draw music!
Designing an accessible and engaging tangible music writing interface for non-musicians

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Abstract

I designed and developed *a* new tangible and accessible interface for digital music sequencing. Taking inspiration from the field of graphical sound, the aim was for this system to be more engaging, intuitive and easy to use - especially for those users less versed in music.

- I conducted a thorough review of historical and contemporary implementations of graphical sound.

- I wrote a total of 2600 lines of source code in JavaScript using the libraries p5.js and p5.sound, for a browser-based web application called *draw music!* The app contains functionality for photographing an image, detecting continuous lines in that image, converting those lines into musical sequences and playing them back, as well as some other basic features of music software.

- I undertook a user study to compare my system with existing music notations and sequencing software to determine whether it meets its goals.

Dedication and Acknowledgements

I would like to express thanks to my awesome supervisor, Peter Bennett, who guided this project along the right track from start to finish, and whose creative suggestions and inputs kept me thoroughly inspired! Thanks also to the kind participants who volunteered their free time for the user study, and my friends who supported the project through its development.

Declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Taught Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, this work is my own work. Work done in collaboration with, or with the assistance of others, is indicated as such. I have identified all material in this dissertation which is not my own work through appropriate referencing and acknowledgement. Where I have quoted or otherwise incorporated material which is the work of others, I have included the source in the references. Any views expressed in the dissertation, other than referenced material, are those of the author.

Peter Marsh, Friday 6th May, 2022

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Ethics Statement

This project fits within the scope of ethics application 0026, as reviewed by my supervisor, Peter Bennett.

Supporting Technologies

- I used the JavaScript p5.js library for the backbone of my application, using many of its classes and functions.

- I used p5.sound.js, an extension of p5.js, to facilitate the synthesis and output of sound for my app.

Notation and Acronyms

I introduce the following acronyms which I will use throughout the paper.

GUI	:	Graphical User Interface
UI	:	User Interface
DAW	:	Digital Audio Workstation
DOM	:	Document Object Model
MIDI	:	Musical Instrument Digital Interface

Chapter 1

Introduction

Music is an innate part of human expression. It is universal across cultures [31], as well as across time, with the earliest evidence of music creation, a neanderthal flute carved from bone, dating back 60000 years [45]. As civilisation and technology has developed, so has music and the way we can produce it. New systems for music creation are always being created, from the automatic player pianos of the 17th century [48]; to modern software that utilises cutting-edge machine learning techniques to emulate the sound of any instrument [10]. These days, each facet of music creation is supported by its own technologies and, as computers become ever more prevalent in society, digital and software solutions are being introduced to allow any person with a computer to get involved at any stage of the musical process. It is this increasing level of accessibility that really captures my attention; only fifty years in the past if an artist wished to create an album, they would require a team of technicians and access to a dedicated studio with expensive specialist hardware to produce an album. Today anyone with a laptop and some software can produce music, and we have artists like FINNEAS producing very popular albums in their bedrooms [4].

Despite this unprecedented access to music technology, there are still barriers to engaging with music that might discourage those trying to break into the field. For instance, users having their first go with music production software are often confronted by complex interfaces with an intimidating array of options, many of which are opaque and difficult to understand for beginners. Learning to efficiently use a Digital Audio Workstation (DAW) often requires months or even years of practise [38] and users often have to turn to instructive websites and video tutorials in order to build competence in the software [12].

An even more fundamental barrier is that of musical understanding. Since musical instruments and many musical interfaces require a prerequisite working understanding of music to be used meaningfully, novices are often discouraged from partaking in musical activity. I believe that for music to be truly accessible, there must be an engaging and rewarding system that produces satisfying musical results whether used by an untrained user or an expert.

It is this problem that I set out to tackle in my project. I developed an app, called *draw music!*, designed to be as accessible as possible for non-musicians. I combined this with my interest in graphical sound i.e. representing and sound storing sound with a visual representation which can be interpreted and played back by a system. If a novice is given a simple interface where they can express their musical ideas through the familiar medium of drawing, it should allow them to engage in music creation in a novel and exciting way which is not available through traditional interfaces.

Before embarking on development, I researched musical representation and sequencing methods and past studies on accessibility for non-musicians (see chapter 2). I also conducted a thorough review of historical and modern examples of graphical sound, exploring the different methods and paradigms that have been implemented (see chapter 3). This research was then used to inform the design of the app.

draw music! builds upon the inventions of the past and present by taking the best features of these existing implementations, streamlining the interface and utilising computational aids to help the user produce something that they can enjoy while also maintaining a sense of ownership of the music. I break down the design and explain the crucial parts of the implementation in chapter 4.

Finally I undertook a user study to validate the app, recruiting eight participants with varying musical experience to see test if the app fulfills its purpose as a composition tool for non-musicians. The testing was carried out over 5 days for each participant, with a different creative prompt each day to encourage different ways of using the app. After the five days, I conducted semi-structured interviews to gather feedback and gain deeper insight into how the app was used by the different participants (see chapter 5).

Chapter 2

Contextual Background

In this project I take a particular interest in music sequencing i.e. devices and software that can record, edit, or play back music, by handling note and performance information [50]. More specifically, I focus on methods of inputting sequence information into a system. In this section I will explain some music notations and encodings that have been used historically, what is being used now, and other ways of representing musical information. After that I will discuss some modern studies regarding how to make music more accessible to non-musicians. The findings of these studies took a major role in helping *draw music!* be a useful tool for novices.

2.1 Musical notations, encodings and sequencing

Writing down, or recording, music is an important aspect of its preservation and communication, and there are countless ways of representing music in written form. The oldest known example is from 1400 BC (a set of songs known as The Hurrian Hymns) which are written in cuneiform inscribed on clay tablets (Figure 2.1). It is interpreted as a set of lyrics and numerals, where each numeral describes the pitch at which the associated lyric is meant to be sung [49].

Figure 2.1: Hurrian Hymn Clay Tablets [59]

Today most of the world has settled on western staff notation, also known as sheet notation (fig. 2.2a). Staff notation establishes a very important convention which we see will keep appearing across almost all systems we will look at: Time runs along the x axis, and the y axis represents pitch. Thus it is consistent with written language in the west, being read from left to right, and higher pitched notes are written higher on the stave. Most musicians would agree that it is very efficient for conveying musical information, but difficult to learn, taking years of practise to interpret fluently. In other cultures, old notations are preserved through tradition and often learned by folk artists (fig. 2.2b).

Another widely used set of notations is tablature, or tab for short. These systems are designed for particular instruments and offer more direct instructions on where and when to move ones fingers, rather than representing information about the sound itself (fig. 2.2c). We also have graphical notation, which often doesn't aim to precisely convey ideas, instead leaving the interpretation up to the musician.

(a) Staff notation is a widely used today. [52]

(b) Notation for the Shakuhachi, a traditional Japanese flute. [54]

(c) An example of guitar tab. The lines represent the strings and the numbers indicate which fret should be pressed to produce the note. [24]
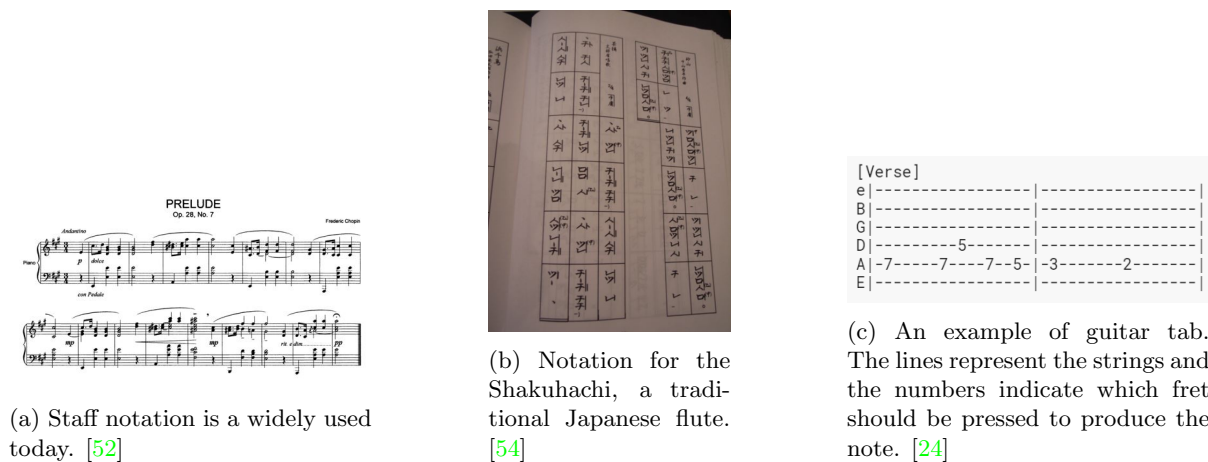
Figure 2.2: Examples of written music notation

When presenting music to a machine we have a different set of considerations. Since humans are not reading the notation, we can focus more on efficient and accurate instructions without making compromises for readability. Before digital computers, it was also necessary to have a representation that could be read by a mechanical system, and we will explore this idea in the following paragraphs.

One of the first systems to play music autonomously was developed in 1881 by Jules Carpentier. His *Mélographe Répétiteur* was able to play back a performance on a harmonium using the input of punched card [42], which had been used previously in the same century to encode loom weaving patterns and went on to become the standard method of programming automated machinery and processing data. The cards are fed into the machine at a constant speed, where it is "read" by the tracker bar, meaning the punched holes cause levers in the machine to open valves, letting air pass through the reeds and causing the machine to play a melody. Similar to staff notation, the distance of the hole along the length of the card would determine the timing of a note, the length of the hole would determine the duration and the distance along the width of the card would determine the pitch.

The evolution of punched card came in the form of Book Music (fig. 2.3a), where long pieces of punched card were strung together in a long connected zig-zag, allowing long pieces to be encoded. Being made with sturdy material, the books were ideal for large, frequently used instruments like fairground organs because they were resistant to wear.

Next to be developed was the piano roll (fig. 2.3b) which used a thinner material such as paper, meaning a piece of music could be stored as perforations on a single continuous sheet which could be rolled to save space. These were read by passing air through the holes where, again, the position of a hole determines the pitch of the note. The piano roll would become a standard way of storing music for automatic playback, and they became mass produced, being in continuous production since 1896 [25]. Instruments utilising the piano roll include the player piano (also known as the pianola), the orchestrion and the music box (fig. 2.3c).

From the inception of synthesizers from the 1950s to the 1980s, we now had ways to produce sound electronically, using analog circuitry. Input signals called control voltages were used control pitch in these instruments and keyboard interfaces were made, which sent the correct control voltage to the synthesizer depending on the key pressed. Along with these analog synthesizers came ways of programming musical sequences, with various interfaces to control how it was done. A common method was to confine the sequence to a certain number (usually 4, 8, or 16) beats or "steps", and allow the user to control the musical output for each step using various knobs and buttons (fig 2.4a).

Soon, sound was being synthesized digitally rather than through analog circuits. The first digital synthesizer to be commercially released was the Casio VL-1 in 1979 (fig. 2.4b), and soon there were many in the market. A problem was that each manufacturer implemented pitch control in a different way, making it impossible for a sequencing device made by one company to control a synthesizer made by another. In 1982, Musical Instrument Digital Interface (MIDI) was released, which was a huge turning

(a) Book music being used to play an organ. [51]

(b) A piano roll being played by a pianola. [3]
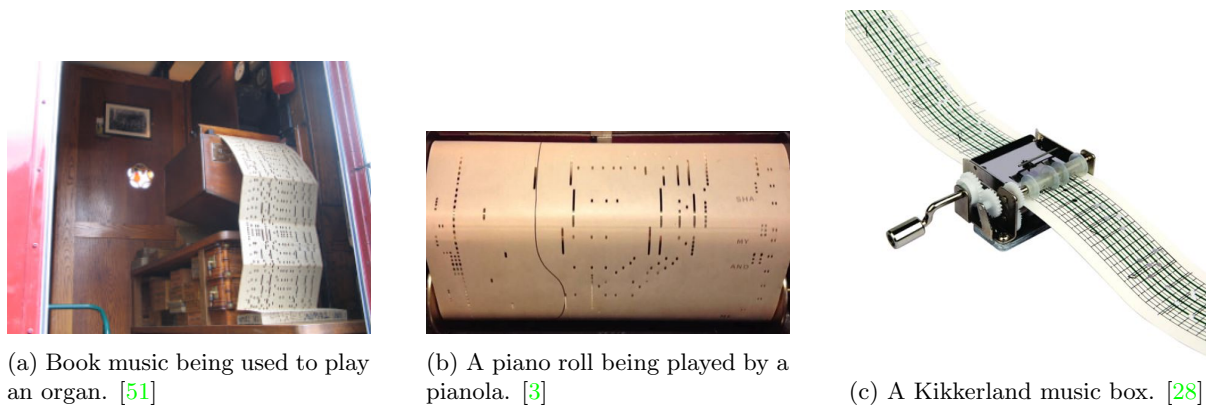
(c) A Kikkerland music box. [28]

Figure 2.3: Examples of automatic music instruments.

point for music sequencing [3]. MIDI set out a standard protocol for sending storing musical information and sending it between devices, and it is still widely used today in many music applications.

MIDI granted musicians the possibility of controlling digital synthesizers with computers. As such, software was needed to input music information into a computer to later be used to control an instrument. Based on the previous success of the piano roll, a virtual version was made to visualise the MIDI information being manipulated (fig. 2.5a). Instead of holes punched in a roll of paper, users would see rectangular bars, indicating notes, on a uniform grid across the screen. It would become convention that the y axis of this grid would indicate the pitch, and the x axis would represent time. This software version of the piano roll would become the most common way to edit MIDI sequences in modern DAWs.

Interestingly, although historically the physical piano roll was purely used for interfacing with machines, this new software piano roll has grown to become a very useful new notation system for musicians seeking to learn songs. Given its highly visual nature, it is very easy to intuit the timing and relationship between notes from looking at a piano roll, especially for novice piano players. In fact, we can see by the number of beginner piano tutorials on YouTube using piano roll visuals, that beginner musicians are turning to this notation even more so than traditional western notation (fig. 2.5b).

People can also write staff notation with a computer using software like Sibelius or Musescore. While these are designed primarily for typesetting, acting for notation as a word processor does for text, they are also able to use the written score to play back the music and essentially act as a sequencer. This is useful for composing because the user can hear what they have written, and quickly iterate on different ideas. Staff notation editors often include the option to export the music as a MIDI file to be used in other music software and devices.

2.2 Accessibility for non-musicians

Even with all this amazing sequencing technology available, it remains a problem that it is difficult for an untrained user to learn how to make the most of it because "current systems aiming at facilitating and extending musical expression typically rely on concepts that non-musicians can hardly comprehend" [34]. So the natural next step is to work on interfaces that encourage this type of user rather than intimidate them. Experts in the field of Human-Computer interaction have began to examine this challenge, undertake studies, and determine what aspects of a system afford the most creativity, fun and engagement for the musical layperson. In this section I review their main findings.

The first obvious design choice is to avoid interactions that assume any prior musical knowledge. An inexperienced user will want to convey their artistic intents in an intuitive way, and it will likely differ from the language and conventions used by seasoned musicians, which are often incorporated into music software. Instead, novices will use visual, textual, gestural and emotional ways of communication, which they are used to employing in their day to day life [34].

A main and unanimous discovery from studies on non-musicians is that the focus should be on the user's learning and exploration [58]. Those that engage with a musical system with an exploratory experiential goal are more easily creatively engaged than those with a utilitarian goal e.g. trying to create something specific [57]. This may be because the pressure of a utilitarian goal limits divergent thinking and exploration of ideas. Hence, an interface for non-musicians should be designed as a means

(a) The ARP Sequencer, one of the first step sequencers (1976). [46]

(b) The Casio VL-1 digital synthesizer. [18]

Figure 2.4: Two early music devices.
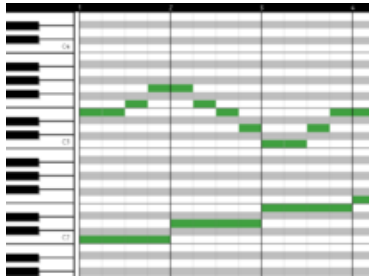
(a) Software piano roll. [3]
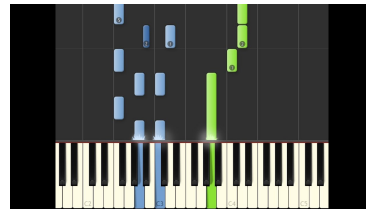
(b) Synthesia is a piano learning software which uses a piano roll. [43]

Figure 2.5: Examples of automatic music instruments.

to a good experience, guiding them towards exploration rather than a means to a particular outcome. A good interface will allow the user to freely interact and find out themselves how their interactions affect the sound, allowing the user to quickly build up a working knowledge base and gain more control over the system. As such, the interface should be able to instantly offer audio feedback and, even better, provide graphical feedback as well to aid their understanding. Furthermore, simplifying the interface and enabling users to isolate and zoom in on different parts of the system, especially isolating specific sounds, really aids in the learning process [58].

Now, a design choice that is important to consider is one of how much control to give to the user. A user should be relieved of the commitment of managing each and every note, and other fine aspects of the sound, since they may lack the knowledge to do this in an intentional way. Instead, they can be offered computer aid, where the user controls some higher-level parameters which are then converted into detailed musical information by algorithms or, indeed, artificial intelligence systems. On the other hand, there should not be so much control taken away from the user that they end up lacking agency in the creative progress and feel that the musical output does not belong to them [34]. Thus there is a fine balance to be struck; one where the user has enough input to enable them to feel a sense ownership of the music, but is not so much that they do not have the experience needed to create something satisfying in a reasonable amount of time.

Chapter 3

Related Work

draw music! is a new contribution to the area of graphical sound, a field of visual music representations and the technologies which convert those representations into audible sound. By building the app on this paradigm, we can have the user create a broad graphical representation of music through the familiar interface of drawing. This increases accessibility because the user is not involved with the organisation of individual notes, and they interact with the sound via a visual medium to which they are already accustomed (see section 2.2).

The idea of generating sound from a visual basis is not a new concept, and technology for facilitating graphical sound has been in development for over 100 years [5]. In this section I will first document some of the most noteworthy inventions in this field from the past, exploring how they worked and how they built upon previous works. We will then see how instruments in this area have been refined to leverage modern technology as well as the alternative methods for converting drawings and images into music.

3.1   An abridged history of graphical sound

Sound-on-film.   Graphical sound was first implemented as a tool for cinema. While film cameras would capture light from a scene and expose it onto a reel of film to be developed for playback, the audio was also captured. The sound waves would be represented longitudinally, or by area on the tape, and a system of photocells and amplifiers would recreate the sound in the cinema [22]. Sound-on-film was used as far back as the 1920s.
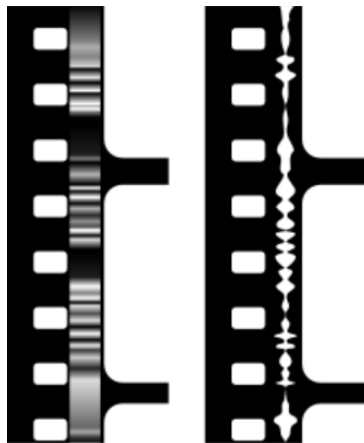
Figure 3.1: Example sounds represented on film. Longitudinal representation (left) and area representation (right). [55]

The Variophone.   In 1930s Russia, Evengy Sholpo invented the Variophone. Using sound-on-film technology, his instrument facilitated the careful development of artificial waveforms onto the film, thus creating a synthesized sound which could then be played back using the same machinery that would play back the audio in cinemas [41]. It worked by cutting the wave shapes into discs of cardboard (fig. 3.2a)

which would then, through a precise mechanical system, be rotated synchronously with the reel of film, and photographed onto the film (fig. 3.2b). Different timbres (sound textures) could be achieved by exposing to the film multiple times, and by recording to several strips of film, and combining them later, one could represent different musical layers.

