AudioPad [48]

TYPES OF INTERACTIONS

Audiopad consists of multiple objects, called pucks, that can be moved around on top of a surface. The objects are tracked with electromagnetic sensors (RF tags).

The interface allows for the performer themselves to assign a set of samples to each of the tangible objects. The position and orientation of the objects are then translated into sound design functions (e.g. filters, volume, speed).

An informative layer is projected on top of the interface providing the performer with graphical feedback on the audio processing (images 34 and 35).

Each of the pucks has its own function in the interface. Some pucks represent specific samples while there are also more global pucks that are used as selectors throughout the whole interface.

The design and evaluation of the interface were part of a study which concluded that use of tracked objects in combination with graphical feedback can be a "powerful and satisfying tool for musical expression" [48].

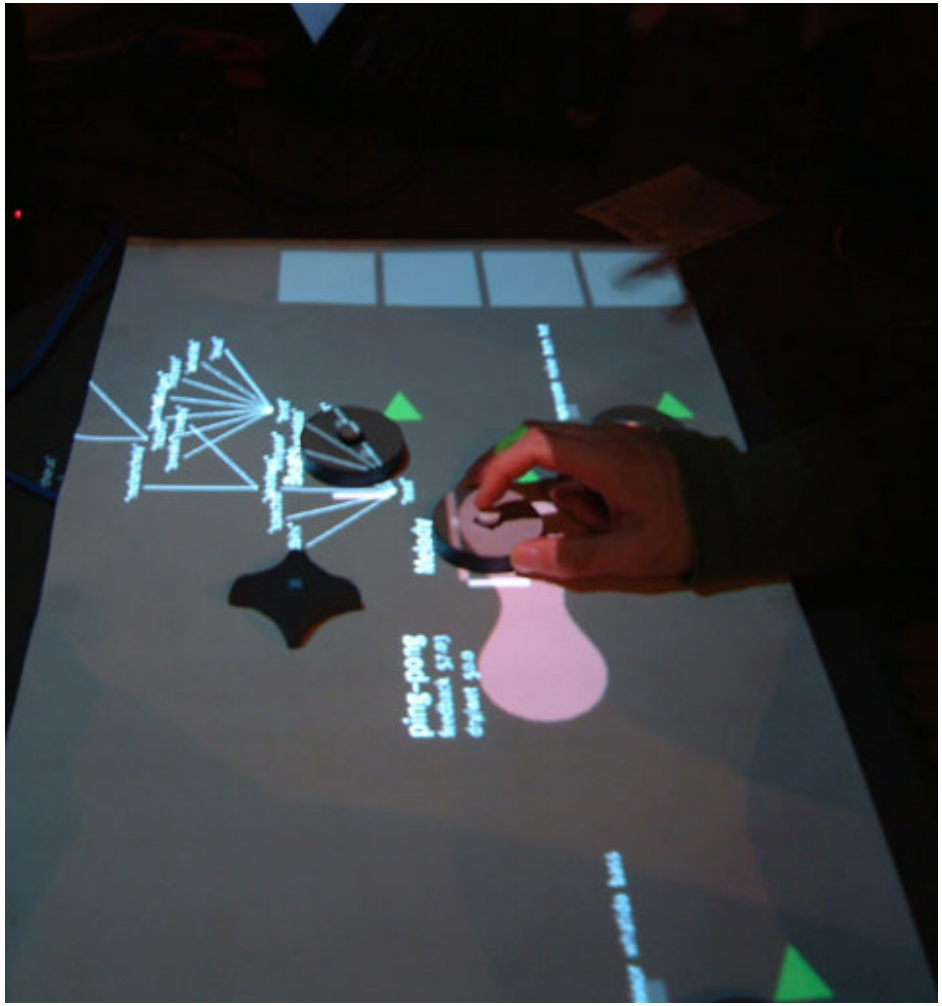


Image 35: Interaction with the decision making tree through the pucks [48]

3.2 How do tangible interfaces work?

3.2.1 Why tangible interfaces

The benefits of a tangible interface, as opposed to a digital one, is that it allows for more physicality, expressivity and ease of learning [45]. It is based on extended cognition, wherein physical objects can be used to lighten the cognitive load during an activity by providing the user with a physical representation of an action [26]. Such tangible interfaces are often used to bridge the world of sound and interactivity. They allow for creative explorations of sound beyond established sound design functions making the sound design more accessible to people with low levels of experience.

Furthermore, physical interfaces, with specific controls and actions, can help improve interaction speed and reliability as well as the speed of learning and becoming accustomed to the interface [45]. These controls could for example be objects representing a certain function. They symbolize a specific activity that can be achieved through interacting with the object. The presence of such an object and knowledge about its function is called external representation.

> *"External representation is putting the information out there in the world, so you don't have to keep it in your mind and thus your mind extends out into the world [through these external representations]"*
> *- Jelle van Dijk, Embodied Interaction Lecture 3 Part 2, 23:30 [22]*

It is important to understand the difference between external representation and external computation, both are beneficial in interface design but have different goals.
Representation is storing the information elsewhere so it takes up less space in your mind.

Computation is manipulating this information in the physical space and using this physical interaction to reason and understand the information [22].

Lastly, in group settings, a visible and tangible interface with artefacts can improve the overall learning process of the group since it facilitates indirect learning, as it is in our nature to copy each other. Learning from observing is a very strong way of attaining knowledge and skills [19].

3.2.2 Thinking through doing

In 'On distinguishing Epistemic from Pragmatic Action' Kirsh and Maglio (1994) [24], explore how performing certain actions in the real world can help one think and solve problems rather than thinking of a solution in their head. The specific focus of this work was on the game of Tetris; the goal of which is to navigate falling shapes towards a space where it would fit most efficiently. The players who moved the shape around while it was falling performed better at the game than players who would first think in their head and only then move the shape.

The reason players would move the shape around, while it's falling, is to explore different options for where the shape should fall. One could as well do it in their head, but performing these actions in the real world (as opposed to in someone's mind) helped the players make the decision. The conclusion from this research was that performing said epistemic, or exploratory, actions (e.g. moving the shape around in the air) can make solving cognitive and perceptual problems easier, quicker and more reliable.
This is an interesting point to consider when designing tangible interactions. Specifically, because it connects with the insights from the interviews with UX experts where one of the participants said that she would prefer a tool similar to a painting palette, where she could quickly try out different variations and iterate [p. 19].

3.2.3 Conclusion Tangible Interactions

Through different activities with participants, it became clear that designers often lack the vocabulary and insight into sound design; this results in them lacking confidence in their ability to work with sounds and communicate about sound design [p. 50].
Physical representations can be used as substitutions for the theoretical knowledge that the designers may lack. Furthermore, said physical representations also create a shared experience with other participants and make it possible to develop a shared vocabulary.
Moreover, giving the users an option to compute through actions in the real world could make it easier for them to explore the possibilities and share their sonic visions, especially when it comes to abstract computing such as sound design.
Although there are certain benefits to using a tangible interface when it comes to usability their physical nature can also be a shortcoming. Looking at the examples of the tangible interfaces [p. 56 - 61] we can notice that many of them require complex installations and the need to be statically installed in a space. This makes them difficult to operate in contexts that require a quick and modular installation. Furthermore, all of these interfaces have a very specific use case for which they were designed, e.g. electronic music composition, DJ'ing, and sequencing of drum beats. This narrows down their potential market reach and could explain why these interfaces are often not available for individual purchases.
In contrast, DAW such as Ableton have a much more flexible installation and can be operated anywhere and in a variety of ways. The trade-off, however, is the ease of use and visibility of interactions.

3.3 Prototyping tangible interfaces

In order to explore how participants would like to interact with a tangible interface a co-creation session was facilitated. During this activity participants were asked to design a tangible sonic sketching interface for a specific scenario. The goal of the activity was to generate rapid prototypes that could be translated into interactive prototypes later on. The guidelines that the participants were given were based on the insights from the exploratory stage.

3.3.1 Co-creation session

Activity: Co-creation session
N Participants: 4 design master students (divided in 2 groups)
Goal activity: To generate concepts & rapid prototypes

First the participants were given a short introduction on the topic and the activity. Then the participants were divided into two groups of two and introduced to their specific scenarios. Both scenarios were based on projects I learned about through the interviews with experts.

Group A was asked to design an interface that could be used in the UX design of a bus ticket machine. Group B was asked to design an interface for sonic sketching for a VR experience. Both groups first got 5 minutes to brainstorm their scenario and ask questions.

Then we had a group brainstorm session on what is important for a sonic sketching session and what tools they needed. Afterwards participants were free to design for 15 minutes. They had access to rapid prototyping materials as well as digital tools (image 36).

Image 36: Participants looking for rapid prototyping materials

Image 37: Co-creation session participants divided in groups

3.3.2 Results group A: (Bus ticket machine)

Group A created a paper-based interface of the ticket machine and brainstormed on how to select proper sounds for each interaction with the interface. They were more focused on the sounds themselves rather than the interface to make the sounds.

3.3.3 Insights group A

Sounds within one interface exist in 'families' that can be related either closely or distantly.
This group would like to have a decision making tree when it comes to sound design.
Sounds were meant to represent specific functions, as if they were translating the functions literally. e.g. using national anthems to represent the language choice.

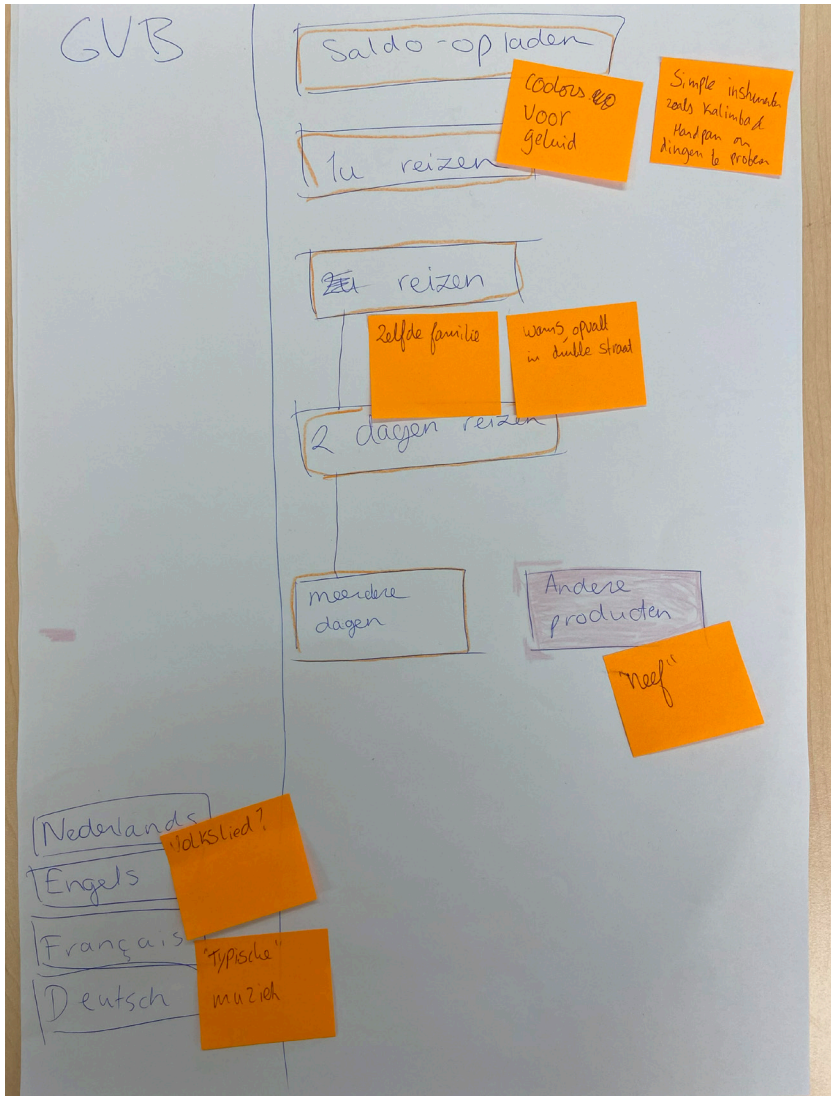


Image 38: The session output of group A, a paper based evaluation of possible sounds

3.3.4 Results group B: (VR Experience)

The VR Experience group had quite a different approach. They quickly started making a tangible interface with physical objects. Their interface consisted of an audio sample library where each object represented either a sound sample or an audio filter.
The objects were placed on the mat between the participants, its position would determine the sound qualities of the sample.
Furthermore this group thought of ways of physically manipulating the sound samples, e.g. changing its duration by physically cutting an object representing it, or stretching it out.

Lastly this group also thought about how this interface could be used in collaboration with people of different levels of expertise. The more experienced participants would get a more conventional audio interface, consisting of knobs and sliders. They would be able to apply specific changes in the samples.

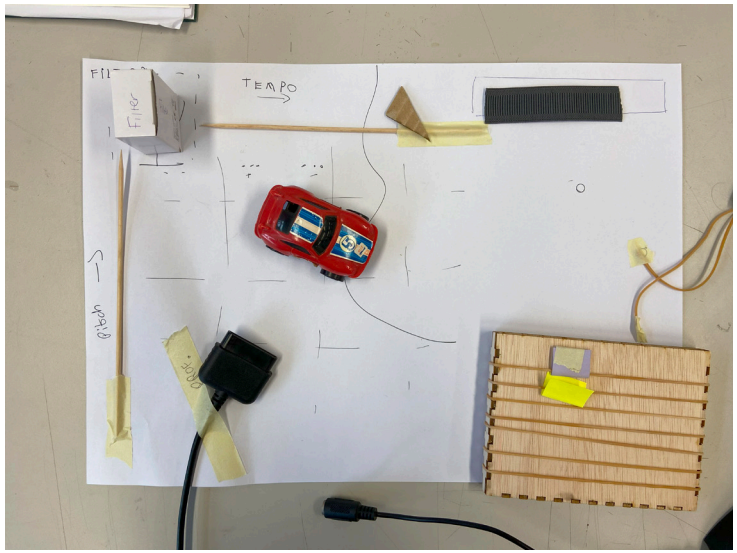


Image 39: The tangible interface prototype of group B

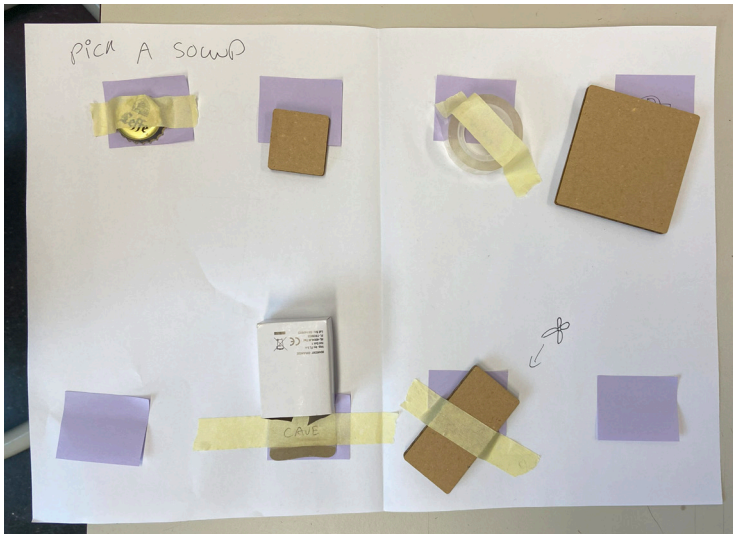


Image 40: The sample library prototype of group B

3.3.5 Insights group B

Physical objects could represent specific audio objects
A lot of the conventional sound design interactions were translated onto the tangible interface, e.g. placing a filter object on top of the sample object.
The interface can be used in different modes of expertise, there is a beginner friendly version as well as a professional sound designer version.
Participants liked to have a clear overview of all the samples and possibilities to modulate them.
Participants resonated with a visual way of interacting with sounds e.g. selecting a specific part of the sample by (literally) cutting parts of its duration.

3.3.6 Conclusion co-creation session

Overall the activity resulted in inspiring prototypes and insights on possible interactions with the interface. Both teams had interesting approaches to the design process however the results generated by group B fit more within the scope of the project and the traditional definition of a tangible interface. This difference in approach could be due to the fact that the groups received different scenarios to work with, team B receiving a more general design brief while team A received a very specific application. As a result team A zoomed in on the little aspects of interaction and thought more in depth about specific sound design approaches while team B focused more on the design of the interface and had a more flexible approach to sound design.

Image 41: The participants at work during the brainstorming part of the session

3.4 Prototyping tangible interactions

The analysis on the tangible interfaces and the interactions has uncovered many interesting approaches to making sound design a tangible process. While the co-creation session resulted in a rapid, tangible, prototype for sound design. The prototype that emerged from the co-creation session, prototype from group B, had a similar type of interaction as interfaces such as ReacTable and Audiopad, where tangible elements and their position were used as input for the sound synthesis.

Modern technology allows us to make quick interactive prototypes and explore these interactions by using software and hardware tools. ReacTable used tags and computer vision to track objects on the tabletop. This type of interaction can be prototyped using a webcam and Machine Learning algorithms.

Two prototypes were made to explore the object recognition functions of P5.js. They were based on machine learning algorithms such as YOLO (you only look once) and TeachableMachine. Machine learning combined with object recognition allows for prototyping without complex hardware, it only uses a webcam for input and through the algorithm recognizes the image and position of the object. In P5.js I have mapped out sound qualities from prototype 2 and connected it to the image recognition function.

Objects were also connected to specific samples, e.g. the cat was connected to the 'Meow' sample and the participants were able to change the qualities of the 'Meow' by moving the cat on the table.

These prototypes were useful to explore the type of input that could be used for the final concept and the way position of the objects could be related to sound design functions.

The interaction itself is quite simplistic: an object is recognized -> type of object represents the sample that is being adjusted -> movement of the object is translated into changes in the sound sample.
The simplicity of the interactions could support the intuitiveness of use and facilitate a clear and understandable user experience.

Another prototype was made to explore how drawing and visual communication could be translated into the temporal qualities of sounds (such as speed, frequency & amplitude over time). However this exploration turned out to be less relevant in the further developments of the research, more on this prototype can be found in appendix FX.

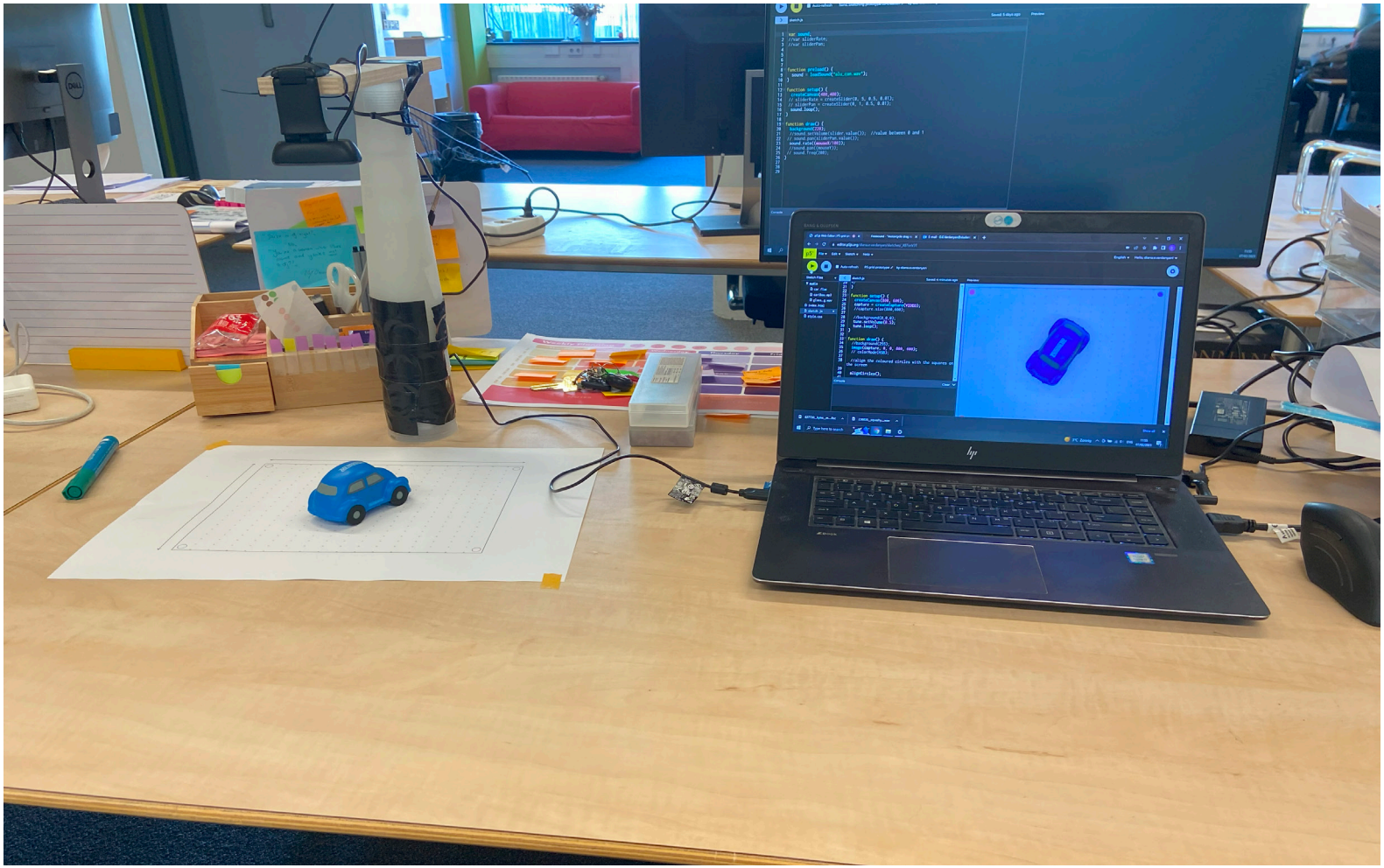


Image 42: The set-up of the object recognition prototype

3.5 Conclusion

This chapter aimed to understand how the process of sound design could be made more intuitive using tools such as tangible interfaces.

Tangible interfaces are often physical set-ups consisting of elements that the users can move and manipulate to interact with digital information.
This bridge between the physical and the digital world results in a more intuitive and engaging user experience. In section 3.1 examples of such interfaces were analyzed: ReacTable, Audiopad and soundForm.

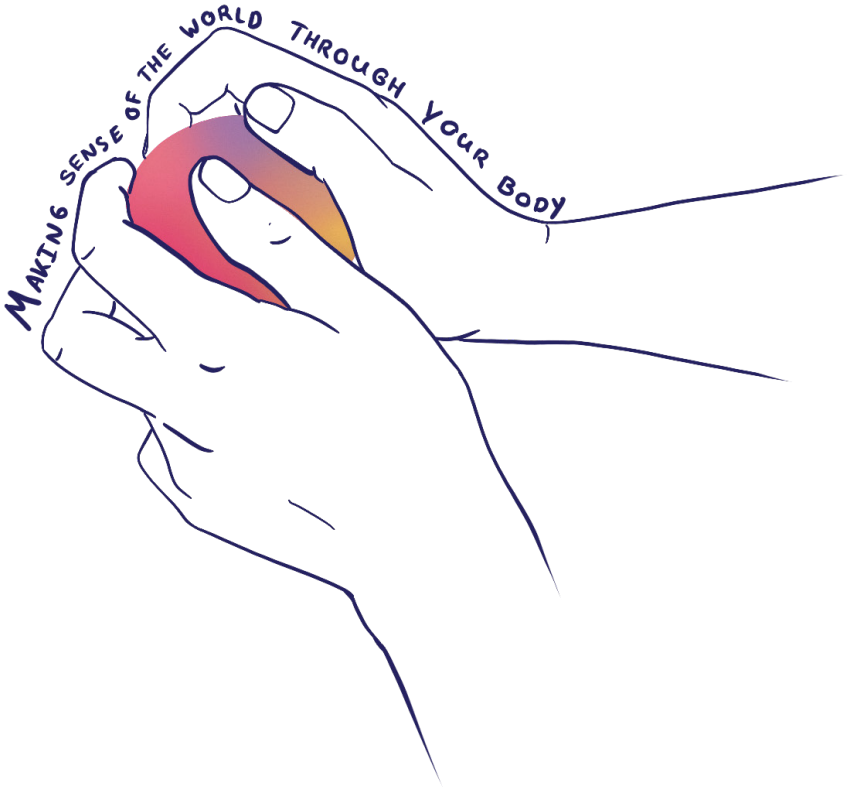
This chapter also highlights the benefits of integrating external representations and facilitation of epistemic actions in interface design, for example through the use of tangible elements. Prototype sessions involving participants further emphasized the potential of tangible interfaces.

Physical representations served as substitutions for theoretical knowledge, creating shared experiences and developing a common vocabulary among users. The results highlighted the importance of clear overviews, modulating possibilities, and visual ways of interacting with sounds.

While tangible interfaces offer usability benefits, their physical nature and complex installations can present limitations, restricting their use in contexts that require quick and modular installation.

Prototyping tangible interactions using modern technology, such as machine learning algorithms and image recognition, allows for quick exploration of sound design interactions. By mapping sound qualities to recognized objects and their movements, intuitive and understandable user experiences can be created and tested with participants.

In summary, the exploration of tangible interfaces and prototyping of tangible interactions revealed the potential to make sound design more accessible and intuitive for UX designers. Such tools can lower the threshold for UX designers to engage with sound and enhance their creative process.


MAKING SENSE OF THE WORLD THROUGH YOUR BODY

Chapter 4

Bridging of the semantic gap between the participants

Introduction

The aim of this section is to answer the question: how can we bridge the semantic gap between the different participants of a sound-design activity? Previously it was concluded that sound-design activities are often carried out in team contexts. Such teams can consist of stakeholders such as the UX designers, sound designers, clients, users and engineers.

The introduction section (p. 1) introduced the problem of the semantic gap between the participants. The presence of a semantic gap basically means that the participants within the activity have different levels of knowledge and perceive the tasks from different perspectives. It presents itself in the possible miscommunications between the participants or inability to communicate, because of a lack of a shared vocabulary or contextual knowledge.

According to the Semantic Models of Sound-Driven Design [33], there are two main research narratives that can help bridge the semantic gap between participants of sound design sessions.

1. 'Understanding, representing, communicating the listening experience' This is a research activity with the goal to establish a common understanding of the auditory experience. For example by establishing a shared vocabulary or shared representations of information that are understood by all of the participants.

2. 'Sensitizing, participating, empowering'
Facilitation of engagement and involvement of participants in the sound design process. For example by providing the participants with tools to inform them about the sound design practices.

Within this section multiple approaches are presented to bridging the semantic gap. The first approach is to provide the participants with a shared vocabulary and fill the knowledge gaps between the participants (4.1), based on the research narrative 2: sensitizing, participating & empowering.

The second approach is to create mutually understandable representations of the shared knowledge through tangible metaphors (4.2), bridging the gap through shared experiences rather than filling in the knowledge gaps, based on the research narrative 1: understanding, representing & communicating the listening experience.

4.1 Semantic Lexicons

Sound semantics refers to the study of the interpretation and communication of sonic experiences (sound). Some semantics have made their way to the general vocabulary, most people can identify whether a sound is for example 'high', 'low', 'soft', or 'loud', more complex descriptions would be 'ascending' or 'harsh'.

Within the context of sound design activities, sound designers can be considered experts in sound semantics. They have the needed background to identify and communicate aspects of the sound in technical terms (e.g. 'low-frequency sound', "low pitch', 'high amplitude').

4.1.1 What kind of information can we get from semantic lexicons?

In a literature review by Giordano et al. (2022), an overview was proposed of verbal sound descriptors, based on an analysis of 36 ontologies and taxonomies of everyday sounds [15].

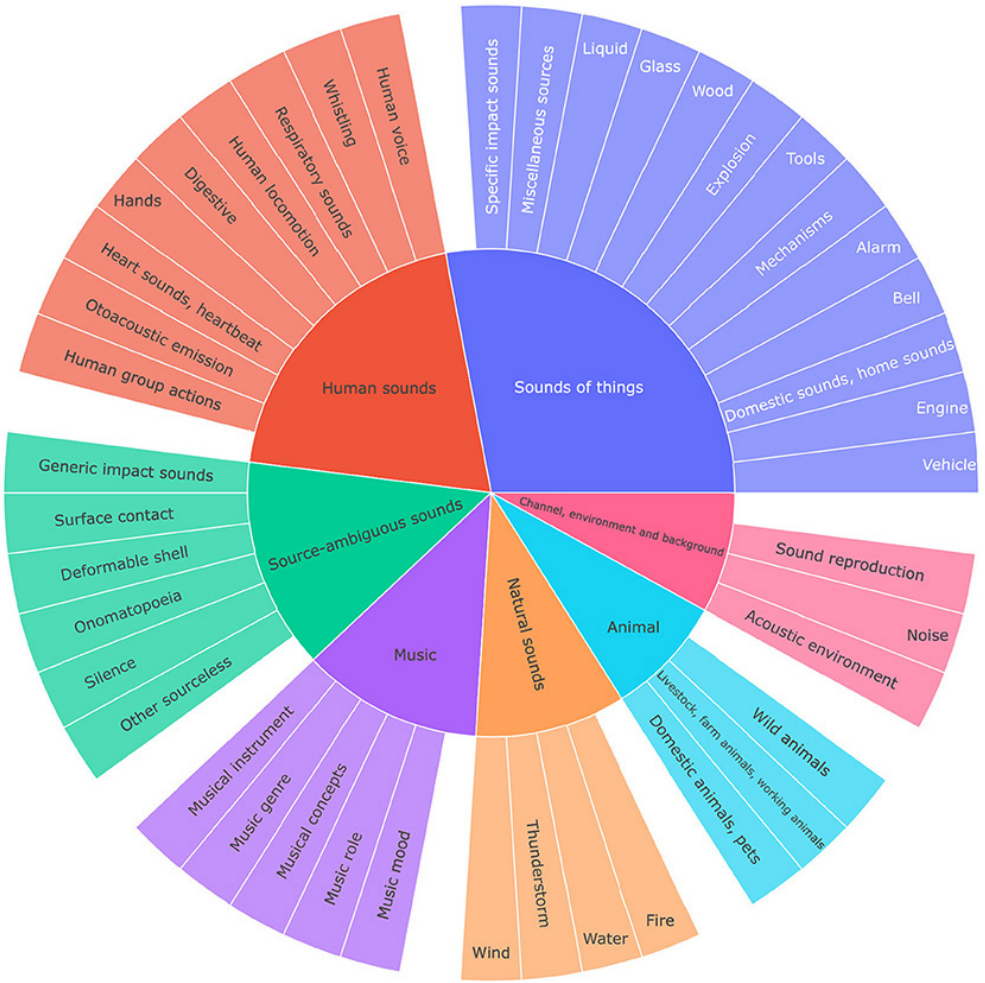


Figure 9: A sunbeam diagram showing the Audioset taxonomy of sounds [15]

The study revealed that most of the existing ontologies focus on the higher level semantic relations when it comes to sounds and their sources. As an example, most of the ontologies provide us with knowledge on how sounds are described in relation to their source (what is making the sound), relative position (where is the sound) and involved actions (how is this sound achieved).

Taxonomies such as the Audioset taxonomy present common annotations of audio-events, based on 632 audio classes [16]. The study presents a set of labels for sounds based on the annotations called the Audio Set.

These kinds of representations of data help us understand the vocabulary that is often used to describe sounds (figure 9). Using the vocabulary natural to all participants of sound design activities can ensure mutual understanding, while using specific technical language, relevant to sound designers, could result in miscommunications between the participants.

4.1.2 Design specific lexicons

There are also specific lexicons contextualized within (product) design. Özcan et al. (2014) [36] present a set of categorical descriptions used to distinguish different product sounds. The study separates product sounds into six categories:

Air
Alarm
Cyclic
Impact
Liquid
Mechanical

Each description of the sound samples from the product sound categories was analyzed using the following mental representations:

Temporal
Source
Sound Type
Psychoacoustics
Onomatopoeia
Meaning
Location
Emotion
Action

This study presents the frequency of the use of mental representations when describing the sounds from product sound categories. From this study, we can conclude that certain descriptions may be more appropriate for specific product sound categories.

This could mean that depending on the product created through the interface, a certain type of verbal representation is needed. For example, the mental representation 'source' is most often used to describe the sound product category 'liquid', if the goal of the interface is to design 'liquid' sounds it would make sense to allow for more 'source' types of input.

However, the product sound categories from Özcan et al. (2014) [36] were based on domestic types of products and the sound samples provided to the participants could be categorized rather as 'consequential' sounds than 'intentional' sounds (see p. 11). This means that, within the scope of this project, the product sound categories and the descriptions may not be as relevant for the UX design projects.

Another study on sound semantics was done by Carron et al. (2017) [7] and presented earlier in the report (p. 38 - 39). The study by Carron et al. resulted in a lexicon specifically aimed at bridging the semantic gap between different participants of sound design activities. This lexicon can be used for consequential as well as intentional sounds as the focus is on descriptions of sound qualities themselves (e.g. high/low, dull/bright, slow/fast attack) rather than the source-based experience of the sound (cyclic, air, mechanical).
Because of the contextual relevance of the words or sounds lexicon it has been selected for further explorations and prototyping within this project.

4.1.3 How does the use of lexicons help to bridge the semantic gap?

A study by Carron et al. (2015) [8] has proved that informing people on the sound design vocabulary, even in a superficial or quick paced way, improves their ability to distinguish differences in sounds and to communicate said differences. Twenty participants were divided into two groups, one group were given one hour to explore the sound vocabulary through a didactic software the other group did not. Afterwards both groups were asked to complete a test during which they had to assign descriptions to sounds.

The group that received the training scored more accurately on the pairing of the descriptions and sounds than the group that did not (57.6% of correct answers vs. 32.2% of correct answers) [8].
Therefore it can be beneficial to add an informative layer to the interface to educate all participants on the sound design vocabulary and empower them to communicate within this area of shared knowledge, thus bridging the semantic gap between them.

4.2 Cross-modal metaphors

Another approach to bridging the semantic gap is to provide the participants with representations of the sound design process and place it within the knowledge areas familiar to them. Within the expertise area of UX designers, we have found that they are skilled in prototyping visual and tactile information. Both of these skills are important in product design since visual and physical aspects contribute to the user experience of a product. Iconography is an example of the visual representation of information and tactile information can be represented as expertise in material qualities and physical forms.

A study on preschoolers has found that the sound quality timbre could be consistently mapped onto visual representations. Meaning that the same types of timbral sounds were consistently mapped onto the same visual input provided to the participants. Tests with adults resulted in similar conclusions [46]. This is an example of cross-modal metaphorical mapping, the connection between multiple sensory inputs such as visual and audio stimuli. Another study on this topic suggested the presence of an experiential congruence between the audio-tactile mappings. Meaning that we may have learned to associate certain types of audio input with specific tactile experiences e.g. fall of a large, heavy object, results in a louder sound than a small, light object. Therefore we may associate a loud sound with large and heavy representations [47].

4.2.1 Exploring cross-modal metaphors

To explore the cross-modal metaphors in the context of UX design a set of visual and tactile representations were created for sound descriptions. As the source of the sound descriptions the words4sounds. SPEAK lexicon was used (p.38 - 39). The different categories of the lexicon were translated into different types of sensory input. General qualities such as: quiet/loud, low/high, and tonal/noisy proved to be difficult to translate into physical representations because of their abstract linguistic nature.
Therefore the general qualities and the morphology qualities were translated into visual representations. The timbre descriptions proved to be more appropriate for tangible translations: qualities such as ‘dry’, ‘resonant’, ‘metallic’, ‘smooth’, and ‘rough’ evoked material-based associations.
The explorations consisted of the creation of the cross-modal representations, a pilot test of the representations with participants and brainstorming with participants on possible representations.

4.2.2 Creation of the cross-modal mappings

I have tried to translate the categories into different sensory inputs, e.g. find material properties that fit a specific sound or can help users identify the sound category without hearing the sample. The goal of this activity was to generate a tangible communication tool to facilitate the discussion about sound between me and the participants.

As I was exploring the crossmodal metaphors I noticed that the categories' general qualities and morphology were difficult to translate into tangible qualities. The timbre descriptions provided examples that could be placed into a physical space while the descriptions of general qualities and morphology were more abstract and had few connections with the physical realm.

Therefore I ended up illustrating these more abstract examples rather than trying to embody them through material properties.

For the 'Timbre' category I tried to come up with objects and materials that represented said sounds. It was clear that some qualities were more challenging to translate when they did not have a tangible physical source that could be associated with them. For example, I associated the quality 'Rough' immediately with sanding paper, however, qualities such as 'Rich/non-rich were difficult to embody.

In the end, I had a set of tangible cards that represented the Timbre sounds of the words4sounds.SPEAK lexicon which I later used in user testing sessions. Furthermore, it is important to note that the crossmodal metaphors were based on my associations. This raised the question of whether sound qualities could be translated into generally understood tangible metaphors.

Image 43: The box containing the cross-modal metaphors blocks

Image 44: Close up of the metaphor blocks. Red colour = timbre category, blue = general and morphology categories


QUIET
WARM
CLOSE
SLOW RELEASE
DISTANT
HIGH
ROUND
DRY
BRIGHT
LOUD
LOW

4.2.3 Testing the cross-modal metaphors

To test the findings from my desk research in practice I set up a user test with four participants and a pilot test. After the pilot test, I iterated the set-up to better fit the research questions.

All participants were master's students in the faculty of Industrial Design Engineering.

4.2.3.1 Pilot Set Up

The goal of this test was to understand whether there are general associations between physical properties and sounds and whether participants preferred to use verbal descriptions to identify sounds or other metaphors such as illustrations or material qualities.

The set-up was to:
1. Provide the participant with cardboard cards that either had a description written down (e.g. sharp) or a crossmodal metaphor for said description (either an illustration or a material quality).

2. Ask the participant to listen to a sound sample and select the corresponding card.

3. Ask the participant to describe how a specific sound is connected to a card.

The initial plan proved not to be as insightful as hoped for. As the associations were very subjective the participants came up with their interpretations of material qualities which rarely aligned with the associations I had.

Since the card elements were based on my subjective interpretations it was impossible to find out whether there were general associations as the participant limited to the selection I placed in front of them.

Image 45: Participant selecting the matches between a sound sample and a tangible representation

4.2.3.2 Iterated Set Up

The iterated set-up provided the participants with much more flexibility as I asked them to first brainstorm about their associations with sounds. I would play four sound samples and ask the participants to think about how they would translate these sounds into other (tangible) metaphors.
Then I would show the participants the tangible elements and ask them to choose which one fits with their associations for the sounds.