Using the Variophone to synthesize a musical score was a lengthy process, involving many different exposures, an array of discs for different timbres and a large grid of score data (fig. 3.2c) to determine which discs and pitches would need to be used for different sections of the film. The results of the process, however, were truly ahead of their time [13].
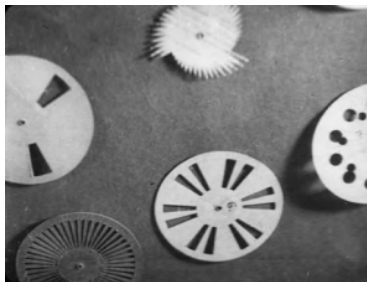
(a) Cardboard optical discs, with wave shapes cut out. [41]

(b) Some film strips resulting from the Variophone. [23]

(c) A table with the numerical representation of a score, ready to be programmed by the Variophone. [41]

Figure 3.2: Depictions of the Variophone creation process.

The ANS Synthesizer. Later, the ANS synthesizer was invented by Evengy Murzin, which was patented in 1957 after 18 years of development. Based on the same principles of photo-optical sound recording as the Variophone, the core of the sound generation in Murzin's machine is a set of discs, which contained 144 independent sine wave shapes in concentric rings each (fig. 3.3a), each representing a different pitch across the range of human hearing. As found famously by Fourier, any wave can be described by the superposition of infinite sine waves at integer multiples of a fundamental frequency. Hence, by combining these sine waves of different frequencies, a person operating the machine could emulate any timbre and pitch; they are in fact directly modifying the spectrogram of the sound [30].

The synthesizer's interface was a large glass plate covered in a tar-like opaque mastic (a type of resin). The user could then scratch lines into this mastic, revealing the glass underneath (fig. 3.3b). A light ray, shone at the glass plate would be able to penetrate only at the scratches, passing though and hitting the wave disc at a position corresponding to a specific wave frequency. On the other side of the disc a photo cell would interpret the wave to be transformed into sound. The plate would be moved via a crank, passing smoothly across the machine, playing a score from left to right (fig. 3.3c).

Since the mastic on the glass plate was non-drying, it meant that the sonogram could be easily edited by adding new scratches or covering up unwanted scratches with new mastic. Combined with the fact that the sound was converted and played back live, this meant that the composition process was very smooth and encouraged iteration and experimentation.

Oramics. In the 1960s in England, Daphne Oram was developing her Oramics machine which, similar to the ANS synthesizer, used pen and paint on glass and film to interface with the music (fig. 3.4a). The Oramics machine supported the control and output of a single tone, whose pitch, timbre, volume, vibrato and reverb [1] could be varied over time. Each parameter be controlled by strips of film, which would be drawn on with pen or paint by the user and the set of films would then all be scanned synchronously by the machine, at which point the sound output could be heard and recorded (fig. 3.4c).

To operate the Oramics machine, a composer would first draw four wave patterns on glass slides, which would affect the timbre of the tone (fig. 3.4b). Three films controlled the pitch, with the main one working simply as a graph of pitch over time. As the film was scanned, 12 LDR light sensors would detect the height of the line, determining the frequency of a control sawtooth signal. This signal was then used as a time base signal for the wave-scanner which would sample the height across the four wave patterns on the glass slides, using a set light emitters and cathode ray tubes, which make the output signal for

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[1]Timbre is the texture of a sound. Vibrato is the rapid pulsing change of the pitch of a note which you would recognise from opera singing. Reverb is an audio effect which mimics how a sound takes longer to fade away in a cavernous space.

(a) The ANS sound disc, containing concentric sine waves of different frequencies. [41]

(b) A scan of an ANS score. The height of the white etchings control which frequencies of sine wave are sounded. [41]

(c) A score etched onto the glass plate, being fed into the synthesizer. [41]
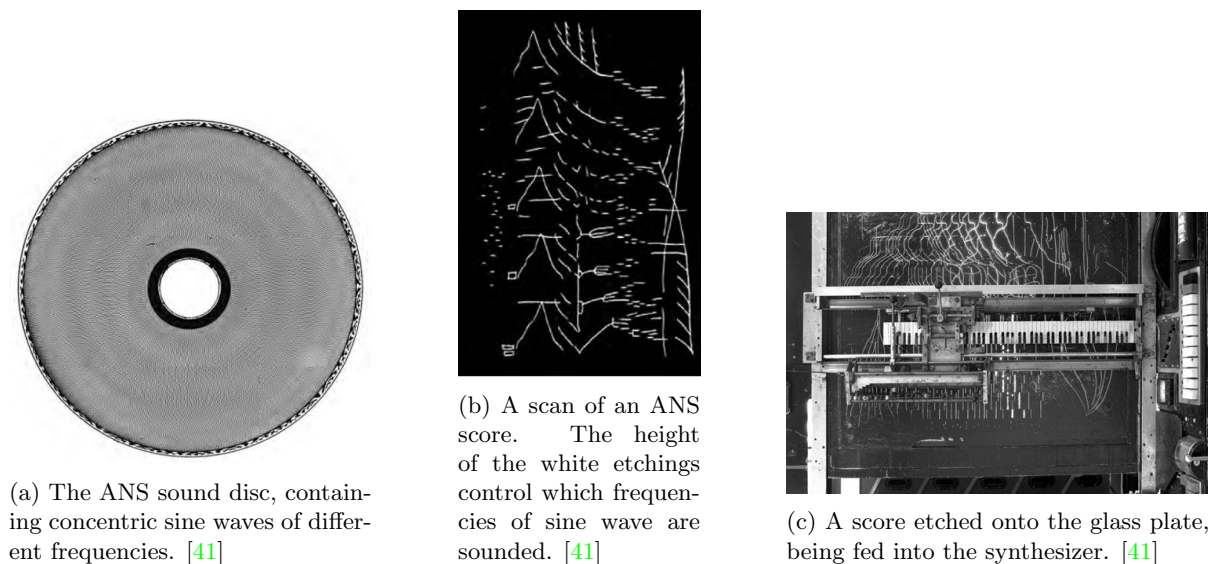
Figure 3.3: Depictions of the ANS Synthesizer

each timbre. Four more film strips determined the volume of the four timbres in the output signal so that they could be mixed together in different amounts, causing the tone to shift and change over time. The vibrato film allowed subtle pitch bends to made with respect to the main pitch information. Finally, the reverb tape simply controlled the volume of a loudspeaker in a separate reverberant room, which would have a microphone in it to capture the reverb sound, which would later be combined with the main dry output using multi track recording technology [44][39].

(a) Daphne Oram, inventor of the Oramics Machine, painting musical data onto film strips. [44]

(b) information painted on glass plate. The wave shapes would determine the timbre of the the output sound.

[35]

(c) Films containing drawn musical data are scanned in parallel, with each strip controlling an aspect of the sound. [35]
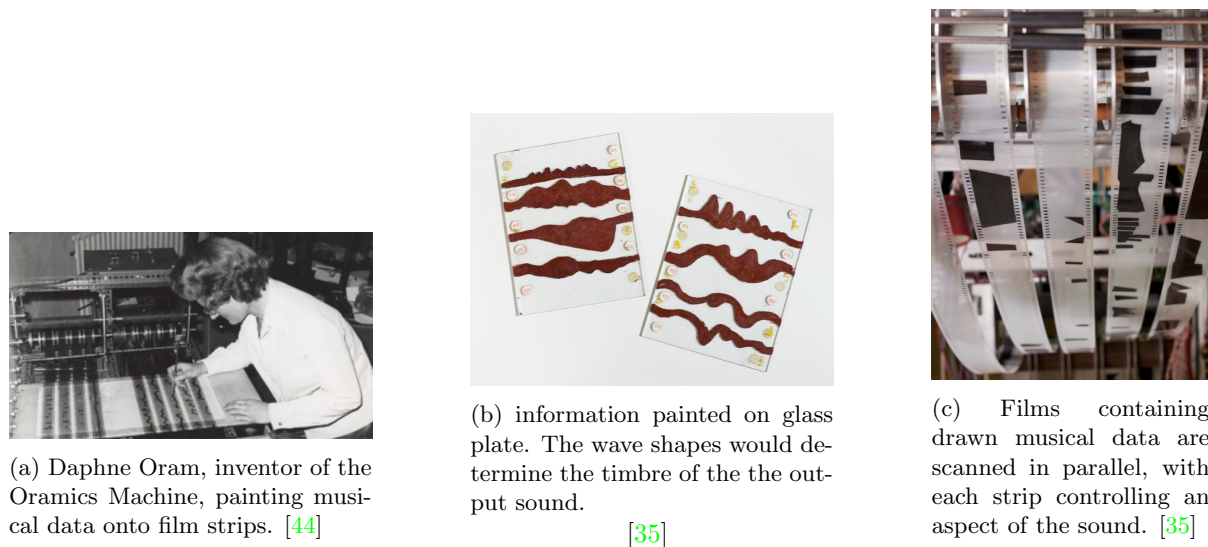
Figure 3.4: Depictions of the Oramics Machine

UPIC. In 1977, the composer Iannis Xenakis completed UPIC, a system which brought drawn sound technology to computers (fig. 3.5a). It took the form of a large graphics tablet (fig. 3.5b) connected to a computer which handled the sound processing. Akin to the Oramics Machine, the user could draw a waveform and volume envelope with the tablet input which would be processed and form the basic sound of the synthesizer. Then, by drawing pitch information, with the x axis representing time and the y axis representing pitch, the synthesizer could be made to play melodies. The software included options for time stretching, transposition and inversion of the input score. As well as this, UPIC could be used for live performance, where the user could use the tablet to control the synthesizer in real time [11].

As opposed to previous systems, which aimed to be used by composers, one of Xenakis's main goals for UPIC was to bring non-musicians closer to the music, leveraging their existing expressive experience

with drawing and transferring it to music through the new interface [36]. In testing and demonstrating the machine, Xenakis and his team worked towards an "educational approach which would prove that the UPIC was indeed an exceptional tool allowing anyone to develop their own musical creativity" [11]. This focus on pedagogy is a continued theme throughout Xenakis's career (fig. 3.5c). UPIC was showcased in many concerts and workshops, with the new paradigm upsetting the perception of musical pedagogy worldwide [7].
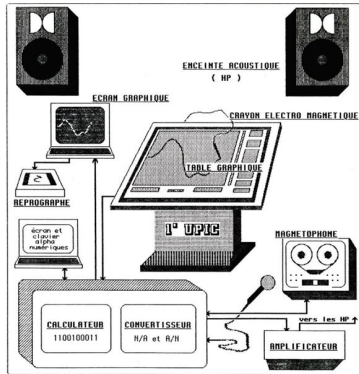
(a) System diagram of UPIC. The main components were the graphics tablet input and the computer.

(b) The main input of UPIC was a large graphics tablet, on which waveforms and pitch data could be drawn.

(c) UPIC was designed partly as a pedagogical tool. In this picture, Xenakis is teaching children to use the graphical interface.

Figure 3.5: Depictions of UPIC.

3.2 Modern implementations

In this section I will review a set of contemporary systems which implement graphical sound. Some build heavily on work of the past, and others offer a new take on the concept. For the sake of structure, I have organised these implementations in three general categories: Parametric music interfaces, which let users directly and intentionally control different pitch and other musical parameters through graphical representations; spectrogram interfaces, which represent sounds by the frequencies that are present in the sound over time; and finally other interfaces, which explore different ways to generate music from image information outside the previously established methods. Please note that these categories are somewhat subjective, and some of these systems might be described by more than one category.

3.2.1 Parametric music interfaces

Mini Oramics. Recall Daphne Oram, the creator of the Oramics Machine. After the success of her first machine, she set out to develop a smaller, more transportable model which would be able to fit on a desktop, as opposed to the cumbersome furniture-sized original. She created detailed designs for the next model but never completed a prototype, instead moving on to other research. The unfinished project was picked up again in 2016 by Ph.D. student Tom Richards who completed an authentic construction of the machine from Oram's original sketches and designs, using only technology that would have been available in the past. Mini-Oramics (fig. 3.6), as it is named, is operated in the same way as the original. To reduce its size, it only has two wave shapes (and thus only two wave shape volume control strips), and instead of a three control strips for pitch, it has only two: The first strip determines the note of the sound within one octave, and the second transposes the chosen note up and down into different octaves. The way that pitch is notated is using dots and lines, with the y axis, again, determining the pitch. In between lines, the pitch is simply held on most recent pitch. The mini-oramics machine has been used in collaboration with several artists, as well as in performance. The artists have remarked that the sound is very organic and expressive - more so, perhaps, than could be achieved using contemporary software [39].

Paper Substrates. A study by J. Garcia et al [14] saw the proposal of a new system called "Paper substrates". Aiming to ease the process for composers converting paper sketches for initial ideas into
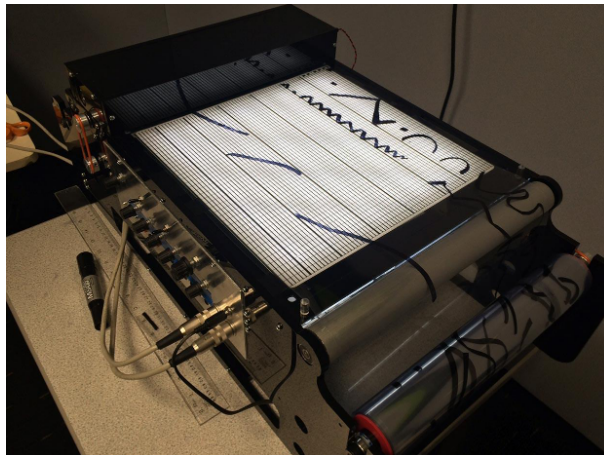
Figure 3.6: The Mini Oramics machine, built based on Oram's original designs, was a desktop-sized successor to the original Oramics Machine. [44]

concrete music in a software environment, each substrate is a drawn image on a piece of paper in a pre-determined structure which the computer knows how to interpret. Several different substrates were created following a prototyping session with composers (fig. 3.7), including ones for sequenced pitch information in piano roll format, and control curves for other musical parameters. The interactive prototype used a digital pen to simultaneously draw on the paper whilst simultaneously capturing those lines in the software. Users were able to combine various substrates to simultaneously control different parameters of the musical output, in the same way that the film strips operated in Oram's machines.
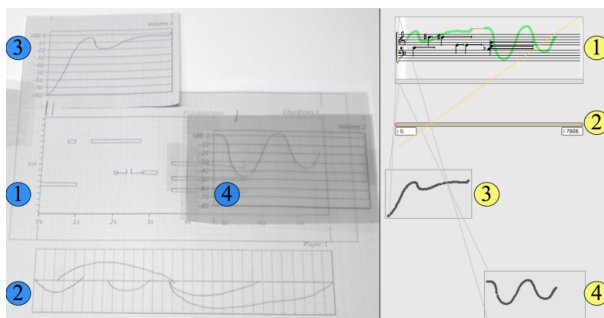
Figure 3.7: Paper Substrates interactive prototype. Users draw musical data on a page (left) which are digitised and interpreted by the software (right). [14]

UPISketch. There are several software adaptations of Xenakis's UPIC, the first of which is called UPISketch developed by Centre Iannis Xenakis [56] [8]. It is designed in accordance with Xenakis's vision for his original system, with an aim to be simple and intuitive, a pedagogical tool able to be used by children. The user can select samples (small audio clips), and draw gestural curves on the score. Each curve corresponds to a single sample trigger, and the sample is re-pitched during playback according to the shape of the curve. By using a combination of different samples and curves, one can build up a rich layered composition. And by considering each curve as an independent geometric object, it is easy to use the tools for resizing, inversion, drag-and-drop positioning and as copy-paste to experiment with different patterns in pitch and time. The curves can be edited during playback enabling opportunity for improvisation and live performance.

Given the intentional simplicity of UPISketch, functionality of the app is limited. This is reflected by the very uncomplicated and intuitive user interface. Apart from the tools to manipulate the curves, there is a grid which gives the user a visual indication of where pitches lie on the y axis, and this grid can be subdivided in custom amounts to allow for exploration of non-standard scales and tuning systems.

UPISketch is open-source and available for PC and mobile devices and, notably, it has been used as an interactive installation for the Urban music boxes & Troubadours exhibition.
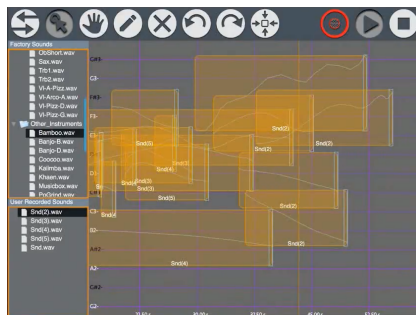
(a) The mobile interface for UPISketch. The left panel shows the available samples to be used as the basis sound information, and the score on the right is made up of independent curves. [47]

(b) UPISketch is designed to be as simple as possible, meaning a novice user coming across it at an exhibition should be able to use it. [56]

Figure 3.8: UPISketch

HighC. HighC is another continuation of UPIC, available for free for PC. It has a much more full feature set than UPISketch, which comes at the cost of having a less simple user experience.

Music is sequenced in the same was as in UPISketch, with individual curves which can be manipulated. However the sounds are generated through direct digital synthesis, meaning that the user can choose a waveform for the sound from a library of preset waveforms, or even define their own waveforms. This is done by altering the height value at separate discrete points in the waveform rather than by directly drawing the wave itself. Equally, envelopes can be custom made or selected from a library. Custom envelopes are edited in a similar way to waveforms, except the height can be changed at any continuous point in time. Editing the waveform and envelope signals in this way rather than by drawing them directly helps threefold: Drawing curves is difficult with a mouse so editing individual values is much easier; it discourages complex curves because those are more cumbersome to produce, which may limit creative freedom, but it means that the program can run faster because there is less load on the processor; it disallows "illegal" signals (ones where there are two height values for one point in time).

The ability to quantise (or snap) pitches to the standers western scale is very useful for creating compositions that sound more conventionally melodious. Another good feature is how it displays the curves. Each curve has varying thickness which reflects the volume envelope, whilst the centre of the curve is positioned to reflect the pitch. The colour of the curve corresponds to the associated waveform, and the transparency of that colour corresponds to the volume of that curve. These extra dimensions of information not only add aesthetic value to the visual score, but it also help the user by establishing a stronger link between the graphic and the output sound.

HighC is a very powerful tool which has been used to make some quite intricate full-length compositions.
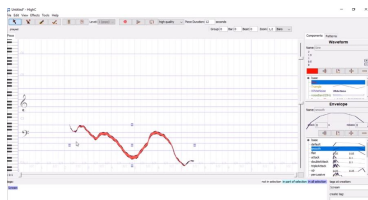
(a) Main interface. Sequence information is represented as curves which can be easily altered in various ways. [20]
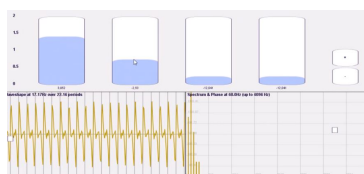
(b) Waveform editor. The bars represent the height of the waveform at four points along its cycle. [21]

(c) The curves represent various musical parameters at once, creating an interesting final score. [19]

Figure 3.9: HighC

FugueGenerator. Another implementation of graphical sound is FugueGenerator ([29]), which has a heavier focus on non-musician users. The goal is act as a computational aid to help users compose melodies that capture desired emotional qualities. Building on a psychological model that characterises emotions by the axes of valence and arousal, their system takes hand-drawn curves of pitch information (drawn on a touch table interface), and augments them according to chosen values for valence and arousal, altering the properties of rhythm, articulation, tempo and pitch range.

This approach sees an incredibly simple interface, where much of the musical expression is handled by predefined computer models. User studies found that the interface is broadly useful and inspiring for all used, but non-musician participants thought the computer's handling of emotion was useful more so than the musician participants. There was also some feedback of mild frustration from the experience.
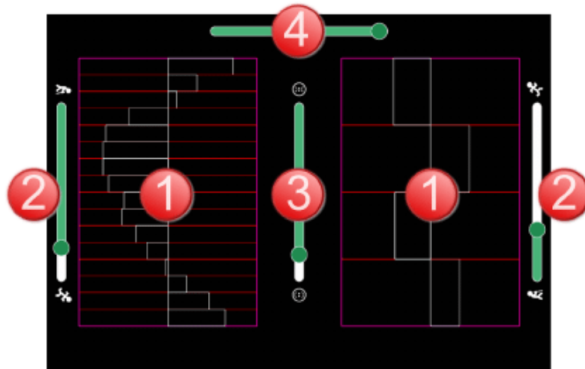
Figure 3.10: Fugue generator has a very simple interface, since most of the musical choices are made by the computer, based on the emotion input from the user. [29]

3.2.2 Spectrogram-style interfaces

VirtualANS. Virtual ANS [60] is a software implementation of Murzin's ANS synthesizer which extends the original functionality to include some important features of modern DAWs, such as looping and input from MIDI instruments. In place of the mastic-covered glass interface of the original, we have a modern graphical spectrogram in the UI (fig. 3.11a), but it is converted to sound in the same way: in places where there are lines or patterns in the spectrogram, pure sine waves with frequencies corresponding to the heights in the patterns are sounded.

The spectrogram can be converted into sound and, unlike the original, a spectrogram can be created from an input sound; the advantage of this two-way conversion is that a user can take a sound recording, convert it to the spectrogram and manipulate the spectrogram directly before converting it back, causing interesting distortions to the source audio.

Virtual ANS comes with a powerful set of tools for editing the spectrogram, and these tools are similar to those one might find in a digital art program such as photoshop. For example there are different brushes for painting textures into the spectrogram, as well as basic tools for clean lines. A more significant feature, my own opinion, is that the user can take any photograph or existing image file, convert it into a spectrogram and play it back. In this way, the user can choose to create a tangible spectrogram on paper using whichever medium they wish and use virtual ANS to convert it to sound, or they can experiment and explore with different photographs they have taken of any arbitrary object.

Virtual ANS is available for PC and mobile devices.

PIXELSYNTH. An extremely similar program is PIXELSYNTH [26], a browser based application which is also based on the principles of the ANS synthesizer (fig. 3.11b). It differs from Virtual ANS in a few ways. Importantly, it has fewer available sine waves to make up the frequency range; where Virtual ANS attempts to have as many different sine waves in order to approximate the continuous range of frequencies in the audible spectrum, PIXELSYNTH has only chromatic tones (the discrete pitches that make up the standard twelve tone western scale). From this design choice an interesting feature arises, which is that the user can filter out the sine waves frequencies that will be played, based on different musical scales. By only hearing tones from a specific scale, we can effectively force the output to sound more melodious or "in tune", but on the other hand, by having so few available sine waves, we are moving

away from editing a spectrogram and shifting more towards the familiar paradigm of midi sequencing on a piano roll.
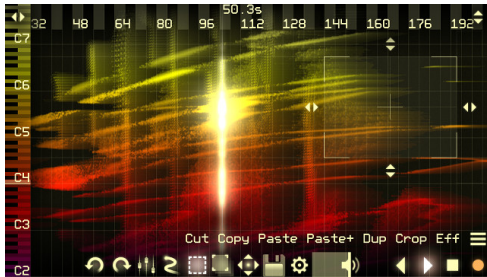
(a) The UI of Virtual ANS showing a spectrogram being played back. The luminous line is where the playhead intersects active parts of the spectrum. [60]

(b) PIXELSYNTH also works by manipulating a spectrogram, except there are fewer sine waves making up the spectrum. [26]

Figure 3.11: Virtual ANS and PIXELSYNTH

The vOICe. In a similar vein to Virtual ANS and PIXELSYNTH, we have The vOICe [32]. Instead of aiming to aid in artistic expression, the purpose of The vOICe is to aid the visually impaired by conveying visual information in a clear and practical way via sound, acting as a sensory substitute. It is implemented for Windows and Android as well as for the web, but the ultimate goal is to embed the system in a pair of smart glasses (fig. 3.12a) with an integrated camera, essentially allowing a poor-sighted person to "see with their ears" [32].

The software works in real time by capturing a 64 pixel square greyscale image and scanning it fully from left to right associating height to pitch, brightness to loudness and distance along the width with stereo pan, before capturing a new frame (fig. 3.12b). So it still effectively treats the captured image as a spectrogram. There are only a few options for manipulating the input image: invert, line detection and zoom. These options are more utilitarian than creative, aiming to clarify the graphical information for the benefit of understanding it better once converted to audio.

Based on feedback from blind users, it seems very effective in allowing them to interpret the world after spending some time with it. They were able to distinguish different shaped items quickly, and would quickly start recognising the soundscapes generated by objects in their own homes. The very interesting discovery is that after a period of use, this interpretation of the soundscapes became automatic, as if the brain would learn to convert the sound back into a sensation of sight. One participant remarked "It took using The vOICe and the web cam to bring my hallway from a blurry image in my minds eye to what seems like actual dimensional sight. It does not matter to me that my ears are causing the sight to occur in my mind" [32]. There is ongoing testing and pending studies regarding The vOICe, to discover its effectiveness and the implications for the blind community and for psychology.

3.2.3 Other interfaces

TuneTrace. Tunetrace [40] is an iOS app that generates melodies from photographs of drawings on a page. Once a picture has been taken, the software generates a graph (from graph theory), by placing nodes at line endings and intersections, and connecting the nodes where there are line segments. It is unclear how the graph is then converted into music, but during playback the UI (fig. 3.13) shows little circular markers traversing the graph, and music events seem to trigger when a marker reaches a node. Apart from the drawing input, there are no additional options for influencing the music generated.

According to the creator, the graph generated from a drawing is analogous to a lines of code, and the purpose of the app is to give users the sense of "mystery and surprise" that usually comes with the process of programming a computer. Regardless, it is a very simple interface for music writing which leans on the familiar creative expression of drawing, and is certainly suitable for non-musicians.

Kandinsky. Next we consider Kandinsky [17] a browser based experience, named for the Russian abstract artist whose synesthesia caused him to hear images and see sound. This interface offers a plain white canvas on which the user can draw brightly coloured lines to generate a score. Provided with no instructions, the user is encouraged to explore and figure out how different sounds can be created.

(a) A person using The vOICe integrated with a headset. The headset takes images which are converted into a soundscape and played back allowing the user to 'see with their ears" [32]
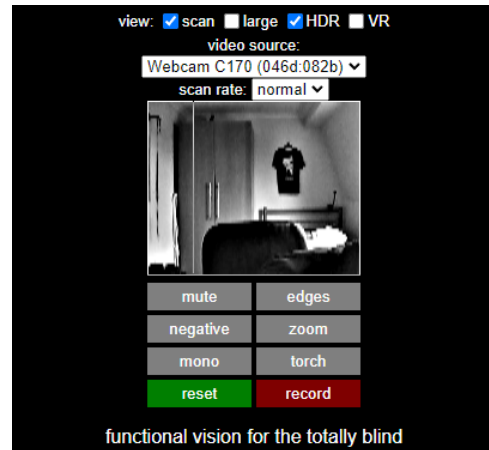
(b) The web implementation of The vOICe, taking webcam input from the device. [32]

Figure 3.12: The vOICe
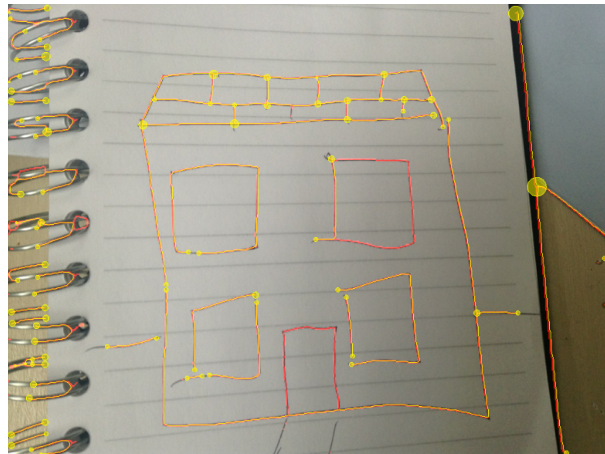
Figure 3.13: Tunetrace interprets a drawing as a mathematical graph, then uses its structure to generate music. [40]

Up to 20 curves can be present on the canvas at one time, and if more curves are drawn, it will cause on that was previously drawn to disappear. The foundation of the interface is akin to a piano roll representation of music. Each curve that corresponds to one trigger of a short melodic sample with a pitch corresponding to the height. Pitches are all from a predefined scale, which helps make generated melodies sound harmonious. On playback, the curves are triggered roughly from left to right, but there is always an equal amount of time between successive triggers which instates a decisive rhythm, and sometimes two curves are triggered on the same beat.

Interestingly, the shape of the curves doesn't effect the usual variable musical parameters. Instead it determines what sample is played for that curve. For instance, a most curves will sounds like a basic instrument, but triangles correspond to drum sounds. Curves that are similar to circles cause a vocal-like sound, and this is reinforced visually by adding cute facial features to the circle. There is an option to pick between three different colour combinations, which also changes the instrumentation.

There is no playhead on the interface. Instead the curves are animated in a playful way when they are triggered, letting the user identify which curves are responsible for which sounds.

The interface is extremely minimal (fig. 3.14), with only options to play the music, undo an action and reset the canvas and change instrumentation. Notably, no part of the interface makes reference to existing musical paradigms, making it easy for anyone to use. Kandinsky is implemented as a web application, and is part of Chrome music lab [15], which is a collection of interactive experiences aiming to make music learning more accessible in a hands-on experimental way.

Figure 3.14: Kandinsky's simple interface is built with playful colourful graphics and avoids and reference to musical paradigms. [17]

Paint with Music. A web app in the same vein as Kandinsky is Paint With Music [16], available through Google Arts and Culture. On starting the app, the user is asked to choose a "canvas" will affect scale used for the music, as well as the graphical style of parts of the interface. The four canvas options available are In The Sky, Underwater, On the Street, and On Paper, and notably it is not stated to the user what affect these options will have. Once a canvas has been picked, the user is presented with the blank canvas, upon which curves can be drawn, much like with Kandinsky (fig. 3.15).

This implementation of graphical music steps away from the convention of representing time on the x axis, and instead the timing of the music works similarly to a loop pedal. There is a master clock that cycles in regular periods all the time whilst the app is running, represented by a turning dial at the bottom of the interface. While a curve is being drawn the height of the brush is sampled at a certain frequency, with times recorded relative to the master clock. Each time the clock cycles back round to the time that the line started being drawn, an instrument sound begins to play, and the pitch changes according to the heights that were sampled during the drawing. In this way the user can record a melody by (on a computer) clicking the mouse to begin a curve, then moving the mouse to different heights at different points in time. The position of a curve on the X axis seemingly has no effect on the sound.

Each curve is linked to one of four instrument sounds which is chosen by the user. There is also a selection of "stamps" for each canvas, which draw a graphic to the canvas, and correspond to a sample trigger. During playback, to help inform the user what curves and stamps are sounding at a particular time there is an emitter of vibrant particle effects that follows the shape of curve at the speed it was drawn and naturally the height of the particles can be associated to the pitch. A handy grid overlay can be toggled which indicates which heights are linked to which notes in the scale. Another helpful visual is the lines that appear rings around the master clock dial at times where a curve would be played.
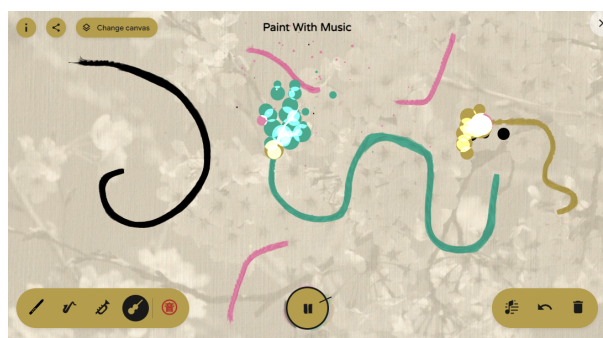
Figure 3.15: The GUI of Paint With Music is affected by the user's choice of canvas. Notable parts of the GUI are the clock dial in the bottom middle, and the particle effects which follow the drawn curves as they are being played. [16]

IanniX. A more free form approach to sequencing is taken by IanniX [2], a software which doesn't produce any sound itself but is designed to link with and control existing music software and plugins. It is inspired by one of Xenakis's concepts for graphical scores, in which each musician of an ensemble takes direction from one line in a score built up of geometric patterns [27].

The user draws curves and other geometric shapes which behave as tracks for cursor objects to move

along (fig. 3.16). Much like the height of the curves control pitch in Paint with Music, the coordinates of the cursors can used to control pitch or indeed any parameter afforded by the linked musical software. Another important object is the event trigger. These are placed around the score by the user, and when a cursor collides with one, it can cause a music event to occur, for example playing a sample [1]. The start times and speed of the cursors along their tracks are controllable by the user, and by having multiple cursors moving simultaneously it is possible to create some very complex musical textures.

The fact that IanniX can be used to sequence any parameter in any software makes it extremely powerful and it can be applied to any digital art, not just music. Light shows, pyrotechnics and robotic actuators are just a few examples of projects that have used IanniX.
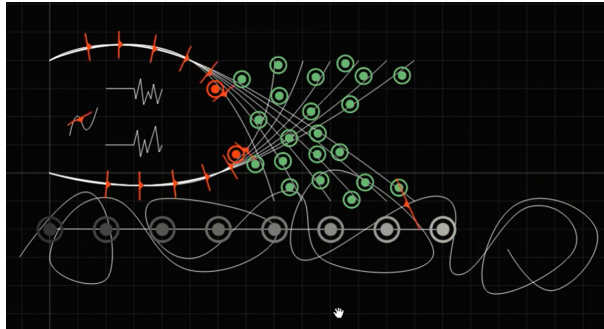
Figure 3.16: Iannix uses tracks (grey lines), cursors (red lines), and event triggers (concentric circles) to create complex musical sequences. [33]

Unspoken Symphony.   Finally, we have Unspoken Symphony, which takes a photograph of a piece of artwork as input and "analyses the shapes, lines, brightness, contrast, dominant colors, and density in each piece of art. It uses that information to determine the tempo, chords, musical style, timing, and pitch for each melody created" [6]. Having tried the web app, uploading several images and observing the music generated, I was not at all able to predict what the output would sound like for a particular image. However all the music that was created was very pleasing to the ear, and seemed to incorporate convectional chord structures, accompaniment patterns and melodic phrasing. This leads me to suspect that there is a set of pre-programmed musical options created by a human composer and the software selects between this options depending on the image.

The musical data is generated all at once when an image is uploaded and played back using instrument samples. The choice of instrument can be made by the user separately for the lead and accompaniment parts.

Unspoken Symphony was designed as a tool for self-expression, specifically for those who struggle to speak. The motivation is that people who cannot express themselves verbally often turn to art and music instead. As such there is less of a focus on facilitating specific musical ideas, choosing instead to provide a simple interface for people to experience art in an alternative way (fig. 3.17).
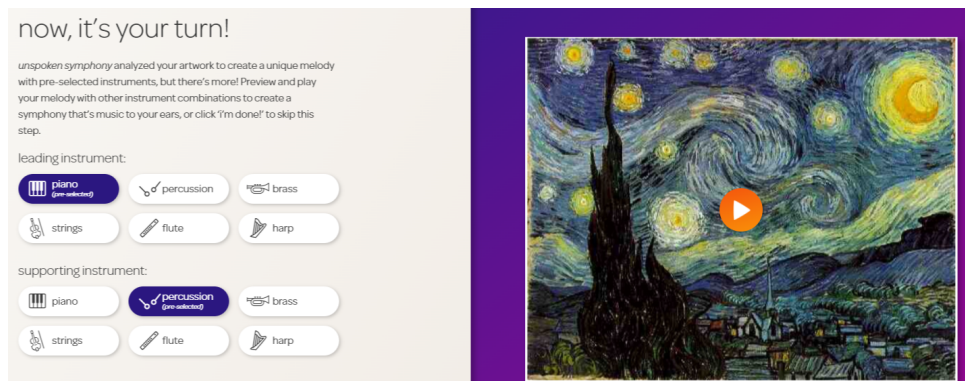
Figure 3.17: Music generated by Unspoken Symphony is done so entirely based on single image. The user has a choice of the instrumentation used for playback [6]

3.2.4 Summary

We have seen many implementations of graphical sound, both historical and modern. Each take a different approach, making different decisions about input methods, the way those inputs are translated to sound and the way that the conversion can be communicated visually to a user to aid in their understanding. Some systems also incorporate computer aid to augment the user's compositions to be more musically pleasing. In the following table (table 3.1) I summarise these aspects of all the systems we considered in this section. This research was essential in informing the design of *draw music!*. I took inspiration from these systems and adapted them into my own new approach for graphical music.

Tool	Category	Direct parameter control	Input type	Computer Aid
Variophone	other	pitch, timbre	physical drawing	none
ANS Synthesizer	spectrogram	pitch, rhythm	physical drawing	none
Oramics	parametric	pitch, rhythm, volume, timbre, tempo, effects	physical drawing	none
UPIC	parametric	pitch, rhythm, volume, timbre, tempo	digital drawing	none
Mini Oramics	parametric	pitch, rhythm, volume, timbre, tempo, effects	physical drawing	none
Paper Substrates	parametric	any	physical drawing	any
UPISketch	parametric	pitch, rhythm, timbre	digital drawing	none
HighC	parametric	pitch, rhythm, volume, timbre	digital drawing	pitch quantisation, time quantisation
FugueGenerator	parametric	pitch, rhythm, arousal, valence	digital drawing	pitch quantisation, time quantisation, choice of rhythm, articulation, tempo and pitch range
Virtual ANS	spectrogram	pitch, rhythm	image, digital drawing, physical drawing	pitch quantisation
PIXELSYNTH	spectrogram	pitch, rhythm, scale, volumne	image	pitch quantisation
The vOICe	spectrogram	pitch, rhythm, volume, pan	video	none
TuneTrace	other	none	physical drawing	almost all computer aid
Kandinsky	other	pitch, rhythm, timbre	digital drawing	pitch quantisation, time quantisation
Paint with Music	other	pitch, rhythm, timbre	digital drawing	pitch quantisation
IanniX	other	any	digital drawing	any
Unspoken Symphony	other	timbre	image	almost all computer aid

Table 3.1: Summary table of the graphical sound systems we considered in this chapter.