"Bright could also be hard on top, the 'dull' side could be soft, something 'slow'. If it is something hard I feel like there is more energy in it" -Participant 4

"To me, something like roughness is experienced through touch. So something tactile would be a better analogy than for example visualization because it's closer to my original experience"
-Participant 2

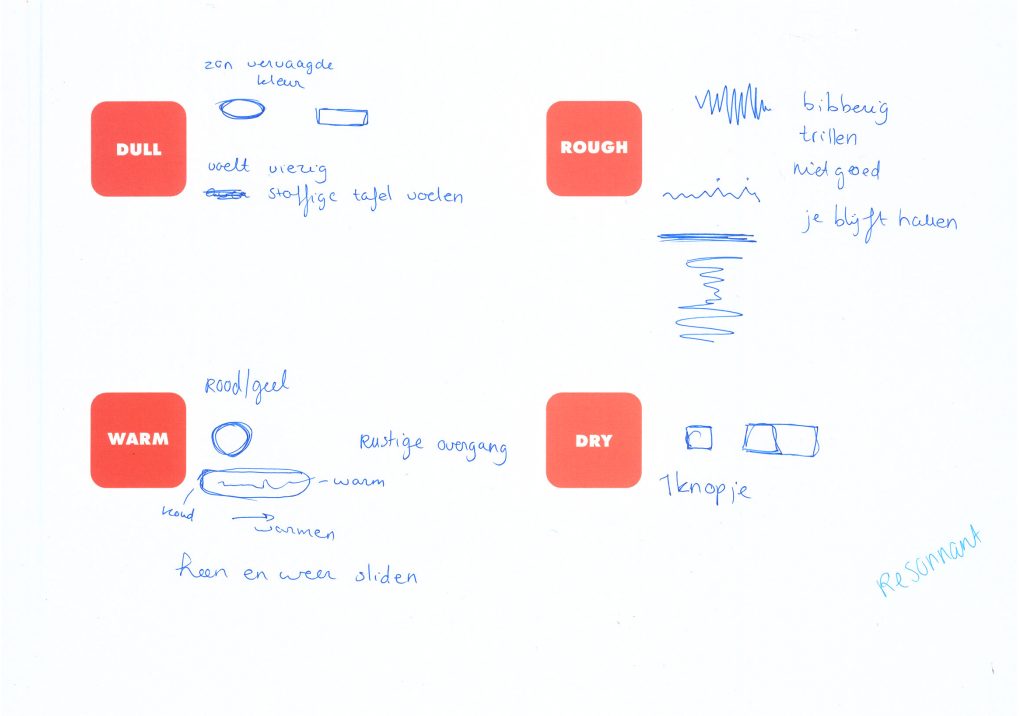


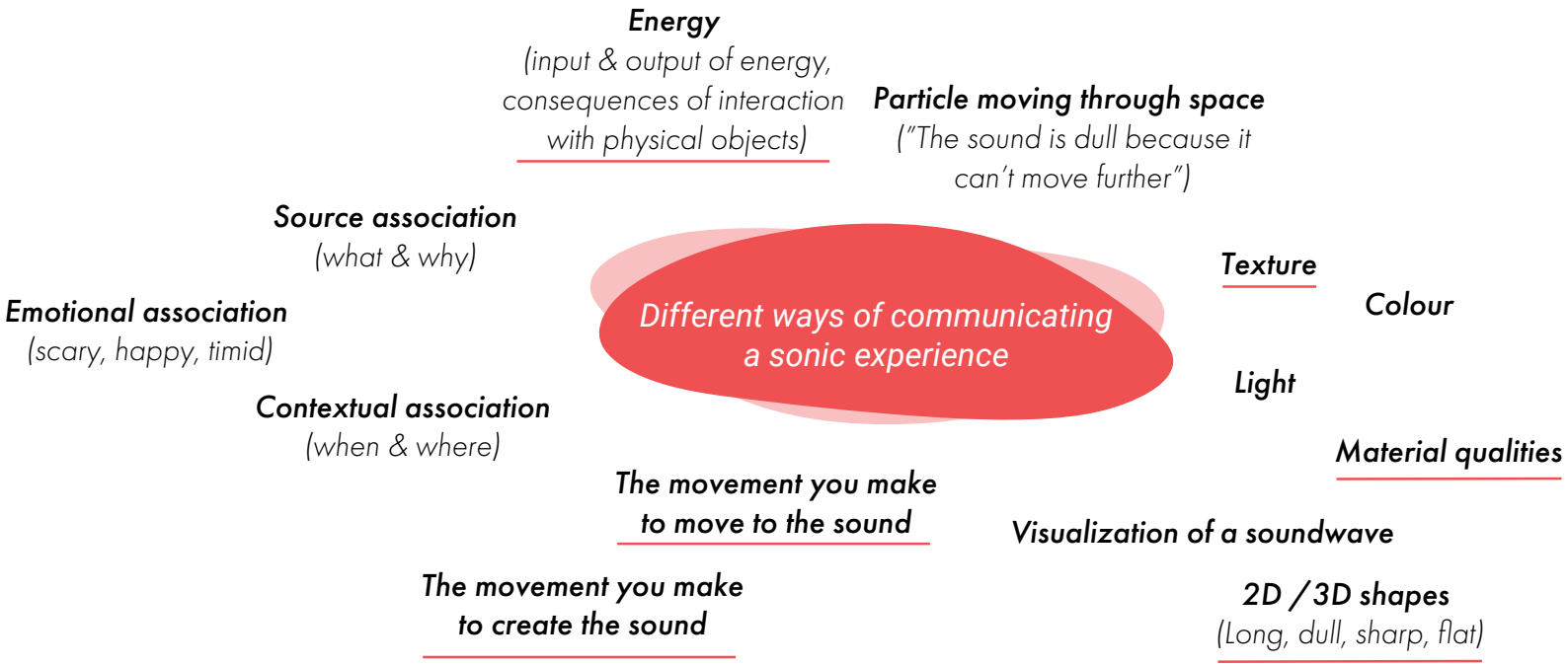
Image 46: On of the results from the brainstorming sesssion containgin the cross-modal mappings of a participant

4.2.3 Conclusion cross-modal metaphors tests

The brainstorming part of the test resulted in many interesting interpretations of the sounds. Although the interpretations still varied per person there were also clear connections for specific sounds between the participants.

Here too, the subjectivity was highly noticeable as each participant would choose a specific tangible card for different reasons, e.g. one participant would choose a card with plastic lego blocks for its complexity to describe a 'rich' sound, while another would choose it for its smooth surface to describe a 'smooth' sound.

Figure 10: Overview of the different ways of communicating a sonic experience, based on the input from the participants



4.3 Challenges of cross-modal mappings

The studies analyzed in this chapter, on the cross-modal mappings between sensory input and timbre, were often limited to only a couple of variables. One of the studies analyzed the association between light and dark visual input combined with loud and soft sounds.

To portray a more complex overview of sounds, consisting of multiple sound qualities, a more elaborate study would be needed on the cross-modal mappings. During the user tests it became clear that the mappings chosen for the test were very subjective, during the pilot the participant had trouble identifying the intended mappings and often created her associations for the presented tangible metaphors and sounds. The same became evident during the brainstorming sessions with participants where each of the participants had a different association for the provided sounds.

These unreliable findings made it difficult to find consistent cross-modal mappings for the sounds. To gain a deeper understanding of this topic an expert on sound semantics has been interviewed in an informal setting.

Patrick Susini is one of the main contributors to the wordsforsounds. SPEAK lexicon and was asked to react to some of the findings from this research based on his expertise. He confirmed that currently there are no direct mappings of metaphorical associations between words, tactile experiences and sounds. Indirect mappings could be achieved, e.g. by asking the participants to describe objects {a, b, c} and sounds {a, b, c} and analyzing how the descriptions overlap. However such mappings, too, are not reliable enough yet to facilitate complex interactions between tangible objects and sound design functions.

4.4 Conclusions

This chapter aimed at understanding how we could bridge the semantic gap between the participants of a sound design activity. The semantic gap in this context is the difference in knowledge and the ability to express this knowledge between stakeholders such as UX designers, sound designers, users, clients and engineers.

The bridging of the semantic gap can be achieved through two approaches: by establishing a common understanding of the auditory experience (e.g. through a shared vocabulary) or by facilitating the engagement and involvement of the participants in the sound design process (e.g. by providing them with tools).

For the first approach, literary research was conducted on sound lexicons. The lexicon most suited for the context of this project ended up being the wordsforsounds.SPEAK lexicon.

Furthermore, (tangible) representations of sound lexicons are explored as ways of making sound design more accessible to UX designers. This is done through the creation and evaluation of cross-modal metaphors, with participants and supported by literary research into sound semantics and metaphorical mappings of sound qualities such as timbre.

The use of metaphorical mappings was certainly an interesting and inspiring experience however the results turned out to be very subjective.

The studies on cross-modal mappings are often limited to only a couple of sound types and mappings (e.g. loud & soft sounds mapped onto dark & light visual inputs). With these limitations, it is not possible (yet) to map out the full complexities of sounds, provided by the wordsforsounds.SPEAK lexicon, onto physical experiences.

This was also confirmed through an informal chat with Patrick Susini, a contributor to the wodsforsounds.SPEAK lexicon, who said that currently there are no reliable direct mappings for metaphorical associations.

Chapter 5

Formulation of the design guidelines for sound prototyping tools

5.1 The User Journey

5.2 Design Guidelines

Introduction

Since the desired outcome of the project is a prototype of a product it could be helpful to have a set of design criteria or guidelines to navigate the design process.
This chapter presents the desired interaction scenario of the sound design activities in UX design, the contents of the scenario are based on the insights from the interviews with the experts (see chapter 1).

Furthermore, a set of guidelines are formulated to navigate the design process of a sound prototyping tool.

The guidelines are based on the questions provided in the 'List of Requirements' methodology (p. 103) from the Delft Design Guide [52]. Parts of the methodology were selected based on the scope of the project.

The explorative nature of this project means that certain design criteria are not as necessary to consider as during a real manufacturing process of a product. Therefore the focus has been more on experiential and functional design guidelines.

Lastly, this chapter presents an overview of the findings from previously conducted research activities and how these resulted in the formulation of the design criteria.

5.1 The User Journey

A user journey, or here rather an interaction scenario, is an overview of the timeline during which a product is relevant to the user. It can serve to visualize the behaviour of the user during the use of the product, their experiences or contextual factors (when, why, where). Creating the user journey was a helpful exercise to understand the different needs of the users at different moments of interaction (figure 11).

The user journey portrays the iterative process of prototyping with sounds in a UX design process. The starting point is often the interaction qualities (p. 22) distilled from the design brief. After that, an explorative stage starts where the designers try to find connections between auditory experiences and the interaction qualities.

Currently, this happens through browsing sample libraries (p. 22) which can be a draining process, both time-wise and energy-wise. In the journey, the preferred way of exploring is by quickly understanding the sonic space in which the designers want to operate and making quick sketches of the sounds that they can compare with each other, discuss, adjust and finally share with the sound designer.

Professional sound designers are often involved in the projects to create the final sound samples, however, this collaboration with the UX designers is prone to miscommunications because of the semantic gap between the participants.

This gap could be bridged by:

1. sensitizing the UX designers to the possibilities of sound design and the fitting vocabulary. That way they can feel empowered to communicate with the Sound Designers using the same lexicon.

2. Providing the designers with tools to generate sonic sketches that they can share with the sound designers rather than having to communicate through metaphors and descriptions.

The final part of the desired user journey is the creation of shareable samples that can be forwarded to the sound designers for further iterations.

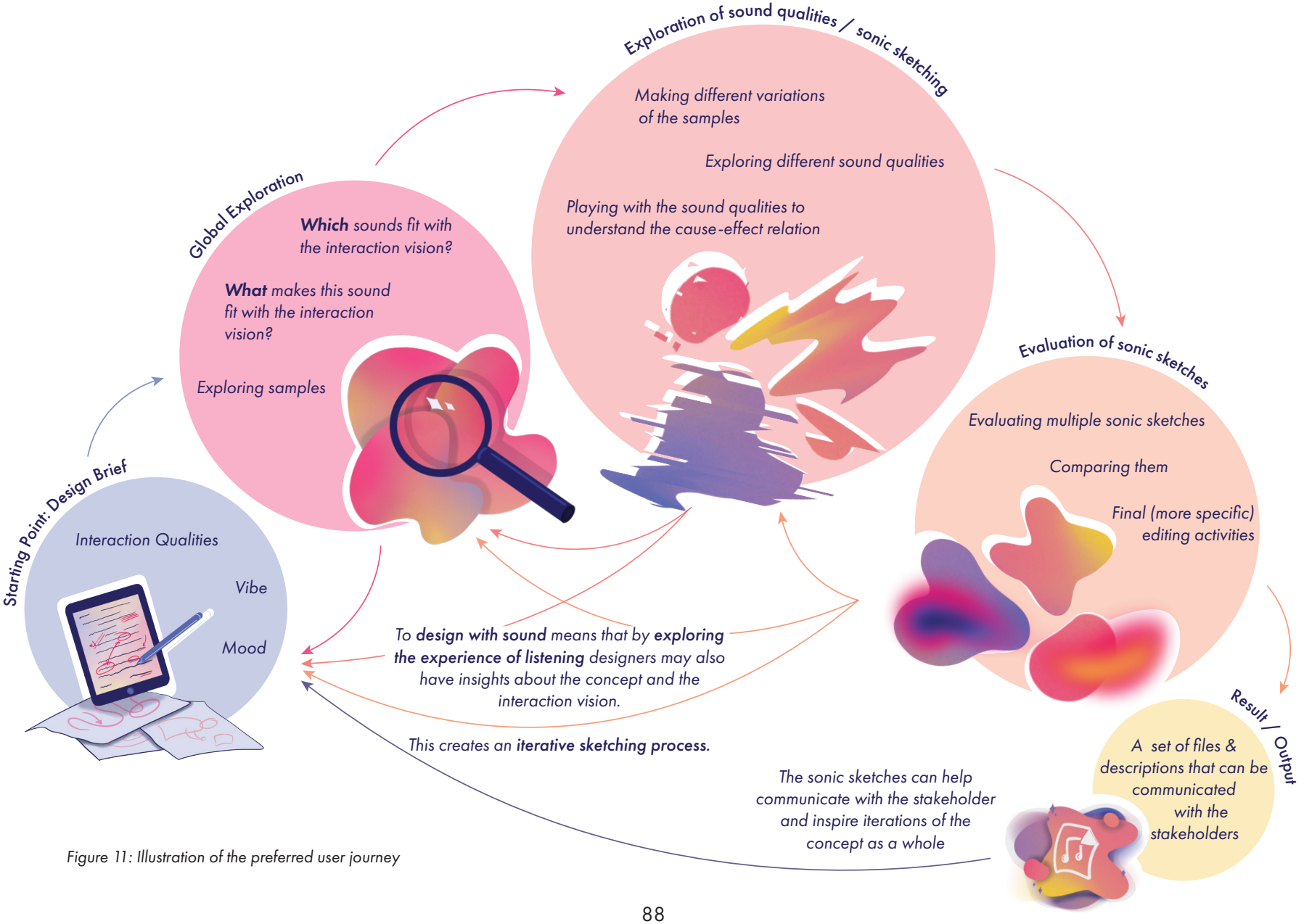


Figure 11: Illustration of the preferred user journey

5.2 Design Guidelines

This section presents the formulated guidelines, based on the insights gathered from the design research activities conducted during the project. The insight from the activity that the guidelines refer to, can be found on the pages noted down next to the guidelines.

These guidelines are based on the insights from the interviews with the experts (p. 22) and are also portrayed in the user journey (p. 88).

1a. The tool should support the traditional sketching process of starting broad and gradually zooming in on specific sounds.

2a. The tool should let users create multiple sonic sketches and compare them to each other.

3a. The tool should be clear, in its form and its functions to facilitate collaboration and discussion.

These guidelines are based on the research into the semantic gap (p. 73) and the insights from the interviews with the experts (p. 22)

4a. The tool should be clear and accessible to users with different degrees of expertise.

5a. The tool should support the formulation of a shared language to bridge the possible semantic gap between the participants.

v

During the user tests the students noted their need to have a clear overview of the possible interactions (p. 50), this was also confirmed during the co-creation session (p. 66).

6a. The tool should provide its users with a clear overview of the functions.

7a. The tool should translate sound design functions into something recognizable to designers from their expertise.

Based on the studies on tangible interfaces we can conclude that the use of tangible interactions in an interface can result in a more intuitive and engaging user experience. To facilitate this in the sound prototyping interface the following design guidelines were formulated.

8a. The tool should enable the user to practice epistemic actions.

9a. The tool should enable the bridging of digital and tangible information through the use of external representations.

10a. The interactions with the tool should be visible to all participants, to ensure indirect learning through observations.

Furthermore, some of the insights from the activities resulted in the formulation of preferred (added) functionalities rather than general design guidelines. These illustrate the desired affordances of a sonic sketching tool in the context of UX design:

1b. The tool should enable the users to add their own (contextual) samples to the interface.

2b. The tool should be easy to transport and set up.

3b. The tool should enable the users to save and share samples.

4b. The tool should allow the users to embed the sound prototypes (sonic sketches) in their context of use.

Lastly, some of the insights were translated into possible guidelines for future iterations. These were outside of the scope of the project due to the time limitations, however, integrating these guidelines in the future could improve the functionality of the tool.

1c. The tool should learn from the process and adapt to the needs of the team.

2c. The tool should enable the layering of sounds and make them more complex.

3c. The tool should support vocal scribbling & imitations but not rely on it.

Chapter 6

Conceptualisation of a tool for sound design

Introduction

This chapter presents the conceptualization steps taken to achieve the resulting preliminary concept for a sound prototyping tool.
The conceptualization steps are organized based on the design guidelines proposed in chapter 5.

Using the results of the conceptualization steps a preliminary prototype was created and user tested with participants. The iterated prototype has been developed further into a digital interface for sonic sketching and evaluated through the second round of user tests.

6.1 Brainstorms based on the design guidelines

The design guidelines are divided categorically to organize the brainstorming activities efficiently. The categories are:
Guidelines regarding the **information presented by the tool**
Guidelines regarding the **interactions with the tool and its user flow**
Guidelines regarding the **functionality and affordances** of the tool
Guidelines regarding the **physical presence/ shape of the interface**

Based on the needs of the UX designers, specifically in collaboration with professional sound designers, it can be concluded that overall designers need an exploratory tool that allows them to quickly explore and iterate sound prototypes. This type of sound design activity fits within the prototyping phase of a design project.

The starting point of the interface should be recognisable to the designers' elements that they can connect to the interaction qualities from their project.

Through the use of the tool, designers want to create several sound prototypes (sonic sketches) and compare them to each other.

To do that it also needs to be decided what type of sound design functions should be available to designers. Commonly used sound design tools such as DAWs often consist of a variety of options that complexify the interface and may be irrelevant within specific contexts, such as the applications in UX design (p. 31).

Therefore there is a balance between the flexibility of the tool and the complexity of the interface.

The desired outcome of the use of the tool is the creation of sonic visions or sonic sketches that can be shared with other stakeholders for further discussion and iteration. Another outcome of the use is the development of sound-related knowledge and expertise of the users.

6.1.1 Guidelines regarding the information presented by the tool:

3a. The tool should be clear, in its form and its functions to facilitate collaboration and discussion.

6a. The tool should provide its users with a clear overview of the functions.

4a. The tool should be clear and accessible to users with different degrees of expertise.

7a. The tool should translate sound design functions into something recognizable to designers from their expertise.

Based on the insights from the user tests in chapter FX as well as the interviews in chapter FX it can be concluded that UX designers lack the knowledge and vocabulary needed to communicate about sounds. Designers do have expertise in visual and tactile types of interactions and can come up with interaction qualities and metaphors to conceptualize their projects (p. FX).

There are no direct metaphorical mappings between sound qualities and interaction qualities (p. FX), however, through listening designers should be able to explore which sounds align with their proposed interaction criteria. To facilitate this listening experience a starting point is needed in the form of a sample library.

As a source of the sample library the wordsforsounds.SPEAK lexicon was chosen because of its contextual relevance. The lexicon consists of three parts: general qualities, timbre and morphology.

General qualities describe the intensity and pitch of a sound. Timbre is associated with what the sound feels like. Morphology describes the temporal variations of the sound.
Because of the experiential similarities between the interaction qualities and the timbre descriptions the timbre category was chosen as the starting point of the interface.