Chapter 4

System Design and Implementation

In this section we present *draw music!*, what it does and how it operates. We will see how it responds to related work and how it offers a new contribution. After that we will discuss each feature of the system individually, look at how I arrived there, and justify design choices.

4.1 Design specification

Given the musical interfaces that exist already, I came up with a design specification for the app. I knew that I wanted the user to engage with music in a tangible way by interacting with real objects, like with ANS and Oramics. However I also wanted to have this interface be accessible to anyone without requiring them to have any specific technology to hand. The solution is to have the user to create their sequence using pen and paper, paint and cardboard, or any combination of mediums, then use their smartphone to photograph their score and convert it into music, like Paper Substrates and Virtual ANS.

Whilst I enjoy the sense of mystery afforded by less transparent apps like TuneTrace and Unspoken Symphony, I wanted it to be clear how an image would be interpreted by my app, so that the user could make more informed decisions about the score that they create. I chose to use the established method of representing musical sequences, with the x axis corresponding to time and the y axis to height. My thinking was that by using my interface, a non-musician would build intuitions that would help them use conventional systems if wanted to. Conversely, I wanted musicians to be able to apply their existing knowledge to my system but at the same time think about sequencing in a slightly new way, removing them from the input methods that they are used to.

Where Virtual ANS and PIXELSYNTH will play several tones that lie the space of a thick line, often leading to a rather dissonant output, I differentiate my app from the spectrograph style interfaces by linking such a line to only one pitch. This makes it easier to generate a singular melodic idea regardless of the medium chosen to draw the score.

Next, I wanted users to have some choice over the timbre of the sound. However, the focus should remain on sequencing, rather than synthesis. Thus, I will provide a selection of predetermined instruments to choose from. These should be able to play at the same time, combining to make different textures, much like Paint with Music and UPISketch.

In deciding which features would be included in the app, I not only had to factor in the time I had available for development, but more importantly I had to consider which options would be engaging, understandable and intuitive for a non-musician user. When first loading up a DAW, or indeed specialist software in general, it is often the case that the number of features is intimidating rather than inspiring, and can often turn users away. Thus, whilst designing the app, I was constantly finding the balance between giving the user options to influence the music, and making minor decisions for them in the background (for example the mix i.e. relative volumes of the instruments) to allow them to focus on the more important aspects of the creative process.

Below is the list of requirements I decided on for *draw music!*

- The core feature of the app is that the user can photograph a curve or multiple curves

drawn on a physical medium, and this will be converted into a musical sequence and played back.

- To ensure that the resulting sequence sounds melodious, the app should include options for both pitch and time quantisation, and these changes should be reflected in the UI to aid the user in their understanding of how their choices affect the music.

- The user should be able to be able to introduce multiple sequences, with each one played simultaneously on a different instrument. This way they can intuit how a complex song is built from individual simpler layers.

- Each instrument should have its own set of options for quantisation, as well as loop length and speed.

Overall, my app takes the approach of drawing curves to the score, like UPISketch and HighC. I combine this with a camera input, using a photos of physical drawings (or otherwise), like VirtualANS. This is a combination which I did not come across in my research.

My app aims to be accessible for non-musicians by following the principles established by previous accessibility studies (section 2.2). First of all we avoid any musical terminology and the usual gestures for sequencing music. By creating the sequence visual in a tangible medium, they can express their ideas in an intuitive way. Furthermore, having the app interpret the graphical score relieves the user from the responsibility of organising individual notes, while still giving them control over the overall structure of the sequences. Exploratory behaviour is encouraged by allowing users to instantly play back a pattern, and the quick process of converting a drawing into a sequence aids in iteration of ideas. Finally, pitch and time quantisation is introduced to act as a computer aid, augmenting the user's sequences to produce more satisfying musical results.

4.2   Operation of the application

I will start by explaining what *draw music!* is, and how it works in its current state. Then, with this context, I will explain some of the important design decisions and details of the implementation.

The application begins on a title scene (figure 4.1.0), with some small playful animations (for example, the pencil and music note icons wiggle) to grab the user's attention.

A simple tap takes them to the main scene (figure 4.1.1), where they are presented with four coloured squares, representing the four available instruments which are the sine, triangle, square and drums. On pressing the large play button, any loaded sequences (no sequences are loaded when first opening the app) will play in unison while a vertical bar called the playhead scrolls across each box from left to right, indicating the current position in the sequence. There are also buttons for changing the master tempo for play back, toggling a metronome and clearing all the sequences.

To add a new sequence, the user simply taps one of the instrument squares which will take them to a scene where they can take a photo (figure 4.1.2). The phone's camera output is displayed prominently in a large square with a translucent border which slightly obscures some of the image. We will refer to the clear, unobstructed square in the centre as the "Capture Square". If the user wishes to use the front facing camera of their device instead, they can press the "flip camera" button, and they wish to return to the previous screen they can press the "cancel" button. The idea is that the user will draw some curves with a dark pen on a light sheet of paper, then photograph it. But in fact any photo can be used as input to the app, with varying qualities of musical output. When the user is ready, they move their device such that their drawing, or scene that they wish to photograph, lies within the Capture Square and they press the "take photo" button.

On taking the photograph, the pixels within the Capture Square are stored as a still image. In the next scene (figure 4.1.3), a threshold filter is applied to that image, and the threshold value can be changed by tapping on the image; the higher the tap, the lower the threshold. If the user is unhappy with the photo they have taken, they can retake the photo, or press "cancel" to return to the main screen. Else, if they are satisfied with their image and the threshold value, then they press the "use this photo" button.

Finally the user is taken to the sequence scene (figure 4.1.4). Displayed in the coloured box is the sequence that was obtained from the thresholded photo, by an algorithm detailed later in this chapter. To hear the sequence, the user simply uses the button with the universal play symbol on it (the right facing triangle), which changes to a stop symbol (a filled in square). Next to this is the "home" button, which sends the user back to the main screen. The controls for manipulating the sequence are contained in the green panel, and are organised under three tabs: "sequence", "pitch", and time.
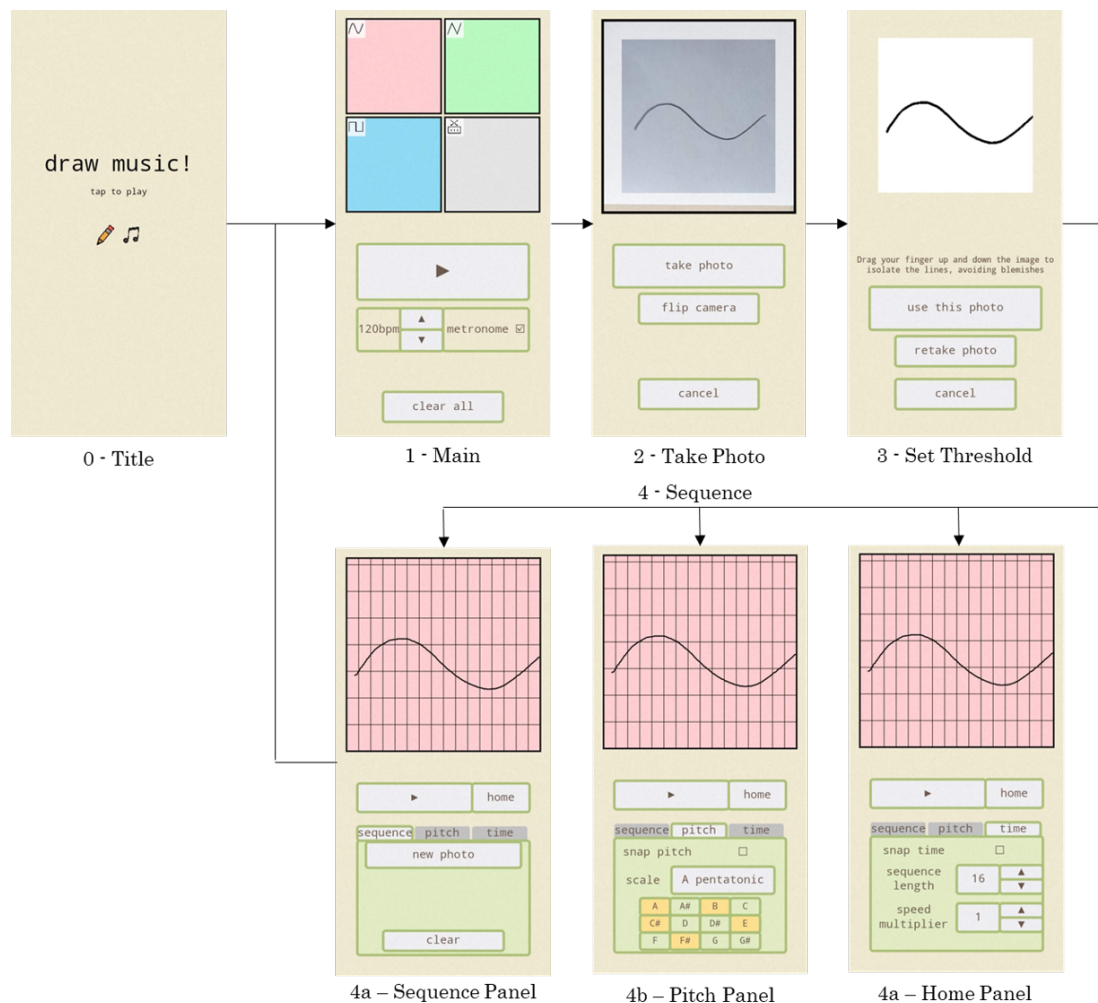
Figure 4.1: User flow diagram for *draw music!* These are the scenes that a user goes through in the process of photographing and converting an image into a sequence.

The "sequence panel" (figure 4.1.4a) has buttons for clearing the sequence and taking a new photo, which takes them back to the Take Photo scene.

The "pitch" panel (figure 4.1.4b) has a checkbox which toggles where the pitch of the sequence is quantised. Underneath that the user can select the scale that the pitches are quantised to, either by cycling through some presets, or by tapping the buttons with the note names to toggle whether they appear in the scale or not.

Lastly, the "time" panel (figure 4.1.4c) has a checkbox for toggling time quantisation, and options for adjusting the sequence length (number of beats in the sequence), and the speed multiplier (speed of playback relative to the master tempo).

4.3 High level Decisions

Before we dive into the implementation details of the app, I will mention a few high level choices I had to make prior to its development, namely why it was developed as a web app and why I chose to use the p5.js library. I also explain some of the core features of p5.js and how I used those in my project.

4.3.1 Web Application

Web browsing and being connected to the internet have grown to become integral components of modern life, and as such you will seldom find a smart device without a web browser of some kind, and furthermore it's rare to find a person without a smart device. As such I chose to write my app for the web, to be run in browsers, which allows the app to be access by almost anyone in the modern world.

Additionally, I wanted access to the app to be as simple as possible. The fact that it is browser-based means there is no burden for the user to download software and have it occupied permanent memory on their device. I also deliberately made the app free to access, without any requirement to sign in or provide credentials. It might be that it makes the website more susceptible to slowing down due to traffic, however I believe that this is not a problem since the app runs client-side, so even with increased volume of traffic to the website, the change in speed should be negligible.

My hope is that by removing these nuisances for the user, they are encouraged to pick up their device and start making music at any time in the day when inspiration strikes. From personal experience, the more steps it takes to access a tool, be it software or physical, the less inclined I am to to and use that tool unless it is really needed in that moment. Making access to the app as easy as clicking a link encourages users to use it, especially those that may be reluctant to use a music app due to being inexperienced. There is simply no time investment to be made, so why not have a go?

The app was implemented as a static website and hosted on GitHub pages.

4.3.2 p5.js

I chose for the foundations of my program to be built with p5.js, a JavaScript library that provides an easy interface for web-based motion graphics, and other small interactive applications, with a focus on creative coding.

My app is relatively complex, with multiple pages, buttons, cameras and other interactive elements. Generally, p5.js is used for more basic single-page applications with limited interactivity. While it is true that there are many other JavaScript libraries and frameworks like vue.js and angular.js which may have been more suitable for an app of this complexity, p5.js is a library that is extremely intuitive and easy to use, and from experience I knew it contained all the features that I would require.

An integral part of a p5.js application is the Canvas object. This is an object defined in the library that provides a layer of abstraction away from the HTML canvas element. Each frame we may call a number of library methods, like line() rect() or circle(), which determine what geometry should be included on the canvas on the next render.

p5.js has a host of useful methods which facilitate basic program functionality and user interactions:

preload(). This method that runs at start of execution of the program. Importantly, the setup() and draw() methods will not run until the preload() method has finished! The purpose of this is that files like sounds and images are loaded in at this point, thus they can be used elsewhere in the program and the information is guaranteed to be there.

setup(). Called exactly once at the start of execution, and after preload(), the setup() method is there for initialising variables and objects and setting up environmental properties, such as the canvas.

draw(). The draw() method is the main program execution loop. Designed for rendering motion graphics, it's default behaviour is to be called exactly once per frame, and the code to put visuals on the canvas is contained in this block. In my program, contrary to the name of the method, I use it to call all other methods that need to run on a frame-by-frame basis, importantly the handling of sound and audio playback.

mouseClicked(), touchStarted(), touchEnded(). These event methods, for dealing with interactions of the mouse and touch screen (where applicable), are simply called once on the event that their respective names suggest. Combined with the boolean variable mouseIsPressed (which reflects whether the touchscreen is pressed as well), and the float variables mouseX and mouseY (which reflect the mouse position or most recent touch in canvas space), we can facilitate all interact-ability we require.

windowResized() This event method is essential in making sure the app is responsive, with the GUI staying readable and clear regardless of the browser window's size. Using the window.InnerWidth and window.innerHeight variables, we can then formulate some mathematical expressions to define the layout of all the elements on the canvas.

4.3.3 p5.sound

The p5.sound library is built directly on top of p5.js, and provides all the functionality for manipulating and outputting audio. The features that I depend on in my project are detailed in the following paragraphs:

Sounds Using the loadSound() method, we can load in any audio file and assign the resulting sound object to a variable, for example "drum". Then we can simply use drum.play() to play the sound! We can also use drum.setVolume() to change the volume of playback, which is useful when it comes to balancing the instruments.

Oscillators In sound synthesis, an oscillator is simply a signal with a simple repeating cycle. Some important properties of an oscillator are its frequency and its amplitude. If an oscillator is used as a source of sound, the frequency determines the pitch of the sound and the amplitude determines the volume. There are some standard waveforms that oscillators can take, for example, the sine wave, the square wave, the triangle wave and the sawtooth wave, and these are all available for the p5.sound oscillator object. To start synthesizing sounds, we first create an oscillator object and assign it to a variable, say "osc", then use osc.start(). Now we can use osc.amp() and osc.freq() to change the amplitude and frequency of the oscillator, and we can even pass an additional parameter to control how quickly the amplitude/frequency changes to the new value, allowing pitch bends and smooth fade in and fade out of notes.

4.4 Implementation of features

4.4.1 Taking a photograph

One of the simplest features to implement was taking photographs, since between p5 and the web browser, much of the functionality is already handled out of the box. In order to do it, we must first access the device's camera. This is made easy by using the HTML5 <video> DOM element, which exists on the webpage and loads in image data each frame. We create the video element with the p5 method createCapture(), which also allows us to choose which camera of the device (if applicable) is accessed.

To simplify the process of creating and accessing the video element, I created my own Camera object with methods for "flipping" the Camera i.e. toggling between the device's front and back - facing cameras, and getting the current image pixel data.

With these tools at hand, taking a photograph is a simple two-stage process. First, each frame we take the image pixel data from the Camera and display it on the canvas, using the p5 method image(). Thus, the user can see the current camera output, and compose their photograph accordingly taking advantage of the video feedback. Secondly, in the event that the "take photo" button is pressed, the image pixel data for that frame is saved to the "photo" global variable as a p5.Image object.

4.4.2 Image thresholding

When programming a computer to interpret a photograph of drawn lines on a plain background, a natural question is: How does the computer identify which pixels are part of the line and which aren't? There were several options to be considered here:

k-means clustering on pixel colour would allow the image to be simplified to its k most "popular" colours. Thus, by picking k to be 2, one can isolate the pixels that make up the lines as long as the background colour could be identified. A benefit of this procedure is that it works for any coloured line on any coloured background, and by increasing the value of k to the number of coloured lines in an image plus one for the background, the program could interpret these colours and have them affect the music in some where, for example darker coloured lines could result in a louder sequence. The downside is that implementing this is very time consuming, even using OpenCV, which has good integration in p5 via the openCV.js library but is very lacking in documentation. Furthermore it is rather computationally expensive when compared to other methods.

Ultimately I chose the simplest solution, which is using basic image thresholding (figure 4.2). If we assume that the photograph is of dark lines on a light background, we can take a take the threshold of the photograph using p5's image.filter() method - i.e. if the pixel's colour brightness exceeds the threshold value, the pixel's colour is set to white, else it is set to black - and we can take any black pixels to be pixels that form a line. The problem now is how we choose this threshold.

A few programmatic ways to choose the threshold are as follows: simply choosing 0.5 i.e. 50%, taking the mean brightness of all pixels in the image, taking the mean of the maximum and minimum brightness values in the image. I chose to allow the user to define the threshold, by touching the image and mapping the y position of this touch to a value between 0 and 1. This approach has various advantages. To start with, it is always going to result in the optimal value with the cleanest looking lines according to the user, regardless of the lighting in the image and the relative brightness values of the lines, background and anything else in the image. Why automate a task that is so quick and easy for a human to perform? Secondly, if the user decided to photograph a subject other than lines on a clear background, it would allow them to dial in the threshold value to their taste, resulting in a more or less dense sequence once converted.

(a) photograph   (b) high threshold   (c) low threshold   (d) good threshold
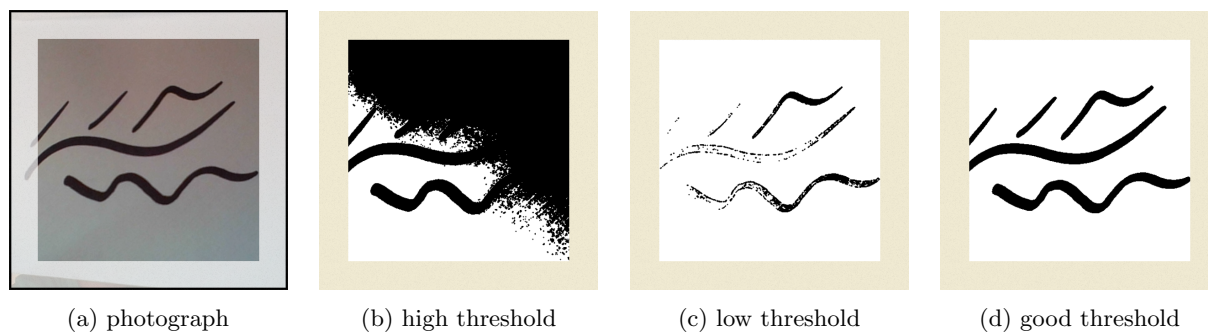
Figure 4.2: Examples of thresholding

4.4.3 Representing a sequence

Representing a sequence in a sensible way within the code is integral to the success of the app, and it took a couple of iterations to get a solution I was satisfied with. As mentioned, I use the conventional way of visualising a sequence with time on the x axis and pitch on the y axis.