To translate the sound function into something recognizable to the users (UX designers) visual representations were used. Although the visual representations can still be considered a subjective type of cross-modal mapping, they serve as a way to differentiate the different elements of the timbre category: *dull/bright, smooth/rough, dry/resonant, non-/nasal, non-/rich, non-/round, non-/warm, non-/strident, non-/ metallic.*

The elements of the timbre categories are differentiated through the following sound qualities:

Amount of high-frequency energy: high / medium / low;

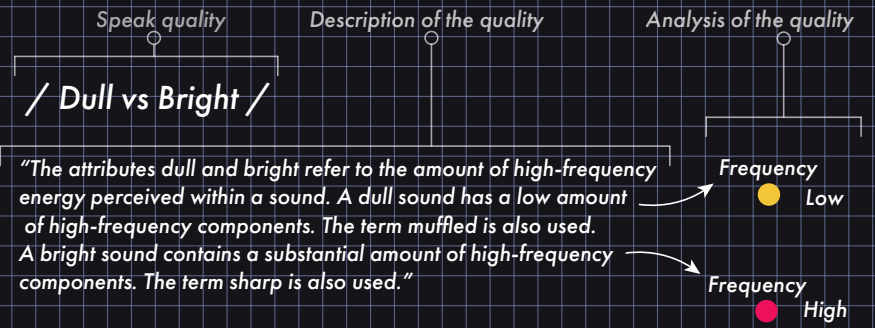
Temporal Asperities: absent / present;

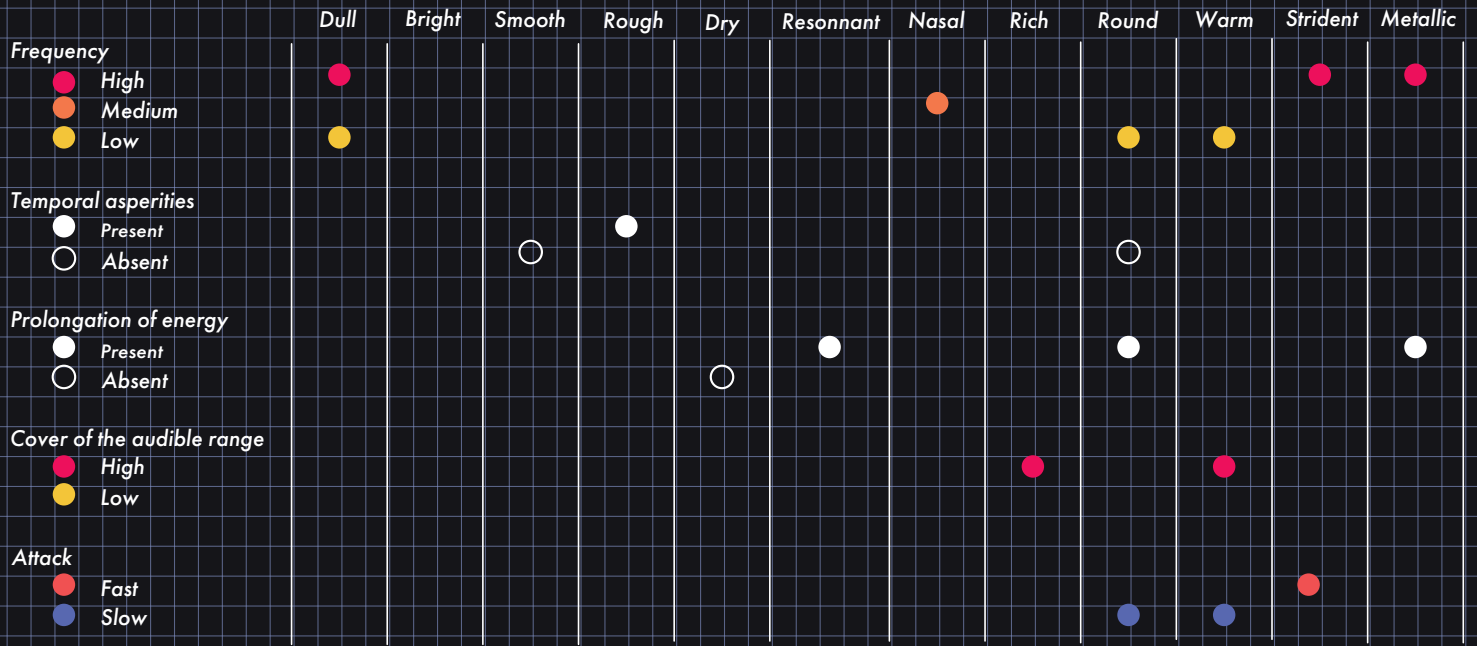
Prolongation of Energy: present / absent;

Cover of the Audible Range: high / low;

Attack: slow / fast.

By analyzing the descriptions of the timbre elements (figure FX) the following overview was created (figure FX), presenting the possible overlaps between the sound qualities. For example, Bright sounds are considered Bright because of a large amount of high-frequency energy in them. The same can be said for Metallic sounds, however, Metallic sounds also have a high prolongation of energy, while Bright sounds do not necessarily.





By analyzing the descriptions of the timbre elements the following overview was created (figure 12), presenting the possible overlaps between the sound qualities. For example, Bright sounds are considered Bright because of a large amount of high-frequency energy in them. The same can be said for Metallic sounds, however, Metallic sounds also have a high prolongation of energy, while Bright sounds do not necessarily.

This is a highly subjective analysis since the sound qualities are more complex than that and we cannot say that all of the Metallic sounds can also be considered Bright. However, this analysis can be used to create a visual representation of the timbre category (figure13).

Figure 12: Analysis of the sound attributes in of the timbre category

Each of the areas in the visual representation stands for one of the timbre elements. Multiple sketches have been made of this visual representation and this version has been chosen because of its similarity to a spatial representation. Portraying the sound design functions through visual representations should help to make the interaction process more intuitive and approachable to UX designers.

The connections between the elements are shown through the overlapping parts. For elements: Smooth vs Rough, Dry vs Resonant, Strident and Metallic different textures were used to differentiate them. For elements: Rich, Warm and Dull vs Bright different colours were used for the same reason.

Patrick Susini (who has worked on the SPEAK lexicon) [FX] has said that the interpretation of the library as a map could be a good exercise to gain insight into the timbral space and although it is a subjective representation it could be interesting to explore how each user would create their map.

This has inspired the idea that the interface could also enable the users to shape their timbreworlds, e.g. by uploading samples or deciding on which samples should be positioned where.

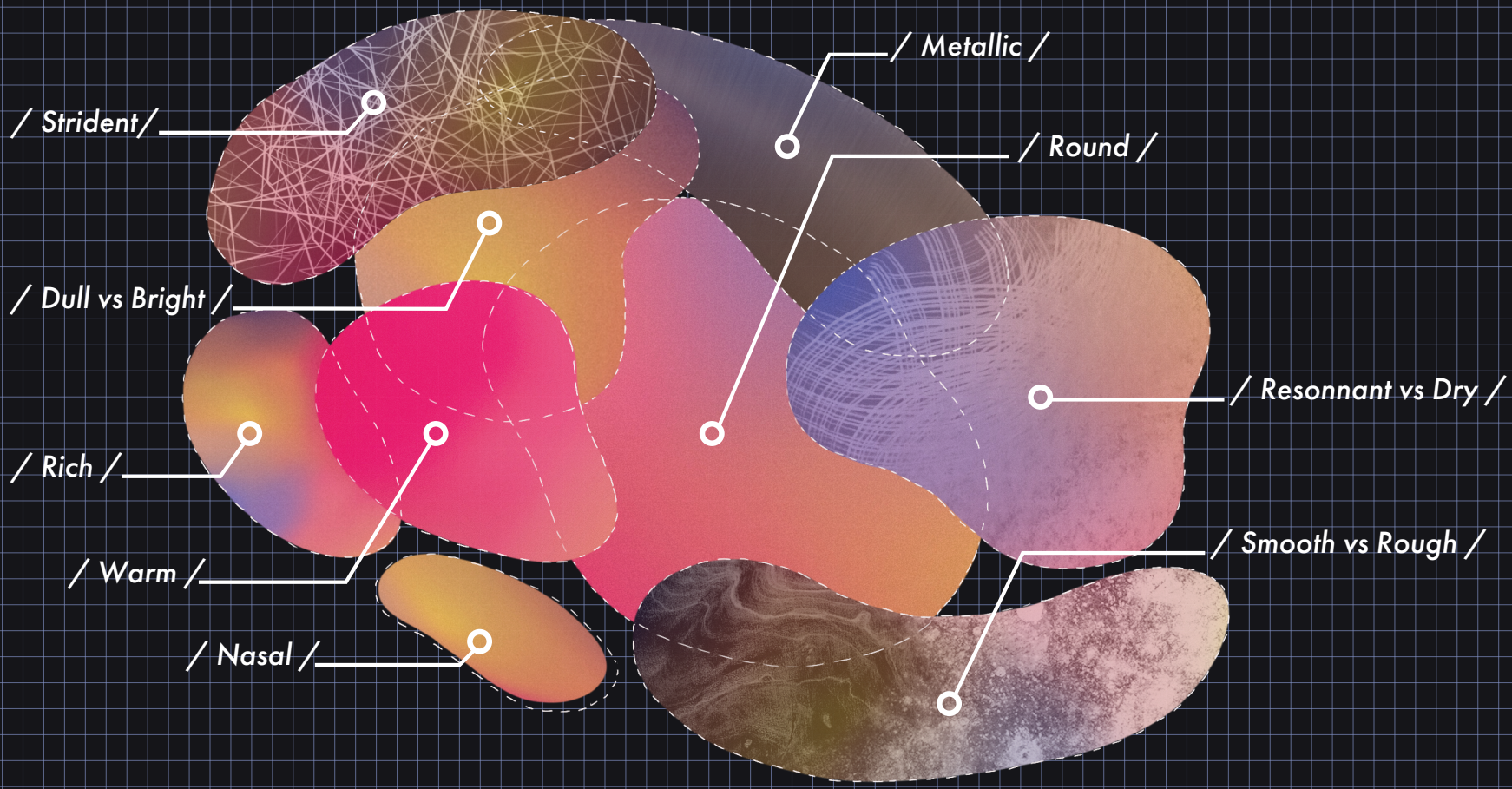


Figure 13: Visual representation of the timbral space

6.1.2 Guidelines regarding the interactions with the tool and its user flow:

1a. The tool should support the traditional *sketching process of starting broad and gradually zooming in on specific sounds.*

5a. The tool should support the formulation of a shared language to bridge the possible semantic gap between the participants.

The user flow with the tool itself can be facilitated around the user journey presented in chapter 5. The explorative aspect of the interface can be facilitated by providing the user with a sample library.

This gives the user a starting point, lowering the threshold of use and allowing the user to explore the sound design functions in a more accessible way. Based on the insights from the user tests (see p. FX) having an overview of possible samples (starting points) is preferred by the users as opposed to having to start from scratch.

After selecting a sample the user can further zoom in on specific aspects of the sound and the sound design functions. To provide the UX designers with information on the sound design function the interface is based on the wordsforsounds.SPEAK lexicon.

This lexicon has been academically proven to be an accessible and easy-to-grasp source of information when it comes to sound [7], [8], [43]. Furthermore, the target group of the lexicon are designers meaning that the use of the lexicon also has a contextual relevance in this interface. Integrating the lexicon vocabulary into the functionalities of the tool facilitates the passive sensitisation of the users towards sound design terminology.

6.1.3 Guidelines regarding the functionality and affordances of the tool:

2a. The tool should let users create multiple sonic sketches and compare them to each other.

8a. The tool should enable the user to practice epistemic actions.
1b. The tool should enable the users to add their own (contextual) samples to the interface.

3b. The tool should enable the users to save and share samples.

4b. The tool should allow the users to embed the sound prototypes (sonic sketches) in their context of use.

To enable the users to adjust sounds and create sonic sketching some type of sound synthesis is needed.

Deciding on which sound editing functions to give to the users has been a big challenge. Since there are so many tools and approaches to sound design it was difficult to pinpoint which of the sound design functions would be most useful for the UX designers.
For example, would the designers like to apply sound filters to the sounds? Change the duration of the samples?

Since the interface consists of the exploration of the timbral space it made sense to place the sound editing functions within that context as well. The sounds in the timbre category are differentiated based on the following elements:

Amount of high-frequency energy: *high / medium / low;*

Temporal Asperities: *absent / present;*

Prolongation of Energy: *present / absent;*

Cover of the Audible Range: *high / low;*

Attack: *slow / fast.*

A way of exploring the timbral space would be by adjusting these qualities. However, it must be noted that other ways of editing sound could also have been used but were not considered further because of the scope of the project.

By adjusting the qualities mentioned earlier the user should be able to create experiential differences in the samples and create specific sonic sketches.

The way the user interacts with the sound editing elements should be inspired by the epistemic actions, allowing the user to think iteratively while adjusting the sounds. To facilitate that a dynamic type of relation is needed between the input and the output; e.g. the user should hear the changes within the sound when they are changing something in the interface rather than needing to first put in all the changes and then wait on the results.

Furthermore, sound editing should be made accessible by limiting the number of options to the user. Simplifying the sound editing to a specific amount of steps could also result in more contrasting sounds and make it easier for the user to notice the differences resulting from the interaction; e.g. instead of loud = 100 and quiet = 0 and giving the user the ability to change the volume one step at the time you could provide them with 3 options: quiet, medium, loud.

Lastly, to facilitate design guidelines 1b, 3b and 4b the tool should have some kind of memory to save and upload samples. However, this is also necessary to be able to compare the samples. To be able to embed the sonic sketches in the context of use a speaker is needed, however, this is also needed to hear the sonic sketches.

Added functionalities such as 1b, 3b and 4b can be integrated into the concept without the need for specific added elements or levels of interaction.

6.1.4 Guidelines regarding the physical presence/shape of the interface:

9a. The tool should enable the bridging of digital and tangible information through the use of external representations.

10a. The interactions with the tool should be visible to all participants, to ensure indirect learning through observations.

2b. The tool should be easy to transport and set up.

To ensure that the tool is visible to all participants it is important to consider the size and orientation of the available information. Furthermore, to enable all of the participants to be able to interact with the interface there need to be flexible modes of interaction that are physically accessible to everyone; e.g. if the interface is on a laptop screen, only one user is likely to be able to operate the tool at once.

A way of ensuring that the interface can be used in a group setting is by spreading out the control elements (such as ReacTable (p. 56 - 57) or Audiopad (p. 60 - 61)).
Using physical objects as control elements could ensure the visibility and direct mappings between the interactions and outcomes.

This type of interaction requires the positioning of webcams (as sensors) and projectors (as sources of graphics). Such installation can get quite bulky which is a shortcoming as we know from PSST! (p. 34 - 35).

However, the modularity of hosting the tool on a laptop and projecting it on a surface also has its benefits:

1. The size is adjustable to the number of participants

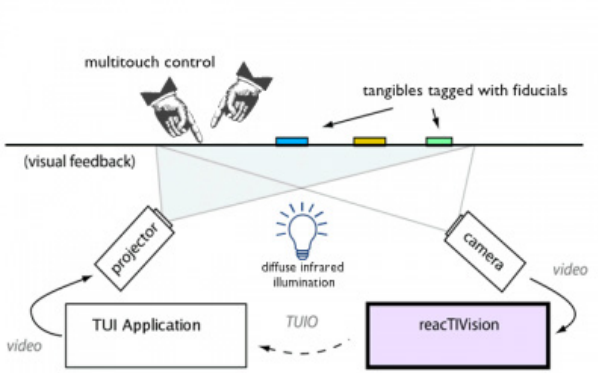
2. The tool can be made accessible financially since it only requires two elements (webcam & projector) that can also be used for other projects

3. Since there are no specific hardware parts the tool can be updated and used online allowing it to become an open-source project

4. The lack of hardware also means no manufacturing steps, making it a more sustainable solution ecologically

On the other hand, the UX designer will need to set up the projection in a specific way, perhaps using a mirror, to have a clear overview of the tool. The setup could be similar to the set-up of the ReacTable (figure 14).

Figure 14: The setup of the ReacTable [ix]



6.2 Prototyping activities

To explore different possible interactions with the timbral space an interactive prototype was created consisting of the visual representations and sample library. Using the creative coding platform, P5.JS, the timbral space (Timbreworld) was populated with the samples from the wordsforsounds.SPEAK library.

6.2.1 Choice of the sonic content

The wordsforsounds.SPEAK library consists of multiple examples of sounds divided into the following categories: Instrumental sounds, human voice sounds, environmental sounds, simple sounds and complex sounds.

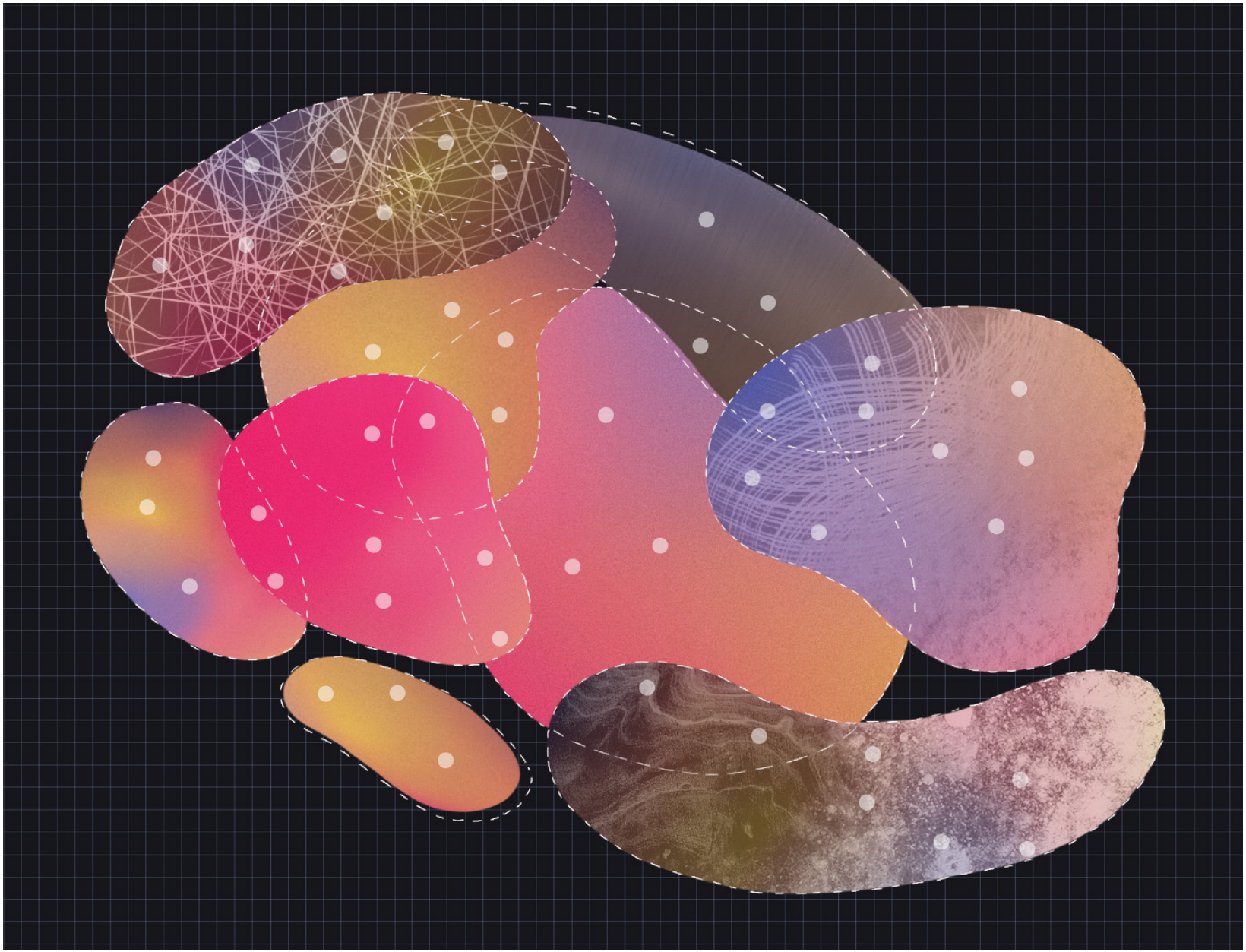
The samples used in the prototype were selected based on their relevance in the UX design sonic space. The majority of the sounds ended up being: environmental sounds, simple sounds and complex sounds. Most of the samples based on musical instruments and human speech have been removed.

The way the sound samples are distributed in the Timbreworld aligns with the sound qualities exhibited by the samples. It was based on my perception of said samples and thus is subjective.

6.2.2 Interaction with the prototype

The prototype is digital and hosted on the P5.js editor website. The samples are triggered by mouse movements. A digital drawing pad combined with a pen can be used as well.
Here participants can explore the map by moving the pen around and triggering specific samples by hovering on top of them.

Figure 15: Timbreworld as a sample library



6.3 User test of the prototype

6.3.1 Research objectives

The prototype has been tested with five master design students to answer the following questions:

1. Does the timbreworld allow for the exploration of sound samples?

2. Do provided sounds spark inspiration for sonic sketching activities?

3. Does the timbreworld translate sound qualities into something easily understandable to participants?

4. What kind of supplementary information would the participants like to see?

5. In what way do the designers want to interact with the sound editing features?

The participants were also provided background information on the sounds and the possible editing features to sensitize them to the activity and allow them to better express their needs.

6.3.2 Methodology

5 participants
All females
23-27 years old
Master Design Students
Individual user tests
Method: observations combined with thinking out loud, semi-structured interview

6.3.3 Results & Interpretations

1. Does the timbreworld allow for the exploration of sound samples?

Overall the participants enjoyed exploring the timbreworld. They would try to find samples that would match each other.

"I want to explore what all the connections are, this one [smooth sound] feels like it belongs together with this one [round] but they are not necessarily connected, I want to understand why"- P4.

They felt like the exploration exposed them to sounds they would not think of themselves and felt more creative because of that.

"I think so [on whether she can explore the sounds], it helps that it looks very creative so I'm drawn to trying everything out" -P3.

One of the participants noted that she liked to have the overview of all the samples at once; she compared it to DAWs where functions/ samples are often hidden in a menu and can be accessed through several clicks. To her interacting with the timbreworld felt more explorative and intuitive.