The first approach I took for storing the sequence consisted of an array with length equal to the width of the canvas. The ith element of this array represents the y coordinate of the sequence curve. On playback, the array is traversed from start to finish, and each y value is mapped to pitch. This simple representation worked well but had a few key issues: The single array meant that only one pitch could be played at one time, we could only access the sequence at discrete indices rather than continuously over time and storing the sequence information in canvas space was problematic if the size of the window changed during playback.
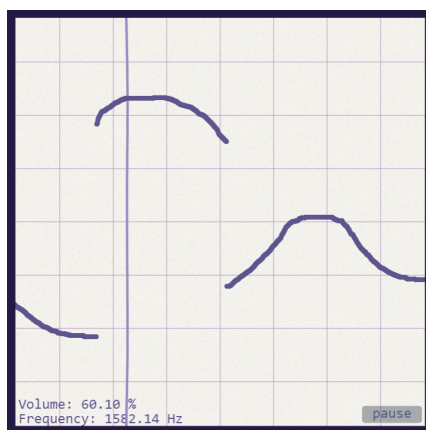
Figure 4.3: First implementation of a sequence. The musical information is stored in image-space, then converted on playback.

And so I set out to create my second prototype of the Sequence class. To allow polyphony, I conceptualised a sequence as a set of voices, and each voice (which may only "sing" up to one pitch at any time) is as a function s with domain $[0, 1]$ and range $[0, 1] \cup \{-1\}$, where $[0, 1]$ is the continuous interval in $\mathbb{R}$ between and including 0 and 1. View the input space as time, which I represent with the letter

t, indicating the progression through the sequence as a proportion. Similarly consider the output space as an 'abstract' pitch value, represented with the letter v, where $v = 0$ and $v = 1$ represent the lowest and highest pitches we will output, and $v = -1$ indicates silence i.e. no pitch. Having such an abstract representation of a voice in the class means that we can then define the relationship between real time and our time value t of the sequence, allowing us to have the sequence be as long or short as we require, and even progress non-linearly if we require; similarly we can then define how our output value v corresponds to actual audible pitches.

Now, we cannot store a pure function like this in a computer's memory given that the input and output spaces are uncountable. We make the output value v discrete by storing it as a float, as per convention for storing real numbers. The values for time are less simple: we introduce the property $numTimeSteps$ to the class, which determines the resolution of our sequence, for example if $numTimeSteps = 50$ then we represent our voice using an array of precisely 50 pitch values. This approach lends itself naturally to my application, since when we convert an image of a curve into a sequence, the maximum resolution we can have in time is the width of that image.

At this point, we may access the voice's pitch value at at time $t = 0.3$ as follows: Find the array index corresponding to the nearest time to t that our resolution allows, using $index = \lfloor t \cdot numTimeSteps \rfloor$. Now we simply output the pitch value in that index of our values array.

4.4.4 Conversion of thresholded image to sequence

Converting the image into sequence information is a crucial step.

One method I considered took inspiration from the Oramics machine, which used a set of light sensors to read the position of a line. The analogous software approach is to consider some number n of buckets along the height of the image. For each column we can sample the pixels in each bucket, and those buckets with a number of black pixels that exceeds a minimum threshold will be known to contain a line. At this point, we can set the pitch according the the height of the bucket. This would be easy to implement, but fails in terms of capturing the continuous spectrum of pitch.

Another option, a common one in computer vision, was to apply a Hough Transform which enables detection of known shapes in an image. In Hough space, there is a dimension for each parameter that determines a shape. To detect a shape, we loop over these parameters, find the shape determined by those parameters, add up the number of black pixels that lie on that shape in the original image and store that value in the relevant coordinate of Hough space. The values in Hough space that exceed some threshold indicate correspond to the parameters of a shape that is detected in the image. Knowing the exact shape parameters gives us a very efficient way to store the sequence information. The downside is that its computationally expensive, and we need to pre-define exactly which shapes we will need to detect,

The final algorithm I designed for this feature works as follows, at a high level view:

Algorithm 4.1: High level algorithm to convert a thresholded image into a sequence

---

INPUT: image;
for *each column in image* **do**
    | get array of pixel values in column;
    | get clusters of pixels in column;
    | get line centres in column;
end
make map from column cluster centres to voices;
make sequence;
OUTPUT sequence;

I'll explain the process step by step with the below toy example. Suppose we have photographed a drawn curve (Figure 4.4a) and thresholded it (Figure 4.4b). For the sake of simplicity, we consider an image resolution of 4 by 4 pixels.
We begin by looping through the columns.

Get array of pixel values in column. This is very simple and involves looping through rows of the image, and fetching the pixel value for the current row and column. So for column 0 we have $colVals = [0, 0, 1, 0]$.

(a) source drawing

(b) Example thresholded photograph
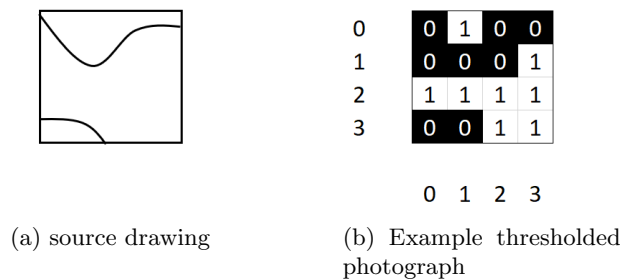
Figure 4.4: Simple conversion example

Get clusters of pixels in column. Now we want to identify which sets of pixels belong to distinct lines. We make the assumption that pixels in one line will all be adjacent in one column, and using this assumption we generate an array of arrays, and each sub-array contains the row index of pixels that belong in one line. So for column 0 we have $clusters = [[0, 1], [3]]$.

Get line centres in column. Now we want to find a single number that describes the height of the centre of each line in the current column, which will inform the pitch of the voice which will be generated from that line. We take the simple approach of averaging out the row indices of all pixels in each cluster. For our example image, in column 0 the row indices of pixels that make up the top line are 0 and 1. So we describe the line centre as being at height 0.5. For column 0 we have, $centres = [0.5, 3]$.

Repeating this process for each column, we obtain the line centres that appear in that column. The line centres for our example are shown in table 4.1.

Column	0	1	2	3
Line Centres	$[0.5, 3]$	$[1, 3]$	$[1.5]$	$[0]$

Table 4.1: Line centre arrays obtained from example image (Figure 4.4b)

We know that one voice can "sing" a maximum of 1 pitch at a time. k line centres in one column indicates that k voices will be singing at once at that point in the sequence, so we can determine from the line centres the number of voices we need in our sequence. Now the problem becomes: how do we know which line centres in successive columns belong to the same line, i.e. which line corresponds to which voice?

Make map from column line centres to voices. To make sure lines are consistent, we can no longer process columns individually, and must at the broader picture, considering the relationship between line centres in different columns. The goal is to create a mapping from line centres in each column to voices such that line centres that correspond to the same line in different columns are mapped to the same voice. With my approach, we work our way from left to right across the image, comparing adjacent columns as we go.

In the initial step for the leftmost column, we may simply map the 0th line centre (0.5) to the 0th voice, the 1st line centre (3) to the 1st voice etc.

Next we compare adjacent pairs of columns and assume that close Line centres correspond to the same line. For example, comparing column 0 and column 1, it is clear that line centre 0.5 in column 0 and line centre 1 in column 1 correspond to the same line. Thus we map line centre 1 in column 1 to voice 0, since line centre 0.5 in column 0 was mapped to 0 in the initial step. Similarly, the line centres with value 3 belong to the same line so we map centre 3 in column 1 to voice 1.

The hard part is when adjacent columns contain a different number of line centres. Consider column 1, which has two line centres and column 2 which only has one. In this case we consider each value in the right column (2) and look backwards to the previous column, greedily choosing the closest centre which hasn't already been picked and mapping to it's corresponding voice. So line centre 1.5 in column 2 chooses line centre 1 in column 1 and so is mapped to voice 0.

In the case where the right column has more line centres than the previous column, we take the opposite approach: Consider each line centre in the left column, greedily choose the closest centre in the right column and assign to the corresponding voice. Once closest values have been matched, the line centres in the right column which have not yet been assigned a voice are assigned to the lowest voice index which is not in use by the current map.

After looping through every column, we finish with an array for each column where the nth value of that array is the index of the voice that the nth line centre is mapped to. The mappings for our example are shown in table 4.2.

Column	0	1	2	3
Line Centres	$[0.5, 3]$	$[1, 3]$	$[1.5]$	$[0]$
Map	$[0, 1]$	$[0, 1]$	$[0]$	$[0]$

Table 4.2: Maps from line centres to voices obtained from example image (Figure 4.4b)

Make sequence. Finally we've completed the heavy lifting and can create our Sequence object, by instantiating the correct number of Voice objects and filling in the pitch value array. To do this, we loop through each column, observe the line centres and which voices they are mapped to. In a nested loop, the pitch value array of each voice is updated to v = the proportional height of the line centre relative to the height of the image.

On testing, I was pleased with how reliable this method was, but I did notice that it fell down in certain situations. If two drawn curves intersected at any point, the algorithm would only recognise one line at that point, due to the clustering technique. In practise, we end up approximating the two lines, by cutting one off at the intersection, and restarting it after (fig. 4.5a). Similarly, if a curve would ever loop back in itself, the small vertical section at the local rightmost or leftmost point is seen as a single line, whilst the places where the curve is doubled up is seen as two. Visually, this results in the interpreted curve being cut off from itself (fig. 4.5b). These problems are only visual in nature while the audio still approximates the line shapes relatively well. In general my method reliably converts distinct lines that do not double back (fig. 4.5c).

(a) Conversion of intersecting lines results in minor artefacts.

(b) Conversion of curves that double on themselves result in minor artefacts.

(c) Distinct lines with no intersection or doubling back are converted very reliably.
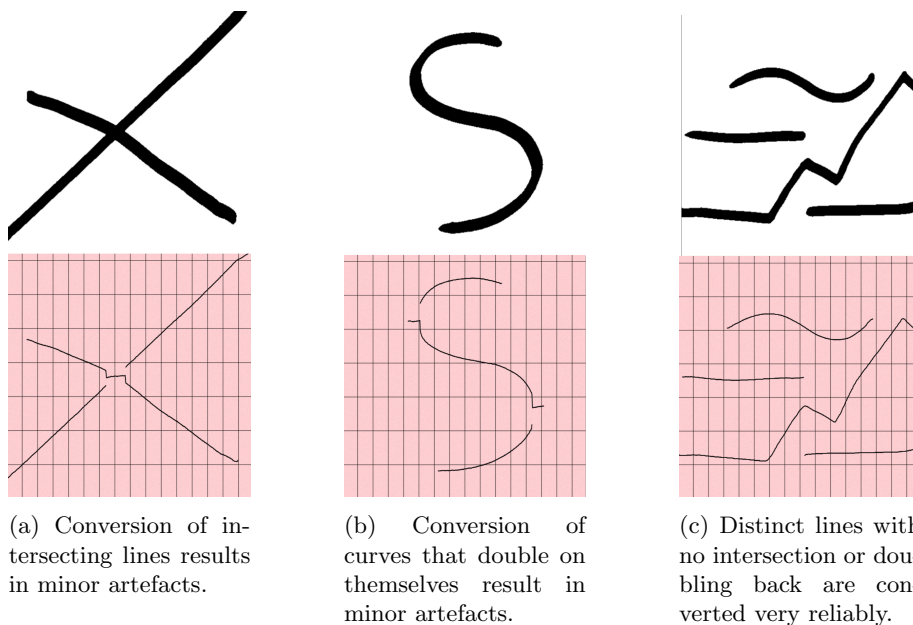
Figure 4.5: Examples of converting thresholded images to sequences using my algorithm.

4.4.5 Sequence playback

Now we have a loaded sequence, represented as described in section 4.4.3, of course we want to hear it.

To control the timing of our sequences, we have a few key variables; *tempo* is the master tempo (or speed) of playback, measured in beats per minute (bpm) and controllable by the user. From this, we calculate $beatPeriod = 600000/tempo$, which represents the number of milliseconds in a beat. Now, each sequence has has some local properties: *speedMultiplier* is tempo of a sequence as a proportion of the master tempo; and *numBeats* is the number of beats in the sequence before it loops back to the beginning.

A the beginning of playback we store the current time and set the global variable *playing* to True. Then on each call of the draw() loop, we update a variable called *masterTime* which holds the number of milliseconds since the start of playback. The next step is, for each sequence object *s*, to call *s.play(t)* where t is a value between 0 and 1 indicating how far through the sequence we are as a proportion. To get t, we divide *masterTime* by *beatPeriod*, obtaining the master number of beats since the start of playback including the decimal. We multiply this by *s.speedMultiplier* to get the number of "local" sequence beats since start of playback. Next we use the modulo operator with *s.numBeats* to get the number of beats through the current loop of the sequence. Finally we divide by *s.numBeats* to get t. Altogether, t is calculated as follows:

$$t = \frac{((\frac{masterTime \cdot s.speedMultiplier}{beatPeriod}) \bmod s.numBeats)}{s.numBeats}$$

Finally we call s.play(t). Note that because the timing t for each sequence is generated from a master time, all present sequences will remain in sync.

Within *s.play(t)*, we loop through each voice v in the sequence s and call v.play(). Each voice has a p5.Oscillator object associated with it that handles sound generation. Below is a simplified version of what happens in *v.play(t)*.

Algorithm 4.2: High level algorithm for playing a voice.

INPUT: t
$timeStep \leftarrow \lfloor t \cdot valuesArr.length \rfloor$
$v \leftarrow valuesArr[timeStep]$
if $v \geq 0$ **then**
$\quad$ Set oscillator volume to 1
$\quad$ Set oscillator frequency to $minFrequency \cdot e^{v \cdot \ln maxFrequency \quad minFrequency}$
else
$\quad$ Set oscillator volume to 0
end

In other words we find the pitch value v that is a proportion of t along the array. If $v \geq 0$ (i.e. the voice in active) then we convert it to a frequency via an exponential scale, reflecting the relationship between absolute musical pitch and frequency [37]. Using this mapping means that at any height, the same *change* in height will result in the same musical interval, as per convention for music sequencers. We make sure the oscillator is audible and we set the frequency accordingly. If $v < 0$, this indicates that the voice should not be playing, so we set the oscillator volume to 0.

Playback is slightly different for the drum track. Once we have obtained v, we map it to an integer index, then trigger a sound from a global array of pre-loaded drum samples.

4.4.6 Quantisation

Sequence playback becomes more complex when we wish to quantise our sequences. We can quantise in both pitch, by snapping to a musical scale and time, by snapping to the nearest beat. These options act as an computer aid, helping to transform a user's sequence into something more musical.

Time quantisation

Given our time value t, instead of finding the pitch value v that is a proportion of t along the array, we find which beat t corresponds to, then access the array at a position corresponding to the time at the start of that beat.

More precisely, we put

$$quantisedBeat \leftarrow \lfloor t \cdot numBeats \rfloor \tag{4.1}$$

$$quantisedT \leftarrow \frac{quantisedBeat}{numBeats} \tag{4.2}$$

$$quantisedTimeStep \leftarrow \lfloor t \cdot valuesArr.length \rfloor \tag{4.3}$$

$$v \leftarrow valuesArr[quantisedTimeStep] \tag{4.4}$$

then we use v as before to control the oscillator. The effect is that at any point in playing back the voice, only the pitch values at the start of beats are considered.

Pitch quantisation

Pitch quantisation harder is comparatively much more complex than time quantisation. The objective here is to take the pitch value v, access a musical scale and set the oscillator to the frequency of the corresponding note in the scale.

When considering scales and musical notes, one must be aware that technically any any set of frequencies can make up a scale and these vary by culture. In my program, I use the convention of 12-tone equal temperament [9], which basically means I will use notes that are available on a standard piano. To refer to these notes in my code, I assign A4 [1] to index 0, then each ascending or descending semitone [2] is the next or previous integer.

I implemented a *Scale* class, which handles pitch quantisation. An instance of the class contains a sorted array of the note indices that are in the scale. To quantise a frequency to a given scale, we convert the frequency to a note index (which could be decimal, meaning the frequency is in between two notes) by $noteIndex = 12 \cdot \ln frequency / 440 \ln 2$. After that we use binary search to find the nearest note index in the scale array. Then to convert the note back to a frequency we do the inverse conversion $frequency = 440 \cdot 2^{noteIndex/12}$.

Each sequence has a scale property and a boolean to determine if pitches should be quantised. If quantising is enabled, we simply find the frequency corresponding to v, then set the oscillator frequency f to scale.snap(f).

Figure 4.6 shows the same sequence with all the different quantisation options applied. The scale is set to only the notes A and E (two notes per octave), to make it more clear when pitch quantisation is enabled and disabled.

(a) Unquantised   (b) Pitch quantised   (c) Time quantised   (d) Pitch and time quantised

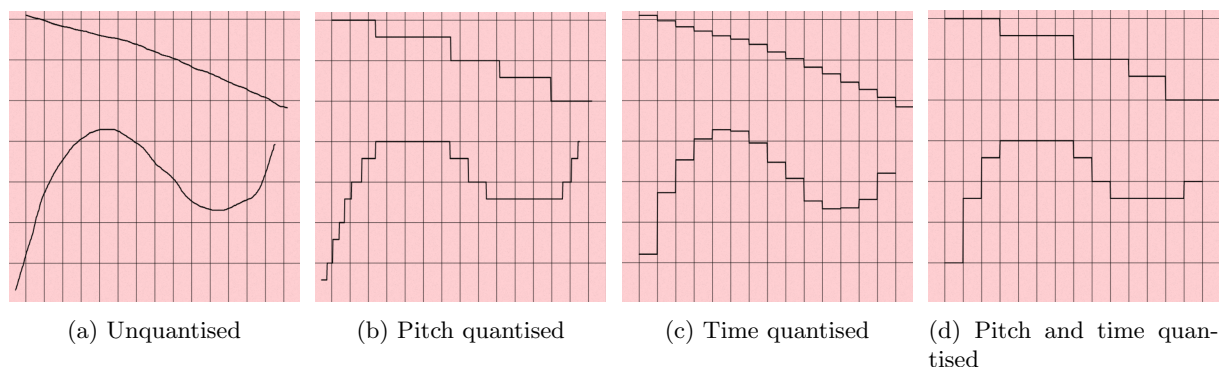Figure 4.6: Different quantisation modes on the same sequence.

4.4.7 Scenes

p5 is normally used for applications with a single UI, but when I looked at the list of features in my application, and different interactions that would need to be facilitated, I quickly concluded that in order

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[1]A4 is the A above middle C [53]
[2]A semitone is the smallest musical interval, or distance between notes

to keep the layout and operation of the app simple, I would need to break down the app into several scenes. Each scene would have its own UI with unique buttons, visuals and other elements.

So what exactly does each scene need to have functionality for? I narrowed it down during the course of development to these things: It needs to hold all the relevant Button objects for the scene; it needs to be able to update those buttons when the window is resized; it needs a method that runs every frame when the scene is active; it needs to respond to mouse clicks; and finally it needs to render the GUI to the canvas.

Thus I implemented each scene as its own separate class with these methods in common:

- *constructor*() is a method that is called on instantiation of any object. For the scene classes all the relevant objects and variables, stored as properties of the scene, are set up in the constructor.

- *windowResized*() handles the updating of all GUI objects in the scene so that they respond nicely to the new screen size according to the layout (for more details see section 4.4.8).

- *mainLoop*() is called once every frame before rendering. The only scene that makes use of this method is *scene$_t$hresholding*. The rest implement the method as an empty block of code, devoid of functionality.

- *mouseClicked*() handles interaction with the GUI, namely for each *button* object in the scene it calls *button.tryClick*().

- *render*() draws all relevant visuals to the canvas.

Since JavaScript is a weakly typed language, this meant that I could create a global variable *currentScene*, set it equal to any of the scene objects and change it at will. Then I could leverage p5's methods to enable functionality for the scenes, for example within the p5 *draw*() method (see section 4.3.2 for details about p5 methods) we include *currentScene.mainLoop*() followed by *currentScene.render*(), to activate those methods. Then, to change the app to a different scene, we simply reassign this *currentScene* variable!

4.4.8 Layout and GUI elements

Layout. I knew that I wanted the GUI to be consistent, responsive and simple. To begin I sketched some designs of what controls, visuals and other elements needed to appear on each scene and where they would be be positioned. Then, using these sketches, I came up with a layout system: The screen of a device is split in half on its short axis, and the maximum possible square that can fit is centered in each half. I call these the *primarysquare* and *secondarysquare* (depicted orange and blue respectively in Figure 4.7). The role of the primary square is to contain the main visuals for a particular screen, for example the set of sequences in the *Main* scene or the camera output in the *TakePhoto* scene, while buttons and other text is positioned in the secondary square. Maintaining conventions and consistency like this in an application helps remove mental load from the user and all goes towards making the app as accessible as possible.

Within the *primarysquare* and *secondarysquare* are smaller squares, which I call *subsquares*. I place elements in here, to allow padding between these elements and the screen edge.

To implement this system in practise, I created the *Layout* class, whose public properties contain screen coordinates and other geometric information for the *primarysquare*, *subsquares* etc. On *setup*() and the *windowResized*() event, these coordinates are recalculated with respect to the *window.InnerWidth* and *window.InnerHeight* variables provided by p5. Now, whenever any element has to be rendered to the *canvas*, we can choose to position it relative to the information in our *layout* object, ensuring the GUI is clear and readable regardless of the device's aspect ratio (see Figure 4.8).

Buttons. One unfortunate downside to p5 is that it has no first-party support for interactive UI elements like buttons, sliders etc. Of course, since the application exists on a web page it is possible to use DOM element buttons, but I decided in the end to implement bespoke buttons to allow for maximum customisation in terms of both functionality and appearance.

Every clickable element in the GUI is an instance of the *Button* class, which has contains all the functionality for detecting a click, displaying the button, and calling back a given function when it is clicked.

(a) Widescreen monitor   (b) iPad Mini   (c) iPhone 12 Pro   (d) iPhone SE
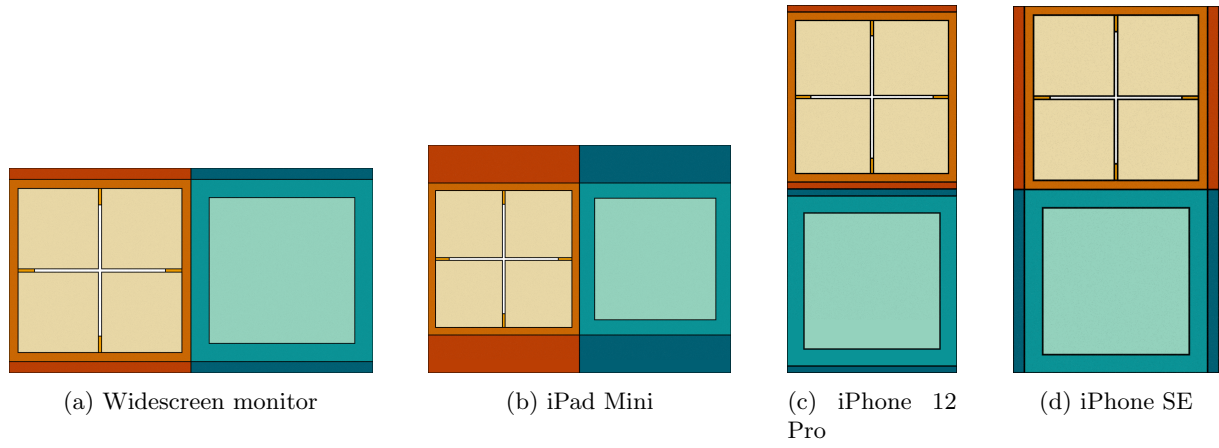
Figure 4.7: Layout template on different devices

(a) Widescreen monitor   (b) iPad Mini   (c) iPhone 12 Pro   (d) iPhone SE
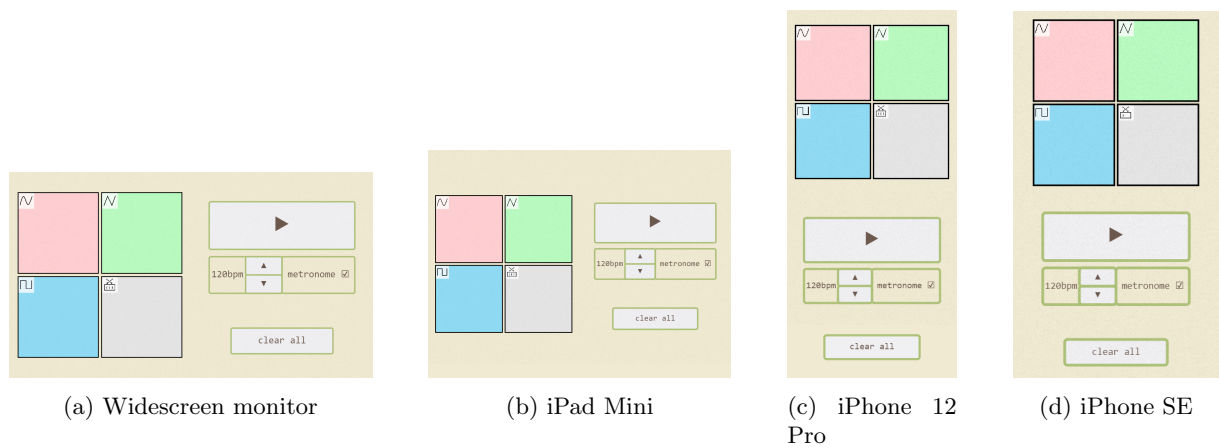
Figure 4.8: Main scene on different devices

Chapter 5

User Study

Having implemented the *draw music!* I set out to determine if it met its goals of being engaging, easy to use and intuitive - especially for non-musicians. The user study saw participants using the app independently for five days, after which I interviewed them to gain insight into their experience. I gathered qualitative data which was explored through thematic analysis. This section will explain and justify details of the study before discussing the outcomes.

5.1 Participants

The study involved 7 participants between ages of 18 and 58, all with academic background, but in various fields, none of which were music study. We shall refer to them as P1, P2 and so on. Based on their answers in the pre-interview, which I will expand on later in this chapter, I assigned each participant a level of music experience (table 5.1). Note that this is a subjective level.

Rank	Low	Medium	High
Participants	P1, P2	P3, P4, P5	P6, P7

Table 5.1: The participants and their levels of musical experience.

Participants were recruited via social media, or in person, by asking them directly. I chose participants with whom I was already acquainted, and I asked them directly rather than sending an open invite. This was due to time constraints of the project: I picked participants who I thought were likely to be responsive and interested and would get involved quickly, allowing time to do the study justice. More importantly, it meant that I could ensure that there would be a large range of prior musical experience amongst participants.

The downside is that most of the participants were of a similar demographic, namely university students roughly my age. I was aware that this could introduce biases, given their interests, level of education, culture and temperament, but I attempted to choose as diverse a group as I could.

Furthermore, I was aware that the fact that the participants were acquaintances of mine might cloud their judgement and influence their feedback. I made it clear to them that they should try to consider the app objectively and provide feedback as honestly as possible, emphasizing that I would not be offended by what they had to say.

5.2 Procedure

Each participant was fully informed about the study and given opportunity to ask questions via video call. I conducted a preliminary semi-structured interview with each to obtain insight into their musical background, before asking them to use *draw music!* for 5 days, following a different prompt each day. Then I carried out final semi-structured interviews to gain qualitative data about their experience with the app. The audio of the interview was recorded, then transcribed to aid in thematic analysis. In the following sections I will detail each stage of this process.

5.2.1   Prior to study

After signing up to the study, I scheduled a meeting with each participant (online or in person, depending on convenience). The nature and purpose of the study was explained to them, as well as their role in it. A full participant information sheet was also provided, via a web page, including advantages and disadvantage s of taking part, and detailing important information regarding ethics and data protection. Once they stated they were happy with all the information, and were given an opportunity to ask questions, they were asked to fill in an online consent form, via Google Forms.

5.2.2   Pre-task interview

Before each I conducted as a semi-structured interview, the purpose of the pre-interview was to gauge better the musical experience of each participant, and also to shed some light on opinions about different ways of interacting with music.

A consistent set of core questions was asked to each participant, though the wording of these questions was not strict. Depending on their answers, probe questions were asked to gain a deeper insight into their experiences. Some of these probe questions were planned beforehand and others were formulated in the moment, usually building off something they had previously said.

Listed below is the set of questions asked to each participant, with the probe questions marked with an asterisk (*).

- How frequently do you listen to, play, and write music?
- What experience do you have with music writing?
- * How do you come up with and conceptualise melodies and other musical ideas?
- * As you write, how do you name a record of your ideas?
- What experience do you have with standard western musical notation?
- * What things do you like and dislike about it?
- What experience do you have with music production software (DAWS) and the piano roll?
- * What things do you like and dislike about it?
- What experience do you have with alternative notation systems, for example tab or graphical scores?

For each interview, the audio was recorded and later transcribed for analysis, after which the audio was deleted.

5.2.3   Task

Participants were provided a link to the study welcome page (fig. A.1), which contained a button to launch the app, a description of the project, and instructions for the participants.

The task was to use the app for at least ten minutes per day for each of five days, following a different prompt for each day. These prompts were designed to encourage different interactions that participants might not have thought of on their own. The list of prompts is as follows, along with the rationale behind the prompt:

1 - Familiarise yourself with the app. Make something that captures your mood.   Easing into the task, the first prompt was to simply spend some time exploring the app and figuring out how it works. The prompt was written in a very open-ended way to encourage free exploration, and to not prescribe a certain way of using the app.

2 - Make a song whilst outside or travelling.   Given that the app was made to be very easy to use and access, I wanted to see if the participant would find it easy to use whilst away from the comfort of their home. Perhaps inspiration would trike more easily in an unfamiliar environment, or they would spot something interesting to photograph and wonder how it would sound once converted into a sequence.

3 - Take a picture of something weird for your sequence! Suggestions: scattered beans, piece of string, an interesting rug. This was one of the ideas I had imagined when first designing the app. The imprecise nature of the interface, I hoped, would cause sequences to emerge which are surprising or unexpected, and be a source of inspiration on which to develop the music. Leaning into this idea, I thought: What if the use could use a random phenomenon, or input from the noisy real world (as opposed to clean lines on paper) as the basis for a sequence?

4 - Attempt to recreate a song that you like. This prompt really tests whether the drawn lines might be a viable way to notate music. I anticipated that this would be the most difficult or frustrating prompt given the nature of the interface, but I hoped it would prove to be a fun challenge nonetheless. I also wondered if participants would be able to conceptualise a song and understand the contour of a melody in order to draw the curve to recreate it.

5 - Use the app however you like to make something cool. The reason for the final prompt is that, after trying the app in various ways and becoming comfortable with its functions, the participants would get a chance to freely engage with the app in a way that they enjoy the most, picking elements of previous prompts to guide them.

I chose to run the test over five days in the participant's own time for several reasons: Firstly participants would be able to engage more naturally with the app, as I imagine it would be used outside the setting of the study. They might use it on the go, or spontaneously when they felt inspired to be creative, which cannot be facilitated in a short space of time. Next, I was curious to discover how the engagement would progress over time: Might users persist with certain creative ideas, or drawings over time? Might they learn and become more comfortable with the app after a few days of use, allowing them to use it in a more informed way? Lastly, allowing the participants to use the app unobserved was important, since I suspected that if they had been observed, then they may have felt self-conscious, or less able to explore the app freely and express themselves as a result of feeling judged by the observer.

5.2.4 Post-task interview

After completing the tasks I conducted another semi-structured interview with each participant. This interview was organised in a similar way to the pre-task interview. There was a list of questions to ask each participant, but I would also ask probing questions depending on their answers. These probing questions were mostly not premeditated.

I chose to gather data via interview, because it affords a breadth of information that is not afforded by quantitative methods, or other qualitative methods like questionnaires. The interview format allowed me to probe deeper into interesting responses to questions, clarify responses and further explore thoughts and experiences that I might not have been able to anticipate.

The questions were broad and focused on the participants' experiences during testing. I aimed to ease the participants in with closed-ended questions for each topic, before asking them broader, open-ended questions. Care was taken to follow good interview technique, for example asking non-leading questions and allowing participants to finish each thought before moving on to a new question.

Listed below is the set of questions asked to each participant, with the probe questions marked with an asterisk (*).

- What device(s) did you use to engage with the app?
- How easy was it to access and start using the app?
- How engaged were you with the app?
- * Did you skip a prompt?
- * How long did you spend with the app?
- What was your favourite part of the app and why?
- What was your least favourite part of the app and why?
- Did you manage to make anything you were proud of?

- Did the fact that you cannot save a tune change the way you used the app?
- Could you predict the melody that would be generated from a line?
- Did you like this way of writing music?
- Did using the app make you think about music in a different way?
- For each of the five prompts:
    - Where were you when you completed the prompt?
    - What did you find easy or challenging?
    - Did you enjoy the outcome?
- Which prompt was your favourite and why?

Then, depending on a participant's past musical experience, I chose questions from the following list:

- How does the app compare to the music systems that you have used in the past?
- Were you able to apply knowledge across from other notation systems?
- How might you use the app if you were setting out to write music?
- What did you learn about music writing and melody?
- Do you think the could be useful in a musical setting?

I ended each interview by asking the participant if they had any comments that they would like to add.

5.3 Pre-task interview results

Recall that the main purpose of the pre-task interview was to gauge the participant's level of music experience (table 5.1), to help provide context when it came to conducting the post-task interview and analysing the results. However, answers to questions provided insight into different aspects of music writing systems.

Find full pre-interview interview transcripts in appendix B.

5.3.1 Opinions of staff notation

The prevailing opinion of staff notation is negative, the reason being that it is difficult to use. P3 stated "I don't find it very intuitive to use" and P4 commented that "It takes a long time to learn" which was confirmed by P2 and P6. Even P7, who uses staff notation often, admitted "it's a little bit bulky".

The only positive comments that were made related to the fact that staff notation is so well established. P4 stated "I like that it's international, it's not written in any language" and p5 said "I think it has some necessity and importance whether I like it or not".

The conclusion here is that staff notation is not an accessible way to represent music, with the participants who can read it fluently emphasizing that they have been using it for many years.

5.3.2 Opinions of tablature and piano roll

In contrast to staff notation, almost all comments regarding tablature and piano roll (made by participants familiar with those systems) were positive.

Tab. By definition, tablature does not represent music information directly, but instead provides instructions for how to create the sounds on a particular instrument. This seems to be seen favourably. P1 said "It's much more direct to me". P7, a guitar player commented that tab is "really accessible and intuitive", but also points out a limitation: "there's a lot of different places you can get [the same note] on the guitar, obviously, and tab only gives you one option of those".

Piano roll. Participants seem to like the visual link between piano roll and music. P2 remarked that " it gives a nice connection between what you're really playing and the musical notes". P7 suggested that "you could definitely argue that it's more intuitive", the reason being that "the notes [have] very visual lengths, and they are up or down".

5.4 Post-task interview results

The result of the post-interview are of high importance because they indicate whether *draw music!* is successful in its goals. After transcribing the interviews from the audio recordings, I used thematic analysis to identify the common types of responses. I will present the results of the interview by theme in the following sections.

Find full post-task interview transcripts in appendix C.

5.4.1 Bugs

Unfortunately I did not have time to thoroughly bug test *draw music!* before conducting the study, thus the participants experienced some problematic behaviours of the app which were not intentional. P4 stated simply "It was quite buggy, and it was laggy", while P3 elaborated "after 5 - 10 minutes of using it and putting in too many inputs, it started sounding all funny". P7's had a similar account, stating "sometimes if you put too much into it, particularly the drum kit, the sound would get more kind of machiney". I currently believe that this is a problem with memory. I did not spend much development time on optimisation, and the implementation runs using many simultaneous instances of different classes. Given that the code is executed client-side, often on a mobile device with relatively low memory, it is unsurprising that there would eventually be insufficient memory to process the audio, causing glitches. P4 also mentioned that after experiencing the glitched audio on their phone, they used their laptop device instead and did not encounter the same issues.

P6 experienced a problem that was not reported by any other participant. They reported that when converting the thresholded image to a sequence "it adds in these weird dots that I didn't always want so then there's like a weird odd note here and there". They clarified that these dots were not visible in the thresholded image, which suggests that there is a problem with the implementation of the conversion, however I have since been unable to reproduce this bug.

5.4.2 Accessibility

Being accessible for non-musicians was an important motivation behind *draw music!*, so it is disappointing to find mixed results in this respect.

The crucial pieces of feedback come from P1 and P2, the participants with a low level of musical experience. P1 reported having trouble understanding fundamentally how the drawn sequences represented music, noting that it was no easier to interpret than staff notation. They explained "it's equivalent to you giving me a piece of paper with the lines of conventional music writing and I wouldn't even remember where the notes go because I can't read music. But I would put dots on the lines [...] It [would] be all very random". They also struggled with the quantisation options, stating "I tried to play with the pitch and the tempo, but because I don't understand music I couldn't quite get it.". They even stated they were "assuming the app is directed to people with a certain level of musical knowledge" so clearly, for them, it did not feel accessible. Similarly, P2 reported that "figuring out what everything did was a little bit challenging [...] because I'm not very experienced in music". When asked about the fourth prompt (try to recreate a song) they responded with "[the hard part] was communicating to the app just because I don't write music. And trying to tell it what I want to do was difficult".

However there were other comments indicating that the app is, indeed, accessible for non-musicians. At another point in the interview, P2 said "for someone without much experience, it kind of gave the basics and an introduction to [music writing] in quite a nice way." and when asked about potential uses for the app, they suggested that "it would be a cool teaching tool because I know it helped me think about melodies more and how to construct them". P5 had a similar comment - "for someone who doesn't have much knowledge, like me, I think this app could be a starting point where you can think about the structure of music while you're using it".

One feature aiming to increase accessibility was quantisation. This computer aid helped P2, who noted that "anything can be a melody, you just have to play with it enough that it sounds good. [...] Like adjusting the settings in the app and using the slider options to try and make the notes clearer and things like that". When asked further about this, they confirmed that it increased their enjoyment of the app, and did not diminish their sense of ownership of what they created. P7 expressed that they "liked trying the same [sequence] with different scales", and this view was shared by P5.

5.4.3 Ease of use

One of the primary focuses for the app was ease of use, with the UI specifically designed to be minimal and intuitive, contrary to a lot of existing music software. It seems to be successful in this regard. P4 reported that "it was very clear how it worked", and this sentiment was shared by P1, P2, P3, P6 and P7. The only exception was P5, who said "it took some time to make myself more comfortable [with the app]". This feedback is especially positive given that, when introduced to the app, each participant was given only a short explanation of how to use it and no further instructions were provided.

5.4.4 Engagement

Overall, participants reported high engagement with the app, regardless of musical experience. P7 commented "You can definitely get into a roll with it and do it for a while", and P2 said that "it kind of turned [music creation] into a bit more of a game, a more interactive way of doing it". Participants often commented on the novelty of the experience, for example P3 stated "I really enjoyed the fact that you can take pictures of random things and it translates it into sound, because I haven't seen that before". They seemed to be attracted to this new paradigm, and that kept them engaged.