"Normally when you work with databases you have to click a lot and then you get a subcategory and then you can listen to a sound in there. You have to 'click' 'click' 'click' it gets you out of your flow. So it would be nice if it was easier to do and to not need to jump between different categories" - P1

2. Does the timbreworld translate sound qualities into something easily understandable to participants?

The visualization did not provide participants with intuitive associations, e.g. metallic was not recognized as metallic simply by looking at it. However, the combination of sounds and the visual appearance did evoke some associations in participants.

"It can be quite surprising, you don't know exactly what kind of sounds you are listening to. I do feel curious to know more" - P5.

What was instantly clear to everybody is that the timbreworld consisted of different parts that overlapped with each other.

"It would be nice if it said where you are at the moment, in which area. That would give me a better overview" - P3.

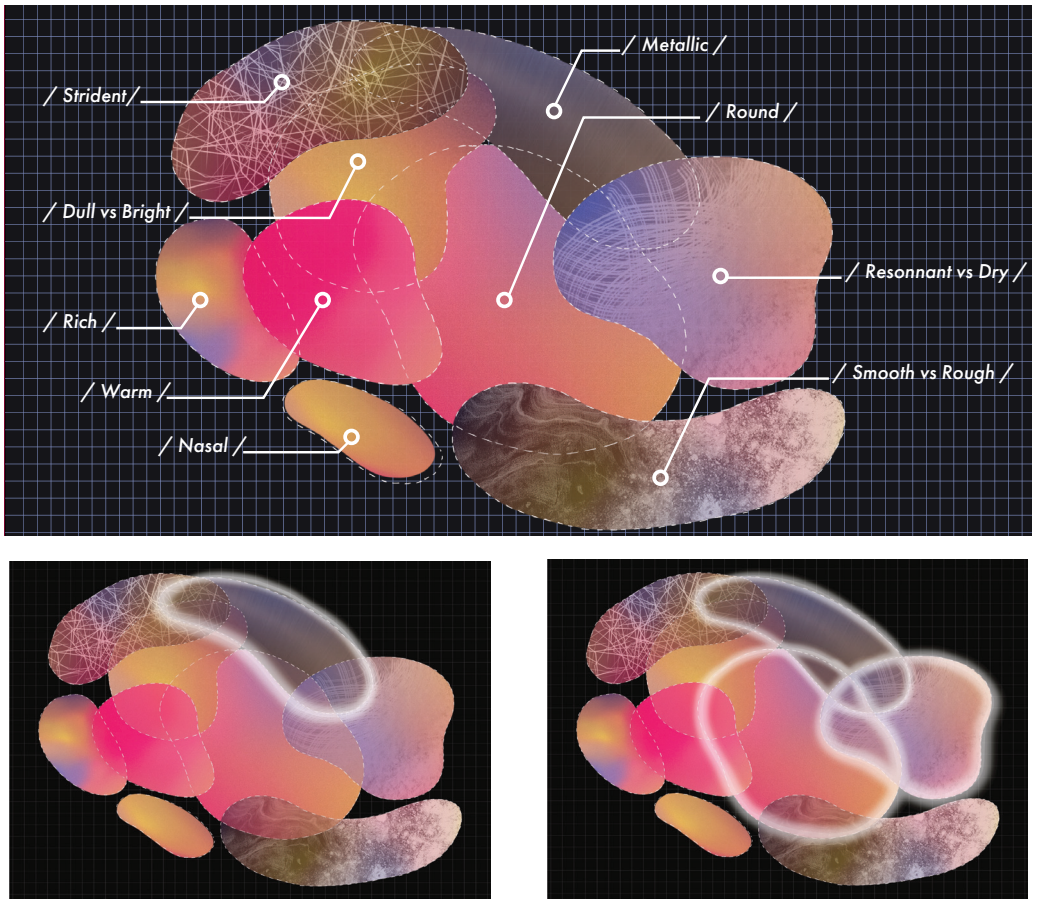


Figure 17: Ways of highlighting the areas of the Timbreworld

The participants did miss some form of feedback (apart from the sound).

"I am a visual thinker, I think a lot of designers are, I think seeing the sounds and the changes could help me understand them a lot better" - P1

They were shown different variations of the interface and generally, everybody would like to have more information displayed about the sounds.

"Now that you explain it [the background information on the sounds] it makes more sense, but I am not completely sure what it means, I don't necessarily know what 'Strident' means so just seeing 'Strident' would not be enough" - P2.

3. Do the samples provided in the timbreworld align with what the participants find useful at this stage of the process?

Although participants enjoyed the explorative aspect they also noted that sometimes it may be more useful to have a sorting system. They recognized that some samples may be more relevant for certain contexts than others and would like for the interface to filter out irrelevant samples.

"Yes [there are samples that would be useful to me], but it will differ per project. Some of these I would like to remove entirely and some I would like to keep in a separate folder for specific projects" - P1.

However, two participants also noted that the variety of the samples helped them to think more outside of the box and felt more creative because of that.

"It takes some time to go through all of the samples..maybe a bit too long.. but it also helps to find sounds that you would maybe not expect? I once had a lecture from a sound designer who told me that he used the sound of a vacuum cleaner for something very unexpected. I feel like with this I could have a similar experience" - P4

The provided samples were seen as diverse and useful for exploration, participants noted that they felt surprised and inspired by the variety of the sounds. Participants would also **like to upload their samples, expand the timbreworld and shuffle it around to generate new sounds.**

4. What kind of supplementary information would the participants like to see?

Generally, participants would like to have more feedback and information about the sound samples. Participants noted that it is confusing that the sound samples have different durations, this was due to lack of predictability. What they would like instead is a representation of the duration or a more uniform duration of the samples.

"I want to see the duration of the sample, some are way too long for example and I never know how much longer they will take" - P2.

"I would maybe like to see something move together with the sound, kind of get animated because of it, I think it would be fun" - P1

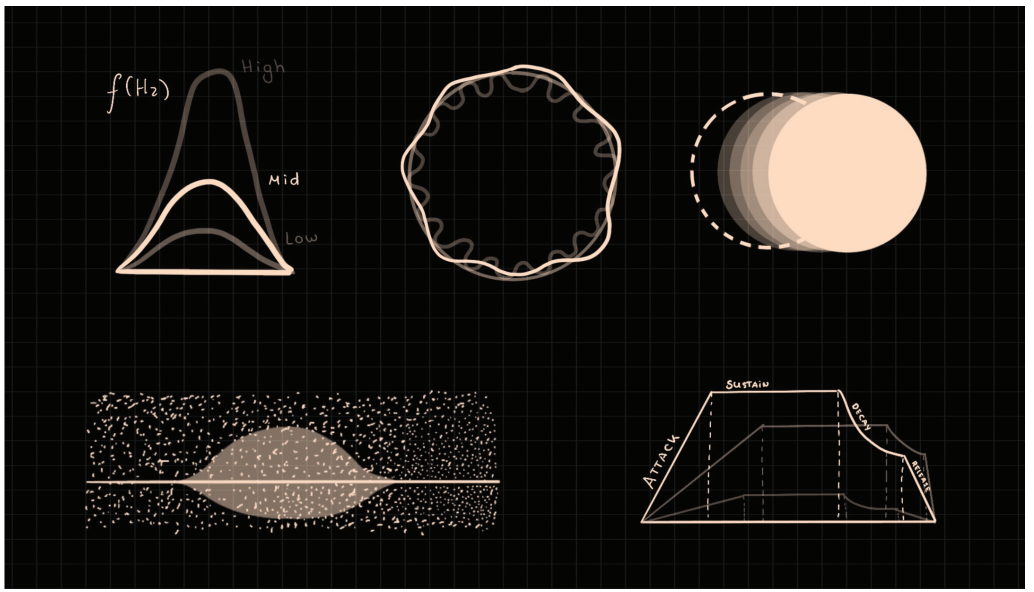
They wanted to have the option to get to know sounds on a more technical level and adjust them using sound design functions. They would also like to get some background information about the sounds and what classified them within a specific area (figure 18).

"I would like to have some background theory on the sounds, like the way you explained them helped a lot but I would not be able to come up with this information myself" - P1.

"I would not want to see the information immediately but rather when I need it, so first I could maybe just try things out and then if I want more background info I would like to know where to find it" - P5.

Participants noted that this would help them to feel more confident when communicating with stakeholders as well as understand how they could edit the samples to create sonic sketches.

Figure 18: Visualisations of the sound editing attributes



5. In what way do the designers want to interact with the sound editing features?

The interactions that were tested during the tests were: using a pen on a surface and moving objects in the physical space (as a cursor). These interactions were compared to using a touch screen or a computer mouse. Using some older prototypes (p. 68 - 69) participants were also allowed to adjust some of the sounds.

Overall participants preferred the tactile experience of holding physical objects compared to using a computer mouse or touch screen. It felt very intuitive for them to both draw the sounds with the pen as well as move objects and adjust the sounds.

"Something tangible [as opposed to using a computer mouse] makes it feel more playful and explorative" - P2

"Would the interaction be the same with tangible elements? Like moving an object with your hands? Then I think it would be very nice and intuitive." - P1.

However, it was not always clear to the participants how they could operate the physical objects. What was confusing to them is what the boundaries were of the movements and how sensitive the sensor (webcam) was to their input.

"Now it's not really clear to me what my working area is, where does the webcam look [I explained how the mouse movement could be translated into the use of tangible objects with a webcam] where are you able to move? I think it needs to be very clear where and what exactly I can do" - P3

Generally, all of the participants were excited about the possibility to edit and adjust sounds. They would like to expand the timbreworld and adjust it to their preferences. They also liked the five sound qualities that were used to categorize the timbres; four out of five participants would have liked to be able to interact with these sound qualities and adjust them for the samples.

"I think there should be more editing options than now presented, but it should be really balanced. If there are too few options it feels like all the sounds are premade already but if it's like a DJ set or something then I will have no idea what to do" - P4

One of the participants also noted that she would like to physically shape the soundwave to adjust it. For example by stretching or pinching the visual representation of the sound wave.

"What I would like maybe is to take a sound sample and continue with that, and really see like the sound wave and pinch it and pull it to adjust it and reshape it. I think that would be very nice, maybe with this one especially [temporal asperities] if I would want a smooth sound I could just draw a constant line" -P3.

Two participants also noted that they would like to change the speed and duration of the sound samples. Furthermore, everybody enjoyed adjusting the volume and frequency through time and saw it as a useful set of functions for the interface.

Other comments:

"There is no tool yet that makes sound design accessible to us [students]. I had a course about it but I still don't feel like I can actually do anything with sound. If you want to learn it you have to find out yourself what to do but there are just no tools to support that available to us" - P4.

"I think it's good that the sound now is really involved. Because I think that sounds often get forgotten and I am not sure how I would be supposed to make them. And now I could maybe make different options of these sounds and I feel like I could just do this for example and make a sound that fits. So this is also very nice if you need to user test the sounds maybe" - P2.

The participants enjoyed the graphic style of the interface and noted it to be exciting and promising. However, the connections between the different areas on the 'map' were unclear.

"I really like the style, it's quite fancy but for example, this thing [resonnant vs dry] is one group right? But are they opposites? Maybe I would put them separately or make a border between them" - P3

Visuals of sound qualities were better received than verbal descriptions of them (e.g. visual of the temporal asperities was more clear to participants than the term temporal asperities). However, at all times, the representations of the sound qualities were best understood when paired with sound samples exhibiting these qualities.

"I think these figures you show [figure FX] tell me more than just the names of these functions" - P2

What was also missed by participants was a 'mute' button. An insightful remark from a participant was that she would like to be able to communicate and brainstorm while using the interface and needed moments of silence to do that.

"I feel like a mute button is missing here, sometimes I just want to talk about the sound but it's still playing" - P4.

6.4 Iteration & Final Prototype

Based on the insights from the user tests the following list of improvements has been set up for the further development of the prototype:

A. There should be a balance between exploration and relevancy

B. Background information about the sounds should be displayed

C. There should be a clear overview of the sound editing options

D. There should be some type of sound visualisation

E. There should be a dynamic relation between the visualisation of the sounds and sound editing

F. The difference between the different parts of the Timbreworld should be clear

G. It should be clear which areas of the interface are interactive and which not

H. There should be a mute button

I. There should be an option to isolate specific time stamps of the samples and change their speed

These points of improvement have been taken into consideration during the iteration of the Timberworld resulting in the second version of the prototype (figure 20, p. 110). This section explores how the points of improvement were applied in the iteration process, which have been successfully integrated and which will need to be noted down for the Recommendations section (p. 141).

6.4.1 Design choices based on the points of improvement.

A. There should be a balance between exploration and relevancy

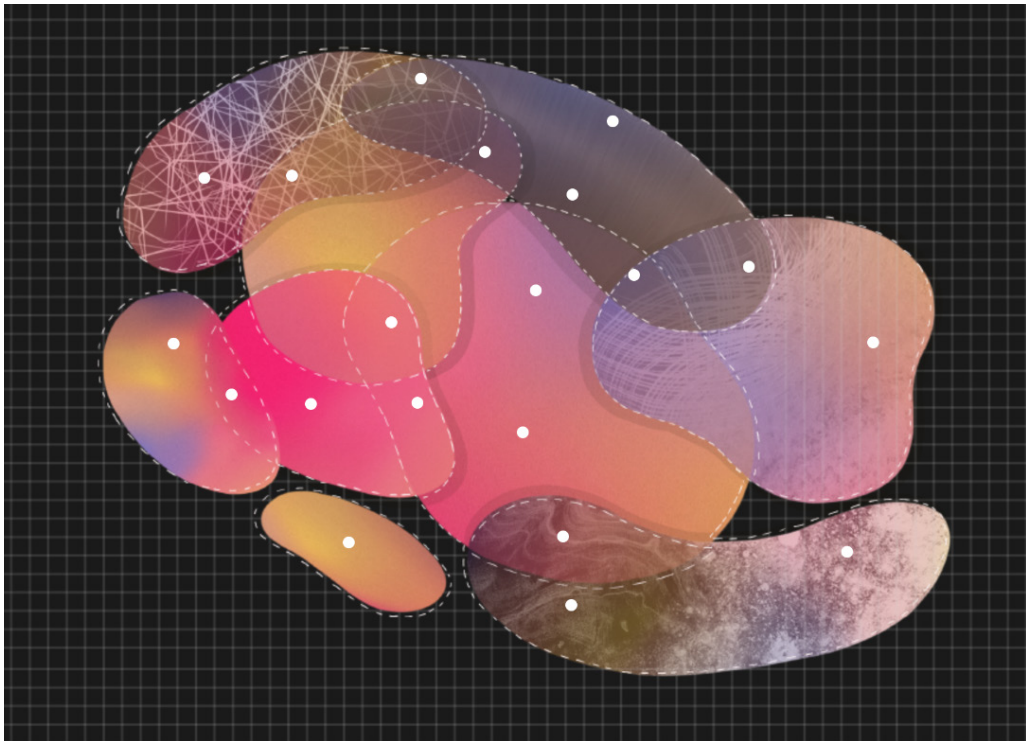
During the user tests it became clear that on one hand, the participants preferred to have some type of content filter to select which samples to listen to, on the other hand not being able to filter nudged the participants to explore more.

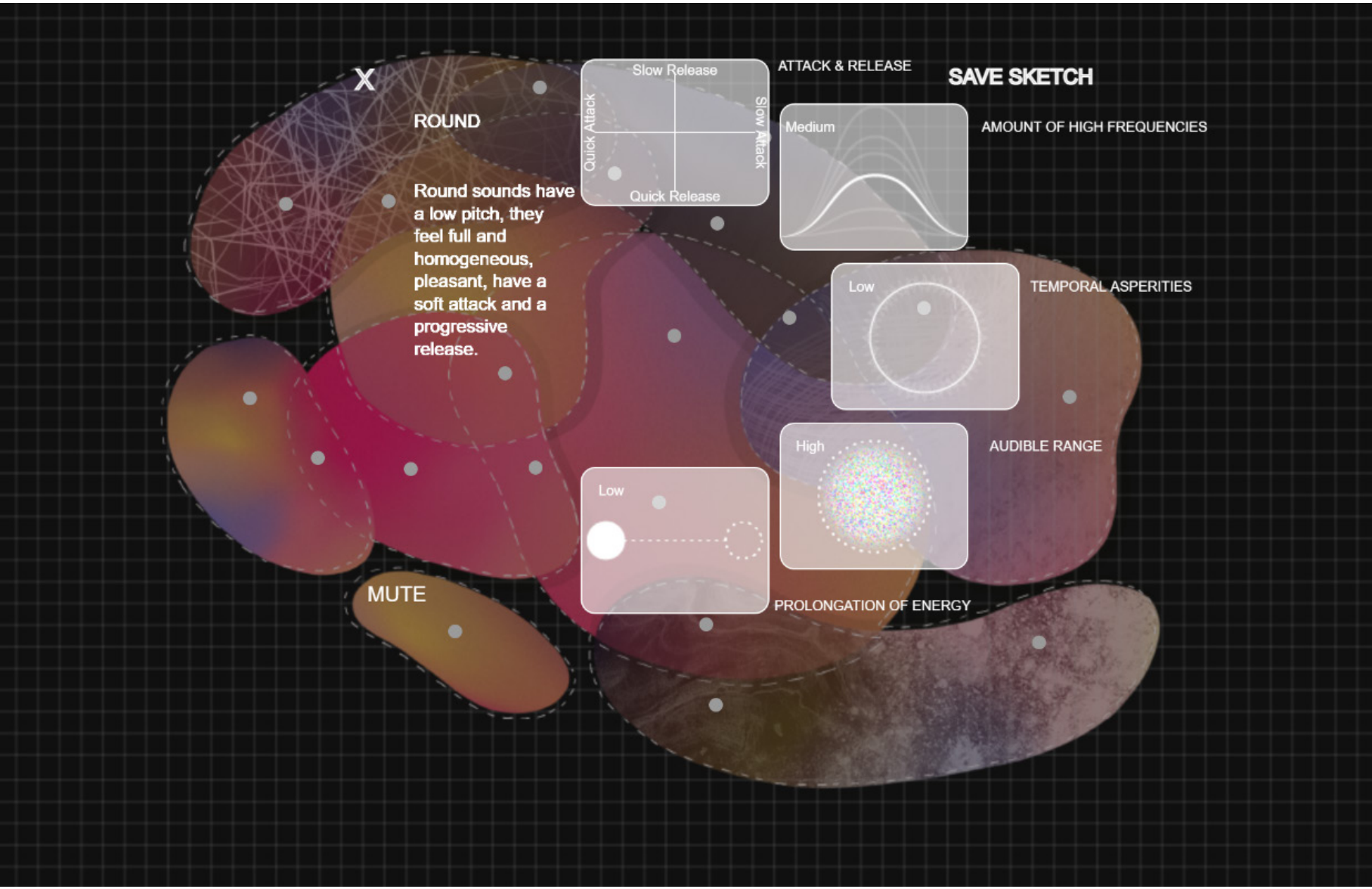
Since exploration is an important aspect of the concept it was chosen to not create specific filters. However, the iterated prototype has fewer possible starter points (samples) to begin with because of technical limitations (see Figure 19).

In the future, filtering of the content could be considered, especially if Timbreworld develops further and expands. Furthermore, if the participants were adding their samples it would be beneficial to add an option for contextual filtering so the samples can be organized per project.

Figure 19 presents the starting point of the interface, when the user interacts with any of the white dots (samples) the following screen will appear (figure 20, p. 110).

Figure 19: The home screen of the Timbreworld
Figure 20: The editing page of the Timbreworld




X
ROUND
Round sounds have a low pitch, they feel full and homogeneous, pleasant, have a soft attack and a progressive release.
Slow Release
Quick Attack
Slow Attack
Quick Release
ATTACK & RELEASE
SAVE SKETCH
Medium
AMOUNT OF HIGH FREQUENCIES
Low
TEMPORAL ASPERITIES
High
AUDIBLE RANGE
Low
PROLONGATION OF ENERGY
MUTE

F. Background information about the sounds should be displayed

The different ways of adding more information & feedback to the prototype would by :

A: highlighting areas where the user currently is positioned and which other areas are connected to it.
B: By showing the names of the areas and specifically the name of the area where the user is positioned.
C: By showing information about the sound qualities that are present in the currently selected sample.
D: By providing design-related information, e.g. “Strident sounds are often used as alarms”

The descriptions from the wordsforsounds. SPEAK web tool were used throughout the project and have been proven to be a reliable source of verbal representation of sounds. Integrating the descriptions in the interface allows the users to get a deeper insight into the sounds and get sensitized to the sound design vocabulary.

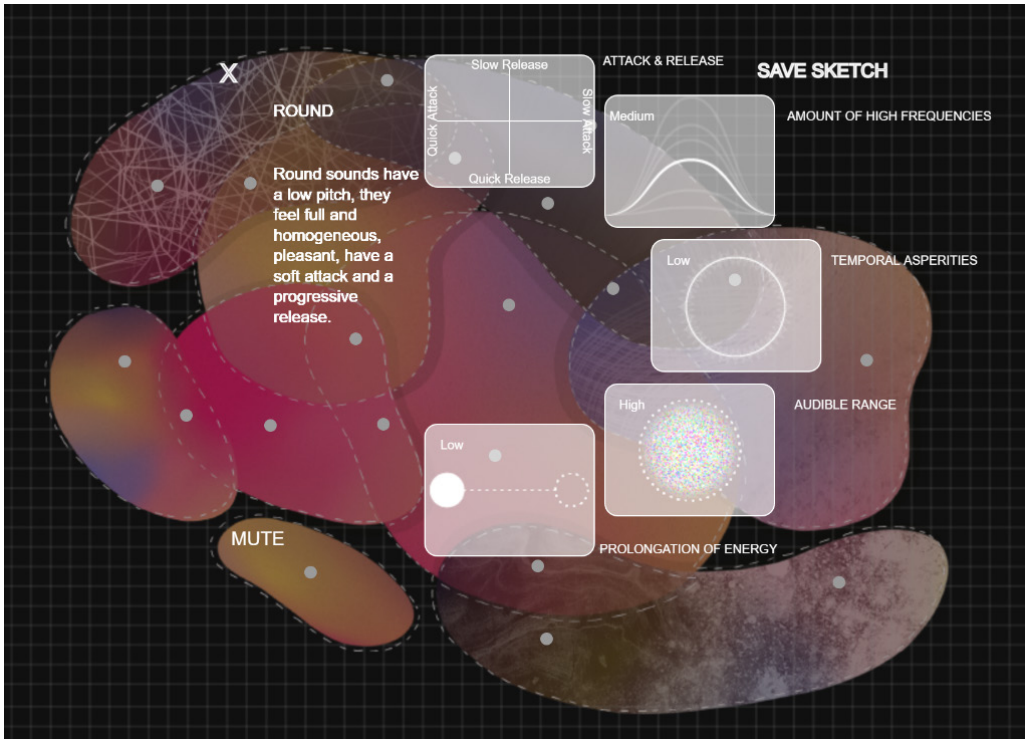


Figure 21: Background information on ‘Round’ sounds

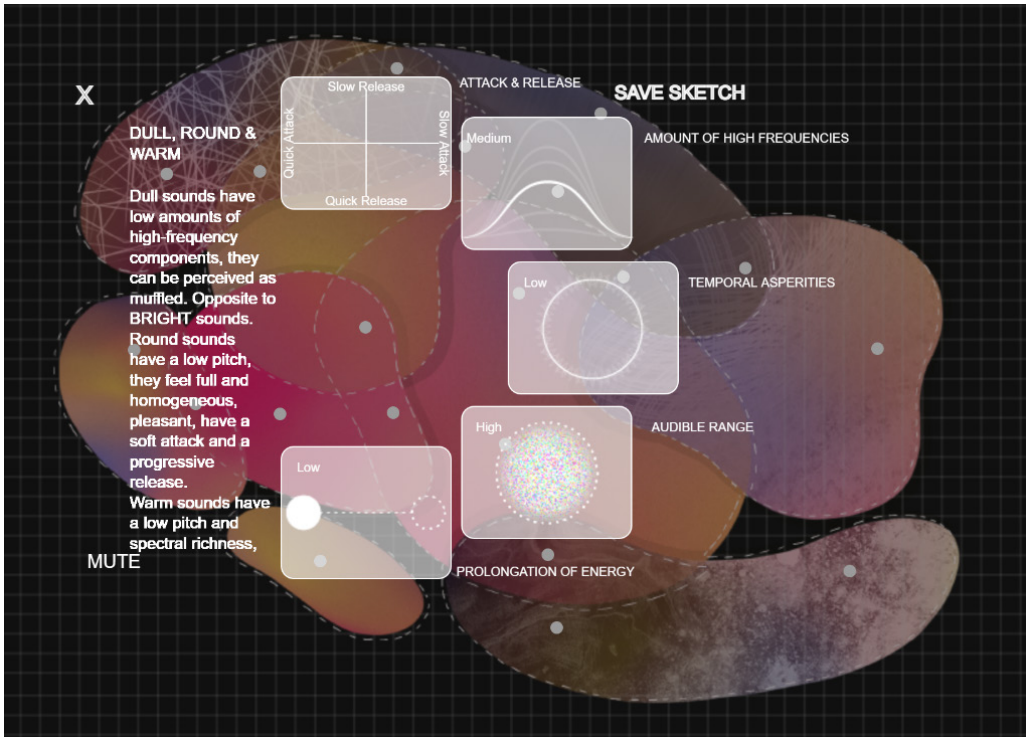


Figure 22: *Background information on sounds that are 'Dull', 'Round' and 'Warm'*

Furthermore, the descriptions align with the sound editing rectangles creating a more cohesive user experience.
E.g. The attribute Dull / Bright is described in the following way:

"The attributes dull and bright refer to the **amount of high-frequency energy** *perceived within a sound. A dull sound has a low amount of high-frequency components. The term muffled is also used. A bright sound contains a substantial amount of high-frequency components. The term sharp is also used." [fx]*

In future iterations, it could be useful to provide the user with more guidance on the relation between sounds and applications in design. However, the guidance should not limit the user to specific sounds, to prevent the tool from becoming too deterministic.

E.g. If only 'Strident' sounds are considered alarm sounds the user may not take the time to explore other options, limiting themselves in exploration and creativity.

B. There should be a clear overview of the sound editing options

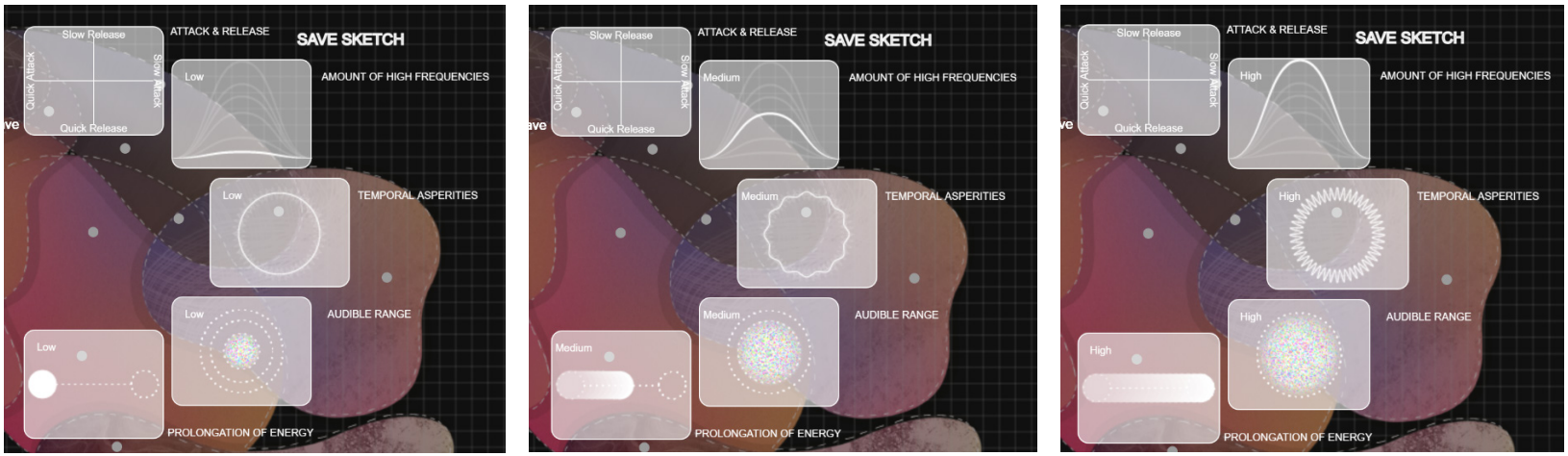
On page 110, when you interact with any of the samples (white dots), a screen for sound editing appears. This screen is the same for all samples and includes the following functions:

Attack & Release
Amount of high-frequency energy
Temporal asperities
Audible range reach
Prolongation of energy

Each function is visually illustrated to enhance understanding and memorization. The visualization style is similar to what was shown to participants in user tests (p. 105). During the tests, participants found the illustrations easier to understand compared to written descriptions alone.

By interacting with the rectangles, you can adjust the corresponding sound properties. Interactions are done through mouse movement and clicking. Each rectangle has multiple visual levels that appear when selected. The number of steps varies for each rectangle, but they are associated with verbal descriptors (low, medium, high) to provide a relative understanding.

Figure 23: Different levels of the editing functions, 'Low', 'Medium' & 'High'



G. It should be clear which areas of the interface are interactive and which not

To ensure the clarity of interaction the editing rectangles are highlighted and placed against a contrasting background. The enclosed shape signals that the type of interaction, specific to a rectangle, is bounded by the area of the rectangle.

Once the user enters the sound editing mode they are unable to click on other samples. This is to ensure that the user feels like they can explore the editing screen without being afraid of switching to another sound.

Once the user is done editing a sound they can switch back to the exploratory screen by clicking on the 'x'. If the user wishes to save their edited sample as a sonic sketch they can do so by clicking 'SAVE SKETCH' (however that option is not interactive in the prototype).

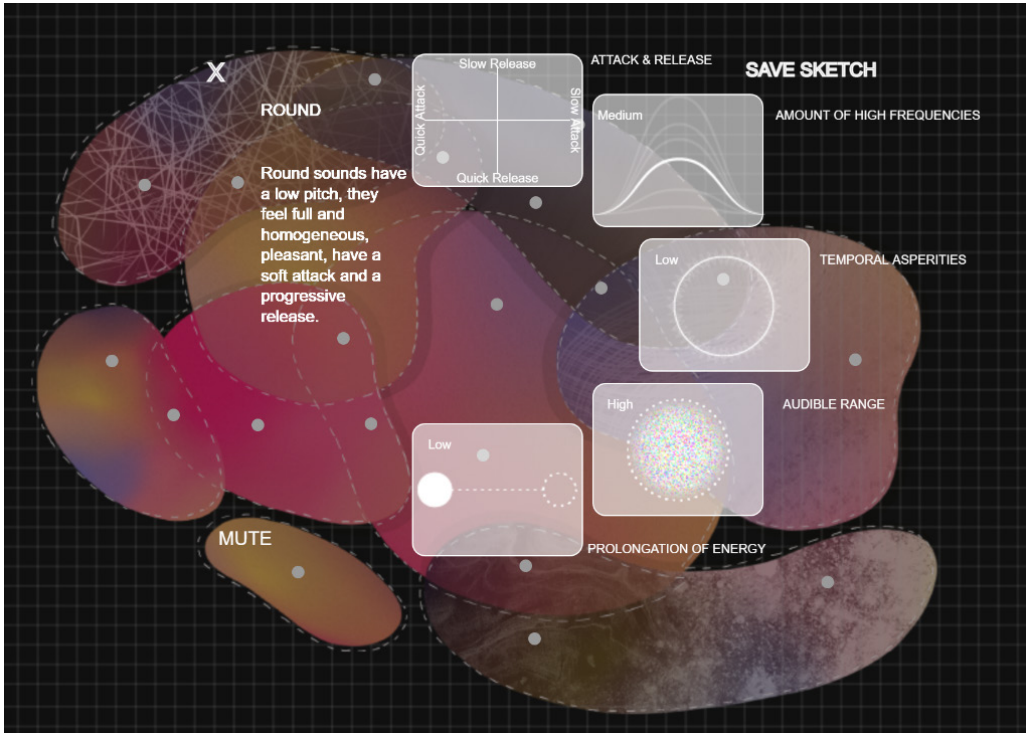


Figure 24: The interactive parts of the interface are white rectangles with low opacity

H. There should be a mute button

Based on the input from multiple participants of the user test a mute button was added. The mute button enables the users to mute the interface, for example, to initiate a discussion.
The sounds provided in the interface are all short snippets (1 sec - 10 sec) that are repeated on the loop. Aggressive sounding sounds, such as bright and strident sounds, can become quite irritating after listening to them on a loop. The mute button ensures that the user can also take some distance from the sound without needing to lose their editing process.

Another useful feature in future iterations would be the addition of volume regulation. For now, however, this can also be done by adjusting the volume of the computer.

Figure 25: The Mute button changes in opacity to indicate its state (full opacity for muted, low opacity for full volume).

Improvement points that have not been integrated into this prototype:

Sound visualisation

Dynamic relation between the visualisation of the sounds and sound editing

Although highly requested by the participants of the user test, this prototype does not have sound visualisations. Sound visualisations are meant that when a sound is adjusted its physical representations also change e.g. in shape, colour, and texture.

This feature is not integrated into this prototype, however, it is certainly possible to add the visualisations to the interface. To do that the sound signal data could be used as an input variable for visual adjustments. To ensure the intuitively simple cross-modal mappings could be made, e.g. dark colours for low amounts of high-frequency energy and bright colours for high amounts of high-frequency energy.

Difference between the different parts of the Timbreworld

The difference between the different areas was not yet clear to the participants of the user test. Especially areas that consisted of two opposites were confusing; e.g. bright & dull, resonant & dry.

As learned in chapter 4 it is difficult to create nuanced cross-modal mappings that would be required to visually portray all of the timbre attributes.

Therefore we can not rely on specific visual elements to convey the different Timbreworld areas, however, we could make the areas more recognisable to ensure recognition and memorization in the long term.

Currently, the contrast between the areas is already enlarged by adding the shades in between the areas. In the future, however, the differences between the different areas could be made even more clear by using contrasting colours, textures and illustrative properties.

Option to isolate specific time-stamps of the samples and change their speed

Some of the participants would like to be able to adjust the temporal qualities of the sounds. This should be possible in future iterations of the prototype. However, it is necessary to consider the placement and presentation of such added functions to keep the interface as simple as possible.

6.5 Editing options & Sound Processing

6.5.1 Editing options

One of the main aspects of the interface is the ability to edit sounds quickly and iteratively. To facilitate that a simplification needed to be made of popular sound editing functions. Since the focal point of the interface is the timbral space, the editing functions are also centred around exploring timbre. Users can modify timbral aspects of the sounds by editing the following attributes: Attack & Release, Amount of high-frequency energy, Temporal asperities, Cover of the audible range, and Prolongation of energy.

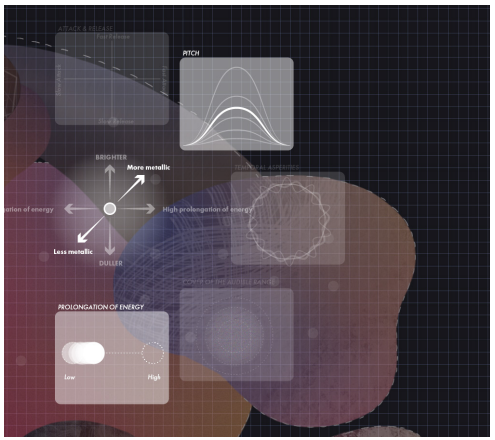
It's important to note that not all sounds are suitable for every adjustment. Each attribute mentioned above corresponds to one to three areas within the timbral space (refer to figure 16, p. 96).

For instance, in the case of "Rich" sounds, their distinguishing feature is wide coverage of the audible range. Adjusting the amount of audible range cover can make a "Rich" sound appear "less rich," but it's not possible to increase the audible range cover for sounds that are not initially considered "Rich."

This is due to signal processing, lowering the cover of the audible range simply put means lowering the diversity of frequencies within the sound. If a sound already has a low amount of diverse frequencies, to begin with, there is simply no room to lower it further.

This results in the following challenge: not all sounds are suited for specific sound editing functions, however, we do not want to limit the user in their exploration. Furthermore, the sounds are way too nuanced to generalize in this way.

To prioritize the explorative nature of the interface a decision was made to make all of the editing functions available for all of the sounds. As a result, some adjustments will not have the intended effect, however, that too is part of the exploratory process.



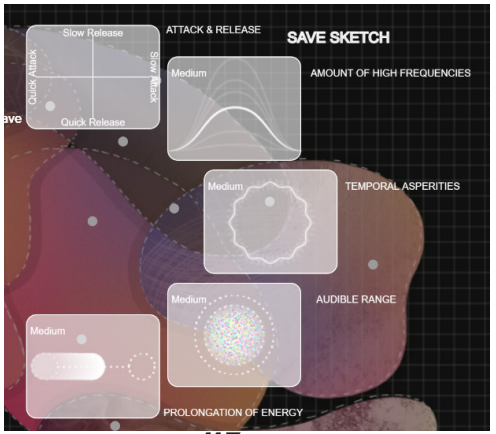


Figure 26: Editing options available for specific sounds (left) versus for all sounds (right)

6.5.2 Sound Processing

To be able to edit the sound samples a way of sound processing needs to be integrated. The sound is facilitated through Ableton Live Lite, which offers a lot of opportunities for achieving high-quality sound editing. The integration of P5.js and Ableton Live Lite is achieved through an OSC (open sound control).

OSC facilitates the communication between the two separate software and allows to creation interactive interfaces that are connected to Ableton sound editing functions.

Interaction between P5.js and Ableton Live Lite

Each of the dots in p5.js is connected to a clip of a sample in Ableton. Clicking on a dot fires (activates) the associated clip resulting in audio feedback.

Each of the sound editing rectangles is connected to a specific audio effect in Ableton Live Lite. When the user interacts with one of the rectangles in P5.js a message is sent to Ableton through the OSC.

That message contains information on what sound effects should be triggered and how much.
An overview of interactions in the rectangles and the corresponding audio editing functions:

Figure 27: Clicking on the white dots triggeres clips in Ableton Live Lite, editing is connected through macro knobs (right)

Attack & Release

The attack and release editing is achieved by mapping the X and Y position of the mouse. For attack, the X position of the mouse is mapped in the following way: {x = 0, attack = 0.00 ms}, { x = 127 (max), attack = 2.00 ms}.
For release, the Y position of the mouse is mapped in the following way: {y=0, release = 1.00 ms}, {y = 127 (max), release = 60.0 s).

Amount of high-frequency energy

For the amount of high-frequency energy, a channel equalizer is used. The Y position of the mouse, in the corresponding rectangle, is translated into the value of High-Frequency Gain {y = 0, Gain = -15 dB}, {y = 127 (max), Gain = 15 dB}.

Temporal asperities

For the editing of the temporal asperties a Low-Frequency Oscillator is used which creates sweeping audio effects, adding irregularity to the input sound. The X position of the mouse, in the corresponding rectangle, is translated into the value of the Low-Frequency Oscillator Volume and its rate {x = 0, LFO Rate = 0.01 Hz, Volume < LFO = 0.00% }, {x = 127 (max), LFO Rate = 30 Hz, Volume < LFO = 100%}.