It is less clear whether the app would engage users over a longer period. P4 expressed this thought - "I'd say that it was an engaging app, certainly to start with. But I don't know how well I would engage with it over a longer time period". Meanwhile P3 commented that "some of the frustrations of using it made me not as engaged as I could have been", and they became much more engaged when a sequence they produced was musically enjoyable - "because it was pleasing to me to start with, I spent longer on it".

An unintended aspect of the app is the lack of any functionality for saving. When I discovered in development that this would be the case, I marked it as a good thing because I predicted that it would encourage rapid iteration on ideas because participants would not grow attached to one creation. This seemed to be the case. P6 noticed "it meant I was more experimental" and P1 and P5 shared sentiments to the same effect. P3, P4 and P7 also noted that it changed the way they engaged with the app, with P7 commenting "given that you're not really looking for something that you're going to save, you're just kind of having a fun time with it".

5.4.5 Response to photographic input method

A key feature of the app is the fact that the main input for sequences is photographic. There were two universal responses to this.

The first was the idea of lack of control. Because of the imprecise nature of photographing the lines, it did not seem as though participants felt command over the music. P4 acknowledged "I couldn't control what I was making because it was just lines on paper" and P5 explained "when I thought of certain melodies or had certain sounds that I wanted to make, it was really hard to make that as a drawing and put that into the app". This was a common view across all participants. Also, no participants reported success when asked about prompt 4 (recreate a song) for the same reasons. P2, P6 and P7 were able to get a melody similar to what they intended. P6 put it delightfully: "if it were possible to squint your ears at something, then I think it would sound like it". P2 and P5 seemed surprised and pleased by the output melody when it differed from what they expected, with P5 relating "I really liked how far it is from what I wanted to do".

The other response was one of disregarding the pen and paper notation, and instead simply taking any arbitrary photograph to be converted into a sequence. In fact, I predicted that this would be an interesting way to interact with music during development of the app. This behaviour was explicitly encouraged in the third prompt, which was the favourite prompt of P1 and P4. Every participant arrived at this behaviour and said some variation of "I really enjoyed the fact that you can take pictures of random things and it translates it into sound" (P3).

Other ideas about the input method were less favourable. P3, P4 and P7 expressed frustration when having to photograph a drawing using the integrated web camera of a laptop, with P3 commenting that "the user experience was definitely worse with having to put up my drawings to the laptop camera". P2 mentioned shadows on the page interfering with the drawn lines despite the thresholding feature, observing that "it was hard to get a clean line that you wanted". Both P4 and P7 asserted that having too thin a pen also made it difficult to obtain clean lines.

5.4.6 Response to curves as a musical representation

The unconventional system of using curves to represent musical sequences was another key idea for the app. Aside from the frustrations resulting from the imprecise nature of this notation, people seemed to respond well. It seemed that for most participants, considering music visually was a new concept. P4 commented "it made me think about how you can basically write music in two dimensions, one dimension being time essentially [and] the other dimension being pitch". Meanwhile P6 said "it made me think more about the pattern of the tune rather than like what the tune sounded like", and P5 commented that the app was "inspirational [in] the way that it connects two different modalities, like sound and visualisation".

5.4.7 Practical uses

One of the final questions I asked each participant was how they could see the app being used practically in a musical setting. The overall response was that it would not be used as the main tool for music writing. The only participant that considered it was P5, who speculated that "if the music you were writing was experimental [...] it's plausible that someone can make an album out of that technology", and went on to say that "in terms of making popular music I think that it could be used but I don't think it would be anyone's first port of call". P3 specifically stated "If I wrote a melody that I wanted to write down, I would definitely use any other kind of notation".

The most common alternative suggestion was to "use the app more as inspiration" (P3). P5 had a very similar comment. P3 continued "it's much better for producing ideas than it is for writing a full song", with P7 imagining the app generating "little sequences of melodic intervals that you might not have thought of".

Some ideas that were particularly intriguing were made by P1. Their first proposal was a visual art exhibition where all the pieces are designed intentionally to produce music when photographed by *draw music!*. Another suggestion was to use the app in an improvised music concert, using photographs from the audience as the basis for a sequence, and having the artist build a song from the generated melody.

5.5 Discussion of results

Overall, participants reported good experiences with *draw music!*. It succeeded in its goal of being easy to use and intuitive when it came to the operation of the app. In terms of accessibility, the results were mixed. Some participants struggled to use certain aspects of the system due to their lack of music experience, but other feedback indicated that the app, having a visual representation of a melody and its structure, would make for a good pedagogical resource.

Unfortunately the app fails in being a useful music representation. None of the participants had success in attempting to write down specific melodies, sometimes expressing frustration at the fact. This is because there is no visual indication of how line heights will map to pitch during the drawing and photographing process. On the other hand, some participants enjoyed the unexpected results. Every participant enjoyed that any photograph could be converted into a sequence, and that seemed to be the way the app was used most.

Finally, in terms of how the app would be used practically for music, participants imagined that either it would be used in an experimental setting, or only as a tool for generating music idea, after which these ideas would be developed elsewhere.

Chapter 6

Conclusion and Further Work

This project has presented *draw sound!* a unique system for graphical sound, taking tangible drawings and using a web application to convert it into a musical sequence with a goal of being intuitive, engaging and easy to use especially for non-musicians. I started by conducting a thorough review of historical and modern related work, then used the information to inform the design of the app, taking into account studies regarding accessibility for the musically untrained. I then completed a user study with seven participants each using the app for five days after which they were interviewed with a view to analyse whether the app meets its goals. Finally I carried out thematic analysis to understand the feedback. *draw sound!* succeeds in providing an engaging interface for graphical sound, however it lacks in accessibility, with less musically experienced participants having some trouble with some of the apps controls. The app is not at all effective for writing down specific musical ideas, but it excels as a tool for exploring music and generating melodic inspiration.

6.1   Further work

There are many ways to extend the app. In this section I suggest several refinements and additional features.

Of course, we first need to address the fact that the app was not successful in its goal of being accessible. Going forwards, I would take the approach of user centered design. This would involve more iterations of the design process; for each iteration I would build a minimum functioning prototype and conduct a study to test if the app is meeting its goals, and receive feedback focusing on the users' needs which I would take on board for the next iteration. Studies would need to have a broader set of participants covering a large demographic with a larger proportion of non-musicians.

Next I would heavily optimise the app, re-implimenting it from the ground up with a focus on efficient code. To get even better performance, I would implement a local software version for mobile devices and PC, to avoid the overhead processing done by the web browser.

Some participants in the user study expressed a wish to edit the imported sequence in-software since the process of editing the tangible drawing and retaking the photo was cumbersome. I would implement some editing tools, taking inspiration from UPISketch and HighC, allowing the resizing, inversion and translation of existing curves. Another way to allow quick iteration over ideas would be to implement interpretation of sequences in a video. This way, the user could point the camera at their sequence and hear the audio output without first having to take a still image, gaining a more immediate understanding of how their actions affect the sound.

In terms of representing a sequence, there are many additional parameters we could incorporate to introduce depth to our notation. We could have line colour and line thickness influencing timbre and volume, for example. We could even entirely change the way the score is interpreted. The same curves we used to control pitch and time could be toggled to act as runners for cursors, like in IanniX, or as a mathematical graph, like with TuneTrace. In the related work, there was no such system that could switch between interpretations of graphical sound.

Finally, I think a great feature would be converting an audio signal to a sequence. This way the user might more quickly build intuition on how the visuals relate to the audio, for example by singing into their microphone and seeing the curve produced. The technology for this already exists, for example in some DAWs audio files can be interpreted into MIDI files, I would just need to apply it to my specific

application. Adapting the app to interface with MIDI would also allow it to be connected into existing musical systems, such as midi controllers and synthesizers, legitimising it as a musical tool.

Appendix A

Study welcome page

draw music!

Run App

What is This?

draw some wavey lines and turn them into music

My name's Peter, I'm a Mathematics and Computer science undergrad at Bristol university, and I have made this app for my final individual project. The idea is to provide a novel interface for music writing, lowering the barrier to entry so that users without musical knowledge or access to specialist software and equipment can explore and create something cool!

Participant Information

thank you for participating in my user study :)

Your Task:

- For 5 days I ask you to have a go using the app for around 10-20 minutes. Of course, if you're enjoying yourself, you may use it as much as you like. You don't need to set aside a time or place to do it, you can use it whenever inspiration strikes!
- Note down any thoughts you have regarding your experience.
- I provide a list of prompts below as a jump off point, so that you engage with the app in different ways.
- Have fun!

Your Prompts:

1. Familiarise yourself with the app. Make something that captures your mood.
2. Make a song whilst outside or travelling.
3. Take a picture of something weird for your sequence! Suggestions: scattered beans, piece of string, an interesting rug.
4. Attempt to recreate a song that you like.
5. Use the app however you like to make something cool.

If you have any problems or questions, feel free to contact me via fw19121@bristol.ac.uk or your preferred contact method. Remember you may withdraw from the study at any time with no reason needed. Click here for the detailed participation information sheet.

Figure A.1: The study welcome page, the first

Appendix B

Pre-task interview transcripts

P1 Pre-task Interview

I: How often would you say you listen to practice or write music?
P1: I never write music. I practice once a week. And at least listen to music every day.
I: Can you read sheet music, traditional sheet notation?
P1: No, not really.
I: Do you know anything about how it works?
P1: sheet music? Yeah.
I: So if I gave you this page of sheet music, could you figure it out eventually?
P1: Oh, no, I don't think so.
I: Have you tried to learn?
P1: Yes.
I: Okay. What do you like or dislike about sheet notation?
P1: I've tried to learn and it took a long time.
I: Why do you think it took a long time?
P1: I think there is a lot there to represent the sound. You know, the number of lines, and between the lines. There is a lot of information there. It looks very distant to the sound itself. My brain just cannot connect it.
I: Okay. Is there anything you do like about it?
P1: Well, I'm sure if I could understand it or if I could learn it in an easier way, the whole thing is good, because that's where the music is.
I: Okay. Moving away from that. Have you ever seen [a piano roll]
P1: No.
I: Do you read tab?
P1: Yes.
I: How do you feel about tab? How do you think that compares to classical notation?
P1: Well, for me, it's much easier because I use the tab for the ukulele. And it's much more direct to me. What note I should produce.
I: Do you think it is more intuitive?
P1: Oh, yes.
I: And have you seen any other ways of representing music? Other than, like sheet music or tab? For notating music on the page?
P1: I don't think so.

P2 Pre-task Interview

I: How often would you say you engage in musical activity, be that listening or playing or writing music?
P2: I listen to music every other day when I go to the gym.
I: You used to play piano or something. Did you used to play music?
P2: WHen I was young I played the violin.
I: Have you ever written any music?
P2: I have not, no.
I: Do you know anything about traditional musical notation, like sheet music?
P2: I'd probably have to say no.
I: Have you ever tried to learn sheet music?
P2: I have when I was playing violin and things like that.
I: DO you remember any of it?
P2: A little bit, not much, but little bit.
I: Do you like it? Do you think it's a good system?
P2: I think it's hard to learn.
I: Why do you think that is?
P2: Because there's a lot of different notations that you need to learn. Like a lot of it can be confusing and similar and difficult to wrap your head around.
I: Have you ever had experience in musical software?
P2: Not really no. I've kind of edited music with things like audacity, but nothing like writing music.
I: You know those piano tutorials on youtube where it's like notes coming down from the sky. THat's called a piano roll and you can think of that as another form of musical notation. Have you ever tried to learn using that?
P2: I don't own a piano, so I have wanted to learn using it and I've looked at a few of them.
I: What do you think of that way of representing music?
P2: I think it gives a nice connection between what you're really playing and the musical notes. But it also means that you can't then use sheet music as easily.
I: Have you ever looked at other notation systems like tab or graphical scores?
P2: I don't think so.

P3 Pre-task Interview

I: How frequently do you engage in musical activities?
P3: Including recreational listening?
I: Yes
P3: At least once per day
I: Can you split up each activity? How often do you write music?
P3: I basically never write music. I listen to music everyday and I play music maybe once or twice per week.
I: What experience do you have with traditional written musical notation?
P3: I can just about read and write it very slowly, but not very well.
I: Do you like it? Are there any parts you like or dislike about it?
P3: I dislike it because I can't read it very well. I don't find it very intuitive to read. I much prefer reading tab than official musical notation.
I: What experience do you have with music production software?
P3: Minimal. I tried Audiotool when I was small. A long time ago. I've used Garageband as well.
I: So you've used the piano roll to sequence melodies? What do you think of that way of writing music?
P3: It's definitely more intuitive, but not necessarily, doesn't necessarily give you the full range of what's possible. As in it's more difficult to make things nuanced.
I: What sort of nuance is it lacking? Can I have an example?
P3: There's absolutely no microtonal harmonics. In general, with the simpler ones, it's harder to do things like have a bar with an odd time signature, or put in a random gap of silence because you're restricted to 4/4 bars or whatever. Obviously the more complicated ones you can do that, but it's easier to do that on notation than it is to do with [piano roll] I think.
I: Have you had any experience with any other weird notations or graphical score, that kind of thing?
P3: I've learned how to play some piano pieces using [synthesia]. I've used that to actually learn songs a very long time ago. Apart from that, just tab.

P4 Pre-task Interview

I: How frequently would you say you engage in musical activity? That could include writing or playing or listening to music.
P4: Every day.
I: What about writing and playing?
P4: I listen to music every day. I don't ever write. I play about once a week on average.
I: You play bass. Do you play anything else?
P4: Ukulele.
I: Did you say you don't ever write?
P4: No. I've tried it before though.
I: Do you know how traditional sheet music notation works?
P4: I know how it works but I can't read it at all. Well, I can spend ten minutes working out each note, but I couldn't [do it quickly].
I: What do you like/dislike about that way of writing down music? Do you like it?
P4: I like that it's international, it's not written in any language.It's just, anyone who writes music can understand it. It's just symbols. But it takes a long time to learn which annoys me.
I: Why do you think it takes a long time to learn?
P4: Because it's just not like any other language. It's like learning a new alphabet really.
I: Do you have anything else to add on that?
P4: I think it's difficult to always get the feel of music across. Because even orchestras need a conductor at the front, even when they all have sheet music in front of them they still need someone to tell them what to do. If you're going to write music, it is easier to have an idea of what it should sound like in your head. Like the tone of it. Sometimes the bar lengths vary even in one piece of music ... it's not standardised. [the physical size of the bar]
I: Have you had experience in musical production software that uses other ways to write down melodies and stuff. So like a piano roll.
P4: Does that include me playing them? Yeah, I use tabs quite a lot. So like ultimate guitar tells you when to play where the lyrics are, but obviously you have to know that song.
I: How do you feel about tab?
P4: I would rather get sheet music in tabs. Because I find that a lot easier.
I: Why do you think you find tab easier than standard notation?
P4: Because it gets straight to the point of where to put your fingers which is what playing an instrument is. Rather than looking at a symbol seeing where it is on the line, converting it to a note and knowing where that note is on the fretboard.
I: Have you seen [synthesia]
P4: Yeah.
I: You can think of that as a different notations system as well, called a piano roll. How do you think that way of writing music compares to tab and standard notation?
P4: I like that it's a visual way of representing musica as well. So you have a whole sheet or something, it's the same as they use for musical boxes. And I guess it makes sense for piano but it's probably less transferable to most other instruments to be honest.
I: Do you have a favourite out of those three systems?
P4: In terms of me personally playing it?
I: Yes.
P4: Yeah, tabs.

P5 Pre-task Interview

I: How frequently would you say you listen to or play or write music? So that's the three different things.
P5: I think I listen to music every day. After I get up, and before I go to sleep, and also in between hours whenever I have a break. But in terms of writing it, I think, I occasionally do it. Maybe once or twice a month?
I: How often do you practice your instrument?
P5: Like, I recently got an electric guitar here. So I think I play it once a day, but not like official practice, so maybe for half an hour?
I: In terms of writing music. How do you conceptualise melodies in your head? Is it a structured way?
P5: I think there's no particular structure because I haven't learned properly how I can write the music or how I can understand it. So I usually come up with some writings first, and then try to convert it into a melody. So probably, I can say it's very much based on concrete meanings of the words. Yeah. The actual events that I know.
I: When you're writing stuff, how do you make a record of what you've written so that you don't forget it later?
P5: I think for now, I mainly use the voice recorder in my phone, or sometimes the recorder in my laptop. But I'm trying to find a more professional

way to learn.

I: Okay. Do you ever write it down in a notated form?

P5: Yeah, but since I am not familiar with writing musical notations, I just use a blank notebook just to make some notes about basic chord progression, or some basic melodies, but not much more than that.

I: In terms of traditional music notation, can you read and write it?

P5: Yeah I know how to read it, theoretically. And I used to play violin when I was young. So I know how to read it. But in terms of playing pianos or other instruments, for me it's more comfortable to memorise a piece rather than reading it.

I: What do you like and dislike about traditional rotation?

P5: I think it has some necessity and importance whether I like it or not. So I feel like it's the way of understanding and preserving the original piece. So in that way we can play exactly what the original composer intended with the piece. And also that makes it possible to interpret the music. So I think, yeah, it has more importance than my preferences.

I: Do you find it easy or difficult to read and write?

P5: Now it's not that easy for me to read and write. If I have a chance to learn more about it, then maybe I'll get there.

I: What do you think makes it not so easy?

P5: What I think, initially, is that I don't have much experience in reading it in casual or in any other situations. So maybe it's more about the time and effort that I need to put into it to memorise it.

I: Do you know the [piano roll]? You can think of that as a different way of notating music. Do you find that easy or difficult to understand?

P5: I watched tutorials on YouTube just to learn new pieces. It's really useful when you want to see how they actually move on the keyboard. I feel like maybe it's more like learning from an actual person. Normally it's hard to get a personal tutor or anyone who can like teach you next to yourself. But it can do the same.

I: Have you ever seen other ways to write down music? So that could be I guess, tab or weird things like graphical scores? What have you had experience with?

P5: I don't think I had a direct experience. But I saw someone who did some experiment about like, different, like, musical gestures you can use so I'm not sure if it's the same one. But like, yeah, I saw some exhibition about exploring different gestures in different instruments. So like, there were some tools that capture different motions, and then turn it into the sound directly. So like, there were Yeah, there are some different gestures we can use musically.

P6 Pre-task Interview

I: Do you have much experience with music writing?

P6: Not really, no. I mean I did sibelius at GCSE and stuff but yeah, I don't really write music.

I: Do you like music notation?

P6: I mean I don't really know anything different other than learning by ear, but it's fine. It's a faff to have to do all the lines and the dots and it takes a long time. No, I don't like it.

I: But you've been using it a long time right?

P6: Yeah

I: You know [synthesia], have you used that?

P6: No, I haven't used that.

I: So that's an alternative way of notating music. Have you tried to learn a thing using that?

P6: No. But it's kind of like Guitar Hero isn't it? SO I've done guitar hero but I've not tried to learn anything using it. I think it's closer to learning stuff by ear because you're not having to understand and read music. It kinda gets into your fingers better and you learn it better that way.

I: If you were to write something in that way, do you think it would be more intuitive?

P6: Not for a violin. But I think maybe for a flute it would be.

I: Why is that?

P6: Because for violin you have all the different strings and positions and then you have double stops and then you have chords and there's just a lot to read on a page. I feel like it would get too difficult to read.

I: Do you have any experience with any other weird notational systems, like graphical scores or tab?

P6: No I don't.