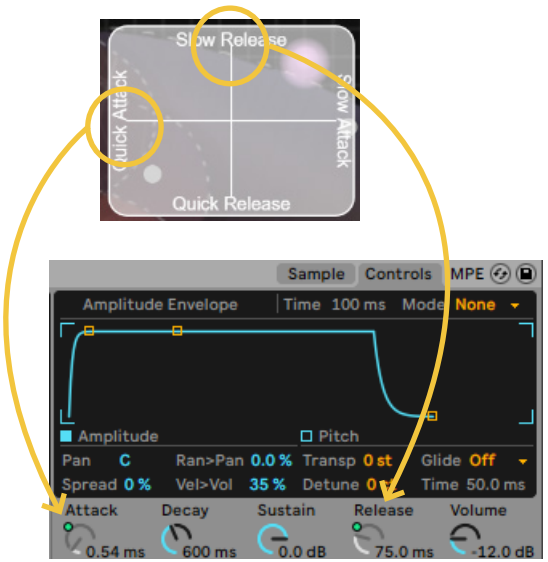


Figure 28: Attack & Release interaction

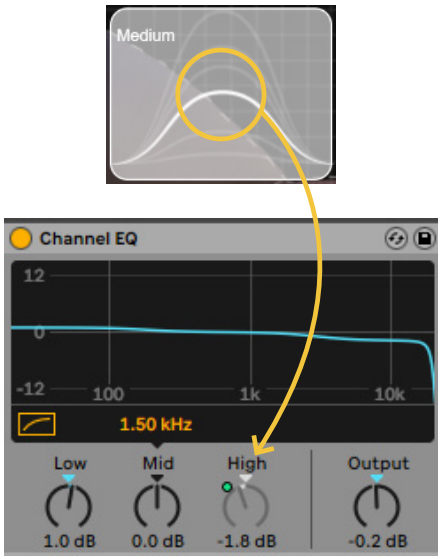


Figure 29: High frequency energy interaction

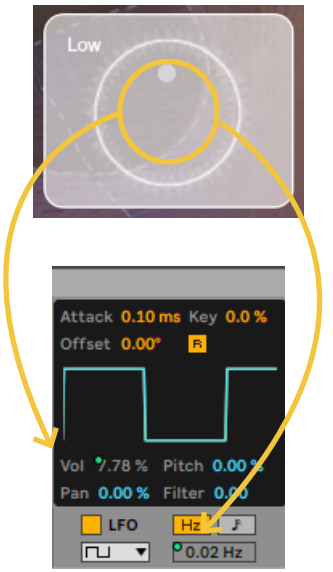


Figure 30: Temporal asperities interaction

Cover of the audible range

The editing of the cover of the audible range is achieved through the implementation of a bandpass filter. The bandpass filter limits the number of frequencies within the sound sample by only allowing a certain amount of the frequencies to pass. This amount, that is allowed to pass, is the cover of the audible range. The X position of the mouse, in the corresponding rectangle, is translated into the value of the Frequency cutoff of the filter {x = 0, Frequency cutoff = 400 Hz}, {x = 127 (max), Frequency cutoff= 19.9 kHz }.

Prolongation of energy

The prolongation of energy is achieved through a slight delay in the sound and the repitching of it. The settings of the delay effect are fixed to experimentally determined values. What the user does adjust is the Dry/Wet balance between the input and output signals. The X position of the mouse, in the corresponding rectangle, is translated into the Dry/Wet value of delay {x = 0, Dry/Wet ratio = 0.00% }, {x = 127 (max), Dry/Wet ratio = 100%}.

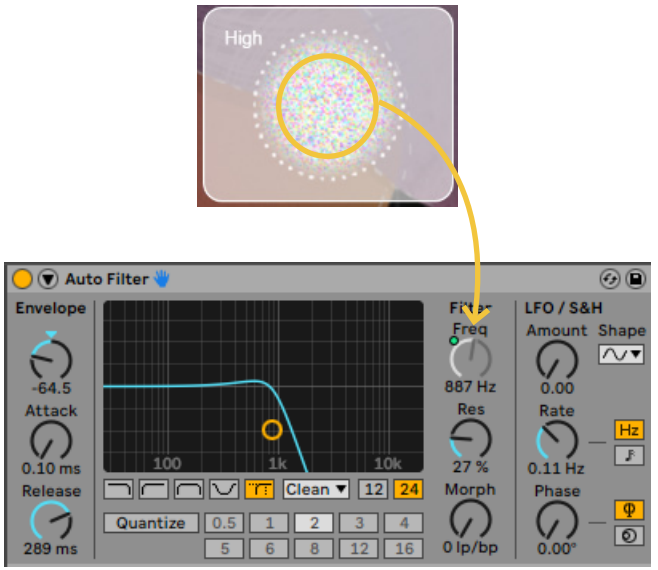


Figure 31: Cover of the audible range interaction

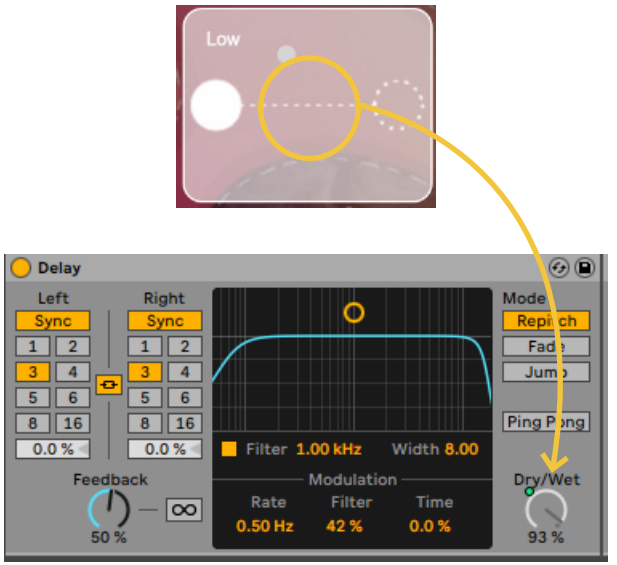


Figure 32: Prolongation of energy interaction

6.6 Final User Tests

In order to evaluate the prototype and how well it represented the design guidelines an evaluation session has been conducted. The evaluation consisted of a pilot test, with two teachers from the Industrial Design Engineering faculty, and user tests with five master design students.

The design guidelines (see chapter 5) have been reformulated to fit the interview format of a user test. The user test consisted of the exploration of the prototype and the answering of the questions. The answers to the questions were noted down during the tests by the interviewer, no recordings were made. The participants were not provided with any background information on the sounds. Apart from the questions, there was also space for participant comments and notes.

6.6.1 Pilot tests

The pilot tests were conducted informally, in order to evaluate the usability of the prototype and whether it was suitable for the user test. The pilots were conducted individually, with two teachers from the faculty of Industrial Design Engineering and took approximately 15 minutes. Overall the participants' impression of the prototype was positive and the use of the prototype resulted in inspiring explorations of the timbral space. What did become apparent during the pilot is that the participants had different preferred ways of interacting with the prototype, one participant preferred to use the mousepad and another a USB computer mouse.

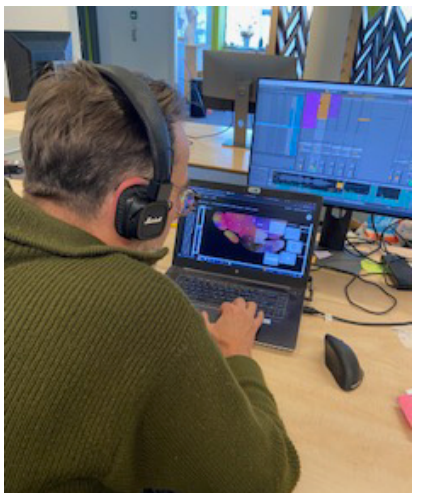
In order to facilitate the different needs three options were provided to the participants of the user test: a mousepad, a USB mouse and a drawing pad.

Lastly, the pilot test uncovered some small bugs in the code, however, these did not affect the quality of the interaction.

6.6.2 Methodology

5 participants
Individual user tests
Observations combined with thinking out loud, structured interview consisting of questions and scales.

The qualitative data, resulting from the user tests, was analyzed using the 'on the wall' approach [41]. Full results, combined with the quantitative data can be found in appendix FX.



Design Guidelines	Interview Questions
1a. The tool should support the traditional sketching process of starting broad and gradually zooming in on specific sounds.	• Do you feel like this tool makes it possible to first explore and then zoom in on specific sounds? • Do you feel like this tool could support a prototyping session? Why?
2a. The tool should let users create multiple sonic sketches and compare them to each other.	• Do you feel like you are able to create sound prototypes using this tool/ sketches?
3a. The tool should be clear, in its form and its functions to facilitate collaboration and discussion.	• Can you imagine this tool helping you facilitate collaboration and discussion? • Do you feel like the functionalities are clear to you? Do you understand what everything does?
4a. The tool should be clear and accessible to users with different degrees of expertise.	• How difficult was it for you to get used to the tool? (1 - 5, 1 = very difficult, 5 = very easy). • Do you feel like the tool is accessible to users with a low amount of knowledge about sound design?
5a. The tool should support the formulation of a shared language to bridge the possible semantic gap between the participants.	• Do you feel like you are able to describe the sounds using the vocabulary provided by the tool?
6a. The tool should provide its users with a clear overview of the functions.	• How clear are the sound functions to you? (1 - 5, 1 = very unclear, 5 = very clear). • Do you feel like the tool provides you with a clear overview of the available sound design functions?
7a. The tool should translate sound design functions into something recognizable to designers from their expertise.	• Do you feel like the sound design here is translated into something accessible/understandable to you?
8a. The tool should enable the user to practice epistemic actions.	• The final prototype was a digital interface. Therefore the design qualities regarding the tangible interactions could not be evaluated properly through use but only contextually.
9a. The tool should enable the bridging of digital and tangible information through the use of external representations.	
10a. The interactions with the tool should be visible to all participants, to ensure indirect learning through observations.	

6.6.3 Results & Interpretations

The results of the interview were analyzed using the 'on the wall' method. Three overarching themes emerged from the results, which are used in this section to present the insights together with the supporting quotes from the participants.

Emerging themes

- Integration of the tool in UX design projects
- The facilitation of the discussion, collaboration and bridging of the semantic gap
- Supporting of explorative and prototyping activities
- Clarity of communication and usability

Expertise in sound design:

Majority of the participants scored themselves as 'Not very experienced with sound design'.

1. Integration of the tool in UX design projects

Generally participants would like to use the tool to enhance their knowledge of sound and how it could be integrated into their products.

"Especially to be able to communicate with others about a sound that you have in your head. I find it difficult to talk about sounds because I don't have the vocabulary. I think this is a bit more convenient for talking about the sounds." - P2

"You can play with it to get more knowledge about what sounds there are. And to gain insight into what kind of sounds you need in the project and discover what feeling you want to give to your project at all and what kind of sound suits it." - P3

Three out of four participants described that they would use the tool after the embodiment of the product is already done. They would first create certain functions and then look for sounds that support these functions.

"I would use it when the app and the functions are already done so you can make the sounds fit to the app. First ' the button is baby pink; then ' so this kind of sound fits it" - P1

"If you want to add sounds to something. Now you look at those sketchy websites with ringtones to find something that fits perfectly. But with this [tool] you can use it to adjust things to the sounds yourself and better find out what it [sound qualities] is exactly and what it is called." -P5

One participant noted that she would like to use the tool during the earlier stages as well as the later stages of the design process, to get inspired and sensitized to the use of sounds in the product.

"Mainly at the beginning to get more of a feel, but more elaborately at the end to really get inspiration for the final sounds. You could also use it in the prototypes for user testing." -P3

2. The facilitation of the discussion, collaboration and bridging of the semantic gap

When asked whether the participants could imagine the tool being beneficial for collaboration and discussion they all answered positively.

"Yes especially if you use it together and it can facilitate the discussion on how different people experience the sounds" - P1

" Yes, to communicate about the sounds with designers or people in your work group. Because we as designers often don't have the words to describe the sound and I have seen how clumsy we can be when we try to describe sounds." -P2

"Yes with sound designers, right? yes, I can really see that especially to clearly speak the same language. I think it is very important." -P3

"Yes, I think that a conversation, with a [sound] designer, I could clarify what I am looking for" -P4
"Yes, because otherwise if you have to describe a sound, you have to say something like 'I want it to sound friendly', but then people still don't know what I mean. Now I can say 'I want a bit of this but not this at all eg.'. I" - P5

Regarding the use of the vocabulary the participants had different approaches as to how they would use it and what their interpretations were.

"I am not sure if I completely agree with the vocabulary of the tool, I think I could use it but also the sound is very subjective so everybody needs to have the same definition of e.g. ; round; sounds. But maybe by using the tool you can actually explain to each other what it means and use this vocabulary." -P1

"I need to play around and try out all of these settings before I feel confident in my ability to understand the vocabulary. Now for example I know, I chose a metallic sound, and I put the prolongation at high so I hear a lot of echo" - P3

3. Supporting of explorative and prototyping activities

Overall the participants were positive in the ability of the tool to support sound prototyping activities. Especially the flexibility of use and the ability to quickly make sounds would make it possible for them to create sound prototypes for their projects.

"With this tool, I could make different sounds for [a product evaluation project]. Normally I use the standardized sounds but with this, I could look a bit broader." -P2

"Yes, I think so, I think it can make prototyping more interactive, especially if you still have a non-working prototype .....you could then more easily iterate and discover how the user reacts to certain interactions and investigate them."-P3

All of the participants could see themselves being able to make sound prototypes using the tool to a certain extent. Participants compared using the tool to using a sound library; they preferred to use the tool because of the ability to adjust sounds.

"Yes, there are a lot of things you can tweak and because of that it feels like you are really making something and not just making something from a library."-P1

Three participants would prefer to create specific sound prototypes and would like to have more functionalities added to the tool such as: being able to adjust the speed, choose specific time-snippets, being able to sequence and mix sounds.

"To a certain extent, yes [I could use it for prototyping], but the sound often has to be adapted to the product or video. Sometimes the sound has to be much longer, for example. I don't know if it is possible here to adjust these time-related things.."- P2

"A bit yes, but rather simple prototypes, not complete elaborations. Prototype is more of a direction and I think it would need to be a bit more complex for real product sounds. You can't really make tunes with this like for example for a washing machine duu duuu du duuu"-P3

"Yes I think so [about being able to create prototypes], the only thing is I would really like to put the sounds on top of each other kind of? So I can make something more like a song" -P5.

Regarding the ability to facilitate exploration, the participants generally agreed that the interface was more explorative than e.g. using a sample library.

"Yes for sure [on whether she would be able to explore], when you see this it instantly feels very inviting and you really want to look around and find out what everything does" -P1.

"Yes I think so, I myself would not be able to come up with all these different types of sounds. Normally I would only think of very standard sounds but now you can think broader and pay attention to what could be changed for example" - P2.

"I think it's cool that the tool forces you to explore the sounds because the names are only shown once you click on something" - P2.

When it comes to the balance between being able to explore and being able to zoom in on specific sounds there were two contradicting opinions:

"You can explore for sure, especially in this big map that you see, but also when you click on one of the samples and adjust it, I think you're still exploring then" -P4

"I think exploring is a bit difficult because the moment you click on a sound you already see this adjusting screen, so you can't really first listen to all the sounds separately and then choose what you want to zoom in on" - P3.

4. Clarity of communication and usability

When talking about the usability of the tool and its accessibility, it was noticeable that the participants lacked a frame of reference. Because of their lack of experience with sound design, they did not know what the alternatives were, such as Digital Audio Workstations.

In order to quickly sensitize the participants the backend of the interface was shown in Ableton. The Ableton set-up consisted of exactly the same functions as the Timbreworld, the only difference was in the presentation and the complexity of these functions. Users were familiar with some of the information they have seen in Ableton, such as the audio filters.

"Compared to Ableton this feels a lot more comfortable because it's more intuitive and visual"- P3

"If I look at something like Ableton, I have no idea where to start, there are so many options and I am scared to click on the buttons because I could mess up with the settings or something. Here [in Timbreworld], I feel free to just click around, you can't really do anything wrong here" - P5

"I think if I just randomly push buttons I will understand better and quicker what they do here [in Timbreworld] than in something such as Ableton" - P4

Generally participants felt like the sound design activities were made more accessible to them through the tool. They noted the intuitivity of use and the ability to navigate the interface even with low amounts of experience.

"When I used to think of a sound design I never knew where to start but here the starting point is already made for you. Half a year ago I would not know what to do but now I can just use this tool and quickly start exploring the sounds." -P1

"Yes [the tool is accessible to inexperienced users] because it's very intuitive, I did not know the words but by trying it out I learned what they make" - P1

"I don't really have experience with sound design and I can still make it work. But also because it's made very visually, so it works for me." - P3

What the participants did miss was some background information. Although the tool provided them with the descriptions of the sounds all of the participants would also like to see more information on the editing functions.

"I am missing some descriptions of what the things are like the temporal asperities, I can hear it and I think I get it but I would like some kind of confirmation" -P2

"I would like to see some more information, maybe only when you need it so only if you click on something but generally I want to learn a bit more about the editing possibilities" - P3

5. Other notes

The appearance of the tool and the visual style evoked positive associations in the participants and made the editing functions easier to understand to them.

"It's very inviting, the colours, the soft shapes. When thinking of a sound design I quickly think of something like Ableton, to me, Ableton is like coding and using this [Timbreworld] is more like drawing, here I feel more comfortable" - P1

One user test participant and one pilot participant also had some input on the positioning of the tool in the context of design.

"I never worked with sounds so I'm not sure but I think that if this tool was part of the course I would surely use it. But it needs to maybe be introduced to me because I am not the kind of person who knows that all kinds of these tools exist and are available to me" - P5

"I think the tool is accessible to me but I would like to get a feeling that it's made specifically for people like me. Because if I feel like it's made for like professionals I just don't feel confident enough then in the choices I make" - P5

"There is a course in the bachelor's where the students have to explore different senses. Usually, they have trouble working with sound and I think that something like this [Timbreworld] could really make it more accessible to them to understand sounds" - Pilot participant 2

Furthermore, participants also had some insights on how the tool could be improved for usability.

"I would like to be able to save my settings and see them somewhere, that way it will be a lot easier to compare different sounds"- P4

"Everything is pretty clear, especially after I had a chance to play with it, but I would like to maybe have some examples of possible combinations so I would know what good combinations are" - P1

"For the mute button it would be better to use an icon and cross out the icon when the mute is activated." - P2

Lastly, one pilot test participant commented that he would prefer for the tool to be tangible instead of on a laptop screen.

"Something like this would be better if you were able to really move things and do it physically instead of on a screen" - Pilot participant 2

6.7 Final Evaluation

Based on the results of the user tests it is possible to conclude that the Timbreworld would, overall, be able to facilitate prototyping activities with sound and support the bridging of the semantic gap between the participants.

The tool was overall perceived as intuitive, and useful for sound prototyping and explorations. The participants would like to use the tool to get inspired, inform themselves and communicate their design choices. According to the participants, the tool is easy to get used to and they could see themselves using it in collaborative settings.

The vocabulary provided with the tool could be expanded further, as the participants would like to receive more information on the sound editing functions and what they exactly do. All of the participants noted how the use of the tool could improve their ability to communicate sounds with other stakeholders.

Participants compared the use of the Timbreworld to the use of sample libraries and Digital Audio Workstations such as Ableton. Generally, the participants preferred to work with sound using the Timbreworld than the other tools because of its accessibility and inviting appearance.

The interface itself was clear to the participants, with a couple of points for improvement that could be made regarding the usability:

- Icon use for the mute button
- A way of saving the settings and applying them to other sounds
- An overview of possible setting combinations for inspiration

Also interesting to note how the participants imagined the tool to be useful in different design stages. Although the tool prioritizes abstract exploration of sounds, the majority of the participants (3 out of 5) would use it to create specific sound prototypes fitting for pre-designed functions and interactions. This connects to the different perspectives of integrating sound in the design process: to design with sound versus designing the sound (p. fx). It would be beneficial in the future to understand how the tool could support the design with a sound approach since it emphasizes the value of sound in the design project.

The evaluated prototype was a digital interface, therefore the design guidelines regarding the tangible interactions have not been evaluated. However, based on the insights from the literature review (see chapter FX) and previous prototyping activities (see p. FX) it can be confidently said that the design guidelines could be integrated into the real tool.

Design Guidelines	Evaluation
1a. The tool should support the traditional sketching process of starting broad and gradually zooming in on specific sounds.	Yes
2a. The tool should let users create multiple sonic sketches and compare them to each other.	The prototype does not allow for saving of sketches and comparing them. However, Participants were confident in their ability to prototype sounds with the tool. Furthermore, participants would like to see functions such as speed control, time stamp selection, sequencing and mixing in the tool.
3a. The tool should be clear, in its form and its functions to facilitate collaboration and discussion.	Yes
4a. The tool should be clear and accessible to users with different degrees of expertise.	Yes, but the participants would like to see more information on sound editing functions
5a. The tool should support the formulation of a shared language to bridge the possible semantic gap between the participants.	Yes
6a. The tool should provide its users with a clear overview of the functions.	Yes, but supporting information is needed
7a. The tool should translate sound design functions into something recognizable to designers from their expertise.	Yes
8a. The tool should enable the user to practice epistemic actions.	Not evaluated
9a. The tool should enable the bridging of digital and tangible information through the use of external representations.	
10a. The interactions with the tool should be visible to all participants, to ensure indirect learning through observations.	

6.8 Conclusion

This chapter presents the development of a concept for a sonic sketching tool: Timbreworld. The starting point of the conceptualisation was the utilization of the design guidelines (chapter 5) which were used to navigate the brainstorming activities and make design choices (6.1).