P7 Pre-task Interview

I: How often would you say you listen to / play / practice / write music? And those are three different questions. P7: Okay, listen to? Every day, almost every day. What was the next one, play? Probably like, five days in the week. If you average it out. What were the other ones? I: Right. How often do you write music? P7: Um, I don't know. Like probably, I don't know, one time in a month or something like that. I: Okay, that's a fair amount. Okay, yeah, P7: I don't know. It happens occasionally. I: You say it happens. Like it's not a choice. It's just something that happens to you! P7: I seldom set out to do it, but I'm not trying to be like, "Oh, the song's just arrived!" I mean, I just, you know, sometimes I'd be like, Oh, that sounds quite nice. Let's make that into a song. I: Okay. So when you're writing and you're thinking of melodies, how do you approach that or conceptualise it? Is there a structured thing to it? Or is it freeform? How do you imagine it in your head? P7: Unless I was like, doing some kind of GCSE music prompt situation, in which case it might be a bit deliberate. If it was a song kind of situation, I'd think of the phrase of the words first, and then find some kind of melody that works with that. Or if it was an instrumental kind of situation, it'd be more likely to come from some interesting chords. I: And then when you're thinking of these ideas, how do you record them so you don't forget them later. P7: Sometimes I forget them. Voice Note kind of situation, or sometimes if it's instrumental video so that I can. Sometimes I'll write the words down and hope that I remembered the melody later. But that actually doesn't work. I: Do you ever write things with actual sheet music? P7: I haven't done this for a while, but if it's for something that would be for an ensemble, then yeah, I'll use sheet music and generally that'll be scrappy bits on paper while I figure it out, and then MuseScore or sibelius back when I was at college, and they had sibelius. That's also a long time ago. I: Moving onto the notation stuff, what parts of it do you like / dislike? On the whole do you like it? P7: Yeah, I mean, I use it all the time. So, you know, it works. You can read it, other people can read it. Drawing the stave is annoying. The fact that you have to draw a stave, and it takes up quite a lot of space in general. And it took me a hot minute to learn how to use MuseScore, but I've got the hang of it now! I: On the whole, do you think it's an efficient way of representing musical ideas? P7: I haven't seen many other convincing ways to do it. In terms of the fact that you can print it and all that kind of thing. You know, it works for the kind of communications systems that we use in general. But yeah, I mean, it's a little bit bulky and if you can't read it, you can't read it. I: Do you think it's intuitive? P7: I mean,

I was taught sheet music when I was about six. So, you know, I've been reading it almost as long as I can read. So for me yeah. But when I was teaching it to other people, I think some people picked it up a lot quicker than other people. I: Okay. Moving away from that, you know, in musical production software, when you want the computer to play a melody for you, you will put notes in the piano roll using MIDI and that sort of thing. Yeah. Are you familiar with that? P7: Like when you've got your sort of piano down the side, and you put your squares where you want them to make a sound. I: So that's called a piano roll. You can think of that as a different form of notation, if you wanted. In terms of writing and reading that, how do you think that compares to regular rotation? P7: I mean, in terms of the fact that the notes are like very visual lengths, and they are up or down, I think you could definitely argue that it's more intuitive. Probably very intuitive if you play the piano, but if you don't, not so much. And also, it would probably not be very good for reading in a sight reading setting. I can imagine it would get very big very quick. I: What do you mean by that? P7: Like in terms of how much space it takes an amount of information, I would presume it would come up bigger. Yeah, it would come up bigger because you need a piano size. You need a lot of notes. I: Last question. Have you got experience with other notational systems like, tab, or even wacky things like graphical scores, etc? P7: Oh yeah, I'm familiar with tab. Really accessible and intuitive, although actually my dad finds it difficult to read. I mean, it's a lot more obvious to learn without somebody teaching you. But there's a lot of different places you can get notes on the guitar, obviously, and tab only gives you one option of those which I don't think is very good.

Appendix C

Post-task interview transcripts

P1 Post-task Interview

I: What device did you use to use the app?
P1: My Phone.
I: How easy was it to access and start using the app?
P1: Very easy. Once I had the app running, yeah, it was just tapping on it.
I: How engaged were you with the app?
P1: How engaged? Well I was very puzzled to start with, so I felt like I needed to understand it, to unravel it if that's the right word. I think I spent most time or in the first two sessions maybe - the first time I accessed the app was just to see if it was working, if I could access it. And I think the second or third time I was thinking, "Oh, what's going on here?" So I was engaged trying to understand what was going on. Yeah, quite engaging.
I: How much time do you think you spent each day?
P1: Maybe between 15 to 30 minutes.
I: What was your favourite part of the app and why?
P1: My favourite part was to reproduce the sound because that was the end result. I also liked to play with the patterns and the shapes to photograph, and in try to test different things to take photos of. The whole thing was quite fun.
I: What was your least favourite part of the app?
P1: Alright, well, the least favourite part is probably to do with my lack of understanding of music, because I tried to play with the pitch and the tempo, but because I don't understand music I couldn't quite get it. It was a bit of a mystery. I enjoy playing with it and seeing what's happening and the difference it's making but even when I could perceive some difference between one setting and another I I wasn't quite sure what that meant. You know when you [use] snap I could see that something was changing when I had it on or off but I couldn't quite get what it was. I even googled it to see if I could understand it better and I think I have a rough idea of what it does, but very rough. So I couldn't enjoy that bit, but probably because I don't understand it. Kind of beyond my musical appreciation or knowledge.
I: Do you think it could have been made more clear if it was presented in a different way?
P1: Well, I don't know. I think it will be difficult to- because I am assuming the app is directed to people with a certain level of musical knowledge, you wouldn't want to explain what snap is would you? I don't think it is the way it is presented. It's just my basic knowledge is lacking really, for making music, for producing sounds. I don't I don't criticise the app. I don't have any suggestions to improve the app. I just think because I never made music- I just listened to music, and I play a little bit of- I repeat, you know, I copy, I imitate, I mimic music on the ukulele. But I don't really understand the language and how to reason with it.
I: Did you manage to make anything that you were proud of?
P1: Oh, I think so. But then again, it is also to do with getting more familiar with the app. I think I will spend more time with Snap to enjoy it. I realised that the bottom right square was a percussion icon. But with the others it wasn't quite clear to me what they were, in terms of what is producing the sound, it was all very electronic. Anyway, then in the last session, or the last two sessions or something, I realised that I could play them all together! Previously I was just doing one at a time. And then I think at some stage, I tried to see if I could use the same photograph to use the different squares, but I couldn't. I realised I couldn't test the app that way. But I did test all the instruments, separately with patterns. But then at the end, in the penultimate session, I realised that I could play them all together! Because I had taken different photographs and left them there - I didn't clear them - And then I realised that when I went to the home the patterns were still there. I pressed play just to see what happened, and they all played together. I was elated!
I: Glad you made that discovery.
P1: I didn't realise that I could do that. And also, I quite liked the sound that came out together.
I: Did the fact that you couldn't save a tune, change the way that you use the app?
P1: I suppose I felt like I needed to start from the beginning. Well, it was fresh all the time. I suppose yes, because every time I kept on having a different pattern, and exploring more what different patterns would produce. It maybe also made me explore the app a bit more. Because I couldn't save, I wouldn't go to the app just to play what I had done the time before. I wouldn't go back just to play something I'd already done.
I: Could you predict the melody that would be generated from a particular line?
P1: No, I didn't get to that point. One of the prompts you made was to produce a sound that you like. And I was thinking, "hmm. That requires

me to have understood the app to make the app work for me." And I didn't get that point yet. I did try to make patterns on the paper in a specific, definite position of the graph. For example, I should have done just one dot and see what sound the dot does, and then change the dot position or something. I did try that, but I still could not understand what was going on. I don't think I am familiar with the app enough to control the lines to produce a sound that I want. At this stage, I have no idea of what sound it's going to make.
I: Were you able to form any sort of conception of how a line would turn into sound? For example, when you press play it reads the line from left to right.
P1: Yes.
I: And did you identify that the height of the line made a higher pitched sound?
P1: Oh, yes. In that sense, Yes. Because I put the dots in different positions, lower and higher, I did get that. That there was a lower and a higher note or pitch. But yeah I realised that it was lower and higher when I controlled the pattern. When I put, you know, like small dots on a piece of paper. But I couldn't identify notes or how to produce notes.
I: If I drew a line on a bit of paper and scanned in, do you think you might be able to roughly sing what, what the output would be? Roughly?
P1: No. But remember, you know, my brain doesn't work musically. So I don't know, maybe I even could! If you give me the line on the graph and tell me to reproduce the sound now, I wouldn't be able to.
I: Did you like this way of writing music?
P1: If it is writing music, I feel very proud of it. But because I don't think I'm quite in control of it, probably because of my limitations, I don't feel like I'm writing music. But I'm playing with it? Which might be just the same, but it is random. At this stage, it feels all very random. I wouldn't need to explore it a little more to see how it works. To see the pattern you see. I don't think I can quite see a pattern there. Everything I'm doing is quite random. Even when I put the regular dots on a piece of paper and photographed them, I still can't link all the different things that are happening there, but I like what comes out of it. So I would say that I'm still exploring what the app does and trying to find out or work out what is going on. If I can ever do that.
I: Did it make you think about music in a different way?
P1: Well it does, because if you call that writing music. That's very interesting. If you gave me sheet music now and asked me to write music.,I could put dots on the lines, but it would be all random dots. Okay, so I think that's what I'm doing with this app. At this moment, I think It's equivalent to you giving me a piece of paper with the lines of conventional music writing and I wouldn't even remember where the notes go because I can't read music. But I would put dots on the lines. And then you could play those dots, and that was it. And I would still not be able to control that. It will be all very random. But with the app, at least I can see it happening. If I could save it, then I could use a certain sequence of lines and then make another sequence of lines and compare them and then maybe learn how to control the app. But I didn't get to that stage.
I: At this point, I'm going to ask you about each prompt. Did you do all the prompts?
P1: Yeah.
I: So the first one was to familiarise yourself with the app and make a song that captures the mood. Where were you when you did that?
P1: I was at home in my sitting room, I think.
I: Did you find it easy or Challenging?
P1: Challenging. It was all very mysterious when I first got in. I thought "what is going on here?" But it was easy to use, it was easy to execute. If that's what you mean.
I: It was easy to execute what?
P1: The app and the actions, like take a photo and minimise blemishes, etc, etc. And then, and then play. So that was easy, but I found it difficult to understand what was going on.
I: Did you enjoy the outcome of the first day?
P1: Yes. I suppose because it made me feel puzzled.
I: And did you enjoy whatever musical results you ended up with?
P1: Not really. I think I just produced noises really.
I: The second prompt was to use the app while out and about or travelling? So where did you decide to do that?
P1: Yeah, I didn't do that. Because I don't have data. You need WiFi.
I: That's a good point.
P1: Sorry about that.
I: That's good for me to know. That's something I hadn't considered when I designed the app. So the third prompt was to use something other than pen and paper for the basis of your sequence.
P1: I think I started by not using pen and paper. I started by photographing patterns - you know the crossword? That was the first one I think. And then I tried the rug. For some reason the rug didn't work because it was all black. Maybe it was the phone not working or something.
I: Did it not work when you moved your finger up and down on the image to change how it looked.
P1: What about it?
I: Could you not make it not black?
P1: Oh I see. No, no, I had photographed the pattern on the rug. And it was all black. I needed to move the finger. Oh, no, I didn't do that. I thought maybe there was a problem with the shade or the pattern with the camera or something. I think I was expecting to see the pattern visible in black and white first and then play with moving the finger. And then when it was all black, I thought it went wrong, so I didn't try to move my finger up and down.
I: What did you find easy or challenging about the third prompt?
P1: Oh, I thought it was very easy. And it was quite curious and stimulating. Yes, because different patterns will produce different lines. I was thinking "why did that pattern produce these lines?" But anyway, taking pictures of patterns was good. But at the same time, because it didn't use pen and paper - I started with patterns, It was all very mysterious and random. And I couldn't understand what was going on. So then I went to pen and paper trying to control the pattern to see if I could understand better. Maybe I got myself confused because I started by the most complicated or random pattern rather than a regular controlled pen and paper produced one.
I: Did you enjoy the outcome for the prompt?
P1: Yes. Yes, I did.
I: Did you enjoy it musically?
P1: No, they were not pleasing or anything but I produced the sound. I made the sound sequence, so that was fun. But I wouldn't record it and play it again to inspire me or anything like that, because it was all too random.
I: The fourth prompt was to try and recreate a song that you like. I think you touched on this already.
P1: Ss I said the last two times when I realised I could play all the four instruments together, and I had used patterns that I had organised on the pen on paper myself, I felt I was more in control. And although the sound is not really a piece of music that I would want to listen to over and over again. It felt pleasant, because I didn't know what was going to happen with that pattern. But I did it. So I'm still kind of trying to make sense

of it. So I made the patterns. And I play them. And then I realised that I could play them all together. So I discovered quite a lot in the last two sessions. And I liked the sound that it made because it was an all together sound.

I: Okay, for the fifth prompt, that was to use the app however you'd like to to make something cool. So how did you end up using that app for that?

P1: Well, that is as I said to you, the last two sessions.

I: Were you mostly taking pictures of lines that you'd drawn or just anything in the room?

P1: lines that I drew.

I: Did you enjoy what you came up with?

P1: Yes.

I: Which prompt was your favourite and why?

P1: The use of different patterns, try to photograph different things. The third prompt. Because it was more explorative I guess.

I: Do you think you learn anything about music writing and melody?

P1: No.

I: Okay. So you can read a bit of sheet music. Were you able to apply whatever knowledge you have to using the app at all?

P1: I didn't try during this experiment.

I: In terms of taking your understanding of how notation looks and how it corresponds to sound, did that inform any of what you do with the app?

P1: No, I didn't try to make the connection. Maybe I should have. You're now prompting me to do that!

I: Do you think the app could be useful in the musical setting? And if so, how?

P1: Oh, yes. I was thinking, you know, you could have a musician in a concert, for example, and have an interactive concert. I thought about that kind of thing. I guess the public can come up with some stuff, and then send it over and then somehow, the musician can control that in a way that produces something that is appreciated. And then, and then the public will see that they contributed to the final sound produced.

I: Could you imagine that might be useful for a musician on their own trying to write a song?

P1: Yes, I would imagine so,

I: How do you think they might use it?

P1: Well, if they do understand how the app works, and how to link the sound they have in their heads or the sound they're expecting with a pattern. You could just play with patterns. Another thing was, you could have a visual artist with some knowledge of music and the app producing visual art that then,is translated into sound. You can have an art exhibition, for example, with sound at the same time.

I: I have no more interview questions actually. So is there anything you would like to add?

P1: I think I just need to play with it more. And discover a bit more. I will try to link the traditional music writing lines with your lines, because I haven't done that.

P2 Post-task Interview

I: What device did you use to use the app?

P2: My laptop.

I: Just your laptop?

P2: Yeah, I did try on my phone, I think the first day, but then I switched my laptop.

I: Why did you switch?

P2: I thought it was easier to like to use the UI on a bigger screen.

I: Okay. Can you elaborate on that?

P2: Just from like, just from my point of view, it seemed easier. With the layout, to have it all on the screen in laptop ratios.

I: How easy was it to access and start using the app?

P2: Very easy. Once you've given me the link to the app, it was pretty damn clear how to use it.

I: How engaged were you with the app? That's quite a broad question. So things you could say are like, did you miss a day? Or did you continue past the time that was suggested? Or that kind of thing?

P2: I didn't do it five consecutive days, just because I was coming back to uni and travelling and things like that. But when I did use it, I did use it for quite a while, I think probably between the recommended time. So like 15 minutes or so.

I: What was your favourite part of the app and why?

P2: ThI think it was the fact that when you took one photo, you could kind of build the photos, build the music in sequence from that origin one. So like, say you started with the drum, you could then choose one of the other three to like, build into that.

I: What was your least favourite part of the app?

P2: Sometimes when you took a photo, even if it was on white paper, sometimes it would recognize dark areas on the paper as part of it. So it was hard to get a clean line that you wanted.

I: Did you manage to make anything you were proud of?

P2: I was having a lot of fun with it. I wouldn't give out to the public what I was making. That's from my untrained skill.

I: Did the fact that you cannot save a tune change the way that you used it at all?

P2: I don't think so because I wasn't trying to make anything to distribute or show off. I think if I was trying to use it actually to create music for everyone to see, it would have made it a lot harder

I: Could you predict the melody that might be generated from a particular line?

P2: After a while of using a go easier, yeah. When I first started out it was a bit of guesswork. The more I got used to using it, the more I was able to see which lines would make which melody.

I: Did you enjoy this way of writing music?

P2: Yeah, I found that it kind of turned into a bit more of a game, a more interactive way of doing it. As opposed to like- I don't have much experience in writing music, of course. But I felt it was quite an easy way to do it. And for someone without much experience, it kind of gave the basics and an introduction to it in quite a nice way.

I: Did it make you think about music in a different way?

P2: Yeah to be fair, over the five days, when I was listening to music at the gym, or anything like that, I could start to start to pick out a bit more of the beats going on behind the music. So the drum instrument on the app, I think that was the clearest one to use. But when I was listening to songs, I'd be like, "Oh, that's a cool drum beat in the background."

I: Why do you think that drum instrument was the clearest to use?

P2: I didn't really know. The other ones were less obvious. With the drum, you kind of knew what to expect. And you knew how it would sound, in a way. And with the other ones, once you started using them, you knew what they were. But from the beginning, you didn't really know what they sound like.

I: At this point, I'm going to ask for some feedback for each individual prompt. The first prompt was to familiarise yourself with the app and just try and make something that captures the mood. Where were you when you did that one?

P2: I was at home.

I: What did you find easy or challenging about the first prompt?

P2: I think getting used to all of the settings and the different ways you could play with it.

I: Was that easy or challenging?

P2: Figuring out what everything did was a little bit challenging, but then it got easier.

I: Why do you think it was tricky?

P2: Because I'm not very experienced in music. So kind of having to look through and see what everything did to the rhythm and melody was interesting. Not in a bad challenging way. It was just interesting to see what everything was doing.

I: Did it become clear what each option would do on experimentation?

P2: Yeah.

I: Do you think it was the visuals or the audio that made it more clear what was happening?

P2: I think it was the audio, because you could have it repeating as you were playing with the metronome and stuff like that. And with the speed, having it repeating as you were changing stuff was really useful.

I: Did you enjoy the outcome of the first day?

P2: Yeah, I mean, I thought it was a really good app to explore around and see where everything was.

I: The second prompt was to use the app while out and about or travelling. So where were you when you did that one?

P2: I think I was on a walk. That was the day I used my phone, I think.

I: What did you find easy or challenging about that?

P2: Because I was out and about it was a little bit more difficult to have a piece of paper to write anything on. But it was easier to take interesting photos to see what they did.

I: Okay, what sort of photos did you take?

P2: I was taking landscape photos or photos of the street and things like that.

I: Did you enjoy the outcome of this?

P2: Yeah, it was cool to see how the app reacted to less standard photos.

I: The third prompt was to take a picture of something weird for the basis of your sequence. Where were you when you did that one?

P2: In my room.

I: What did you find easy or challenging?

P2: Because I kind of experimented a bit on day two, when I was out and about, finding something weird and new to challenge the app to see what it did was a bit challenging. Obviously, once I'd decided what I was going to use it was easy, but it was trying to find something weird enough that the app would play with it a bit.

I: What do you mean by that?

P2: Well, I was trying to find anything