The conceptualisation led to the development of an interactive prototype, a visual representation of a sample library based on the wordsforsounds. SPEAK lexicon (6.2). The preliminary prototype has been tested with participants and the insights from this activity have been integrated in the further development of the prototype (6.3).

The final prototype of the Timbreworld is a digital interface which allows users to explore a sample library in a timbral space and adjust different audio qualities in order to create sonic sketches (6.3 & 6.4). This digital interface has been used for the final validations of the concept in a user testing setting with five participants (and two pilot tests) (6.5).

The results of the evaluation are positive (6.6), the prototype allows for exploration of the timbral space in an intuitive and user friendly way. The information provided by the interface empowered the participants to feel more confident in their ability to communicate about sounds.

Furthermore the Timbreworld prototype was evaluated as accessible and easy to navigate. The participants were able to imagine themselves utilizing the tool in their projects as a way to explore sound design, create prototypes and facilitate communication with other stakeholders.

The concept of the Timbreworld is a tangible interface that is meant to be used in group settings. The prototype however was a digital interface, therefore the tangible interactions were not evaluated in the user tests.Some points of improvement have been noted down and will be taken into account for the recommendations section of the project (chapter 7).

Chapter 7

Timbreworld: Final Concept

Timbreworld
- Why
- What
- Where / When
- How it works
- Setup

Recommendations

Introduction

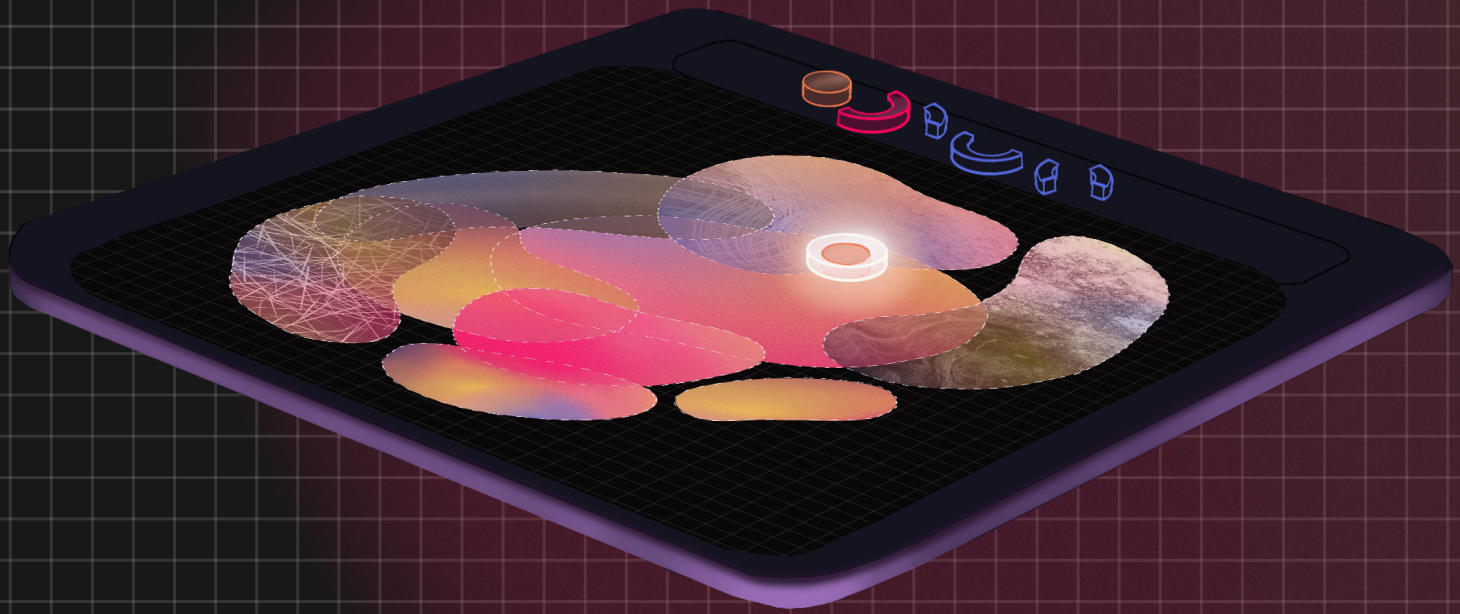
This chapter introduces the final concept of Timbreworld; a tangible interface used for sonic sketching in the context of UX design. It focuses on providing information about the context of use, technical setup, and interactive features of Timbreworld. Completing the previously discussed aspects of the concept such as the digital interface setup (Section 6.4) and sound processing (Sections 6.5 & 6.6).

The final section of the chapter offers recommendations for the future development of Timbreworld and similar tangible tools for sonic sketching

Click on the image to try out the graphic interface of the prototype (no sound)

Or use the qr code, however the interactivity only works on a laptop/desktop

TIMBREWORLD



An intuitive sound design tool that makes prototyping with sound accessible to novice users

WHY

Even though sound is invisible to the human eye, its value in product design should not be overlooked. When done right, sound design can greatly enhance a product, however, designers often lack the needed tools and skills to integrate sound design into their process; specifically in collaborative design activities such as prototyping.

Ideally, sound design activities would be integrated into the prototyping stages of the UX design projects. However, tools that are frequently used for sound design, such as Digital Audio Workstations, often consist of complex interfaces and are difficult to grasp for inexperienced users. There is a need for tools that can be operated in a quick-paced and iterative way which is so characteristic of prototyping activities.

The lack of tools is just one side of the problem, on the other hand, UX designers lack the vocabulary needed to communicate about sounds. Resulting in miscommunications when collaborating with professional sound designers. Timbreworld aims at bridging this semantic gap and providing UX designers with appropriate tools for prototyping with sounds.

WHAT

Timbreworld is an interactive, tangible tool, created specifically to facilitate sound prototyping activities of UX designers. The goal of Timbreworld is to provide its users with an environment where they can explore sound design functions in an accessible way as well as create their own sound prototypes (sonic sketches).

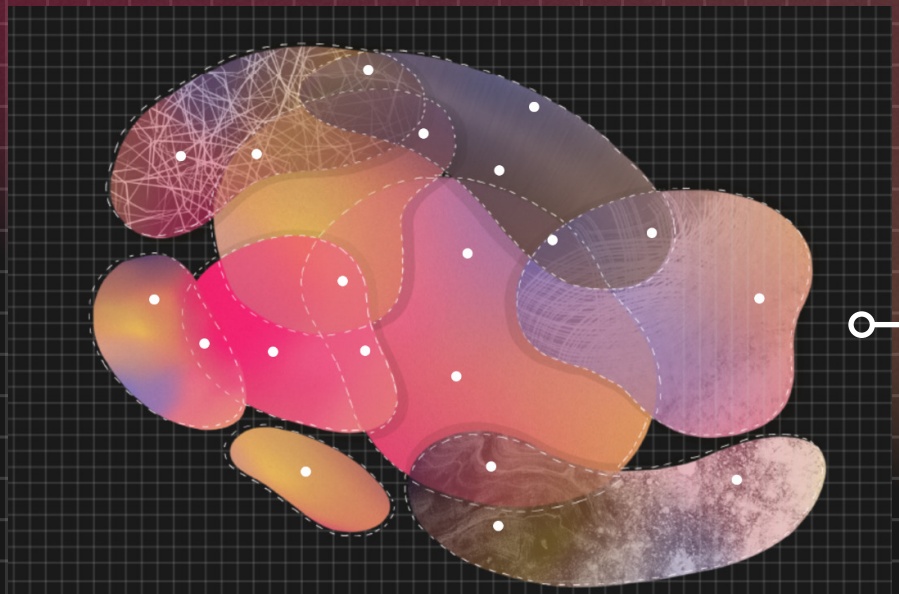
Exploration allows the users to get to know the sound design vocabulary at their own pace. In the end, the interface should help the users to expand their sonic vocabulary and improve communication on sound design between different stakeholders.

By integrating prototyping activities with sound in their process, designers can achieve a deeper understanding of the value of sound. Furthermore, the creation of sonic sketches enables designers to create rapid sonic prototypes and integrate them with their other design activities, such as user tests.

WHERE / WHEN

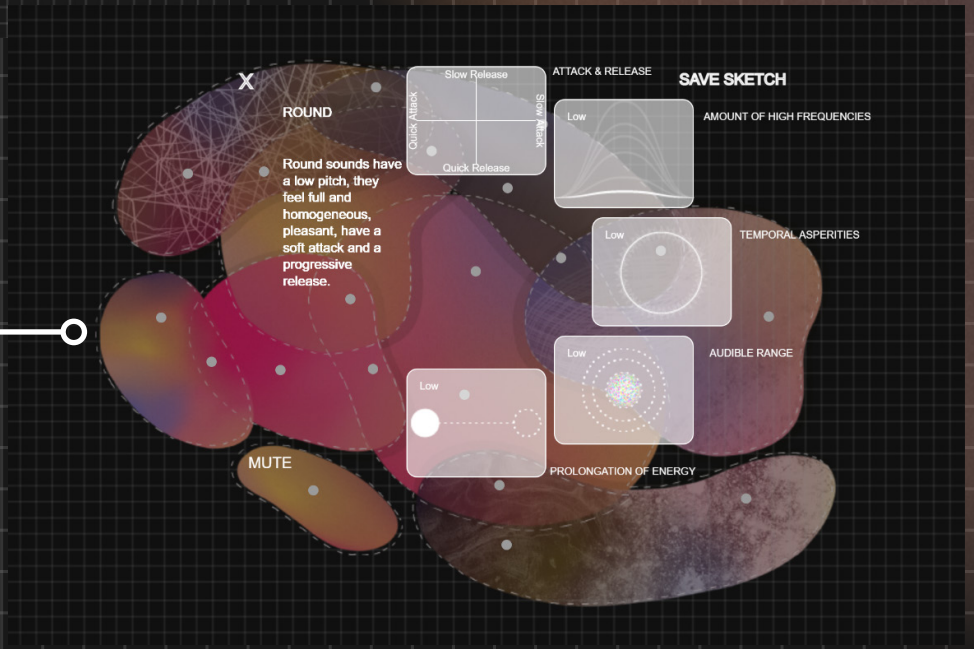
The Timbreworld is meant for use in the context of UX design, specifically during the brainstorming and prototyping activities. It translates the traditional sound design functions into accessible-to-user representations. The product is intended to be used in a group, it facilitates discussion and collaboration between the participants through its shape and type of interaction.

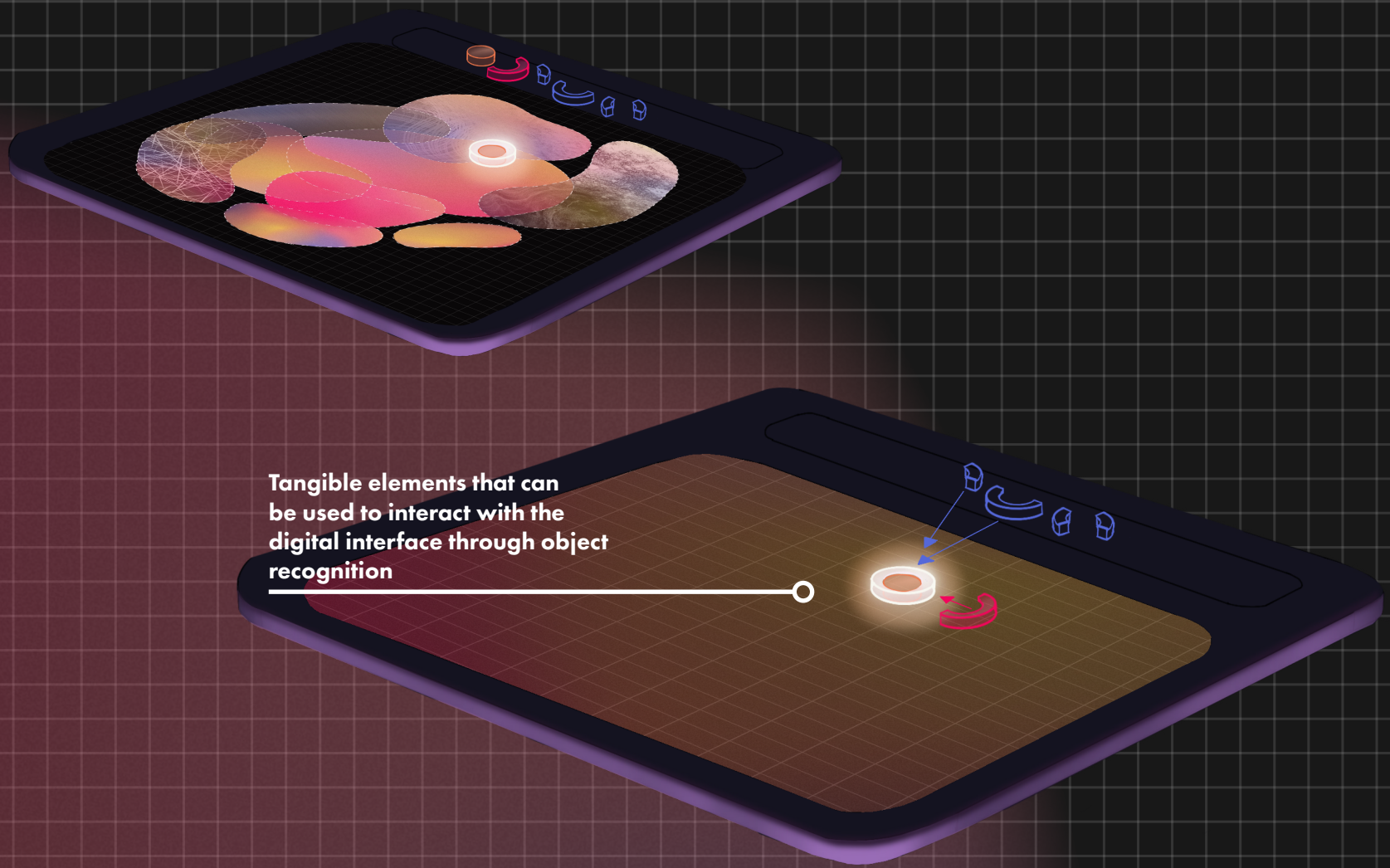
The interface can be projected onto a flat surface, allowing it to be easily adjusted to the size of the group. The flat interface, combined with physical interactive elements, allows for the tool to be appropriate for collaborative settings. The visibility of the actions ensures the passive learning of all participants.



Explore the timbral space of the wordsforsounds.SPEAK lexicon

Play with the sound editing functions and create your own sonic sketches




Tangible elements that can be used to interact with the digital interface through object recognition

HOW IT WORKS

The Timbreworld consists of a projection in combination with a set of tangible objects and a webcam (sensor). Through the webcam, a machine learning algorithm recognizes the objects and allows the user to manipulate the projected information by moving objects on top of the projection.

The information that gets displayed when using the Timbreworld is a clear overview of all the functions that can be accessed. This overview makes it possible for the user to explore while also feeling like they are able to access the functions at any moment. The amount of editing possibilities is limited, to fit the context of UX design, resulting in a straightforward and intuitive user flow.

The tangible elements, which are placed on top of the projection, can either be printed out or made by the users themselves. Machine learning in combination with object recognition tools such as YOLO (You Only Look Once) [53] allows the users to create their own control elements; making the Timbreworld an accessible interface all over the world.

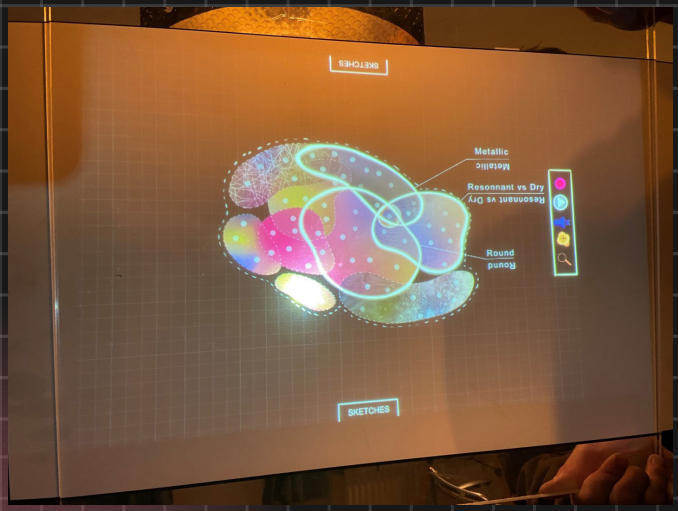
The control elements are used in a similar way as mouse movement on a computer screen. They signify the position and selection aspects of a cursor. Similar to the use of pucks in the tangible interface Audiopad (p. 61 - 63).

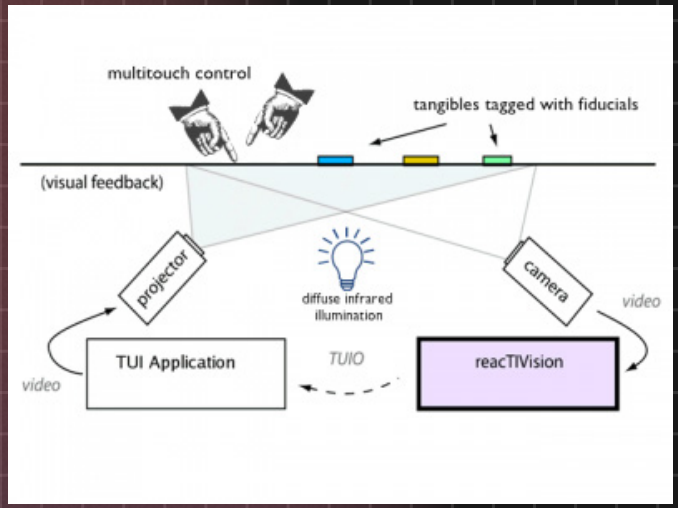
SET-UP

The current set-up consists of a projector, a webcam, a transparent surface, a mirror and elements that can either be printed out or made by the users. There is no specific hardware necessary for the use of the interface. It is an online tool that can also be used with a (computer) screen instead of a projection, however, the intention is for it to be projected onto a flat surface.

This set-up makes Timbreworld accessible to designers from all over the world, ensuring that they can participate in the activity of sonic sketching without needing to purchase a specific hardware instrument.

There are also ways to expand the system, e.g. by providing users with specific tangible elements that correspond with functions in the interface. Or by accessing new sample libraries through recognition of corresponding tangible elements.





Set-up of the projection, webcam and surface of the interface similar to the ReacTable (p. 56 - 57)

Recommendations

This section presents possible implementations that could improve the functionality and usability of Timbreworld.

Although the project is finished, and with that, most likely the development of the Timbreworld as a concept; the recommendations could still be useful for future developments of other tangible interfaces for sonic sketching.

Tangibility

The Timbreworld prototype has only been evaluated as a digital interface. Because of the time limitations of the project other aspects of the concept were prioritised; such as creating the sonic sketching functions and developing the visual and communicative aspects of the interface. It should be possible to expand the digital interface into the physical world using technology that is commonly available, such as object recognition machine learning algorithms or sensor tracking. However, the digital interface may need to be adapted to facilitate intuitive interaction with tangible elements.

Use in collaborative settings

During the project the concept and the prototype have only been tested with individual participants. The evaluation participants were confident in the application of the interface in collaborative settings, however, it is not clear yet whether multiple participants will be able to interact with the tool at once.

Sound design expertise

The Timberworld was developed from the perspective of a UX designer. This posed several challenges during the project, especially during the conceptualisation of audio processing. Although some experts in sonification were involved in the project what is perhaps missing is the insight of a professional sound designer that collaborates with UX designers. By combining the expertise of UX design and sound design, Timbreworld could take a significant step towards bridging of the semantic gap.

Added functionalities

At the moment the tool allows for exploration of the tangible space through adjustment of six sound attributes. During the evaluations, it became apparent that a more complex functionality would be preferred by the users. Especially the ability to sequence sounds was missed, along with adjusting the time-related qualities such as duration, start and endpoint of the sample.

Setup

The current, conceptual, setup of the Timbreworld is inspired by the ReacTable interface which uses an upward projection onto a transparent surface. The promise of the Timbreworld is to facilitate UX design activities which may require modularity and the ability to transport the interface to different contexts. This is difficult to achieve with the current set-up as a transparent surface is needed that should be positioned at a table-top height. Another iteration of the set-up would be needed in order to ensure that the tool is truly applicable in the context of UX design.

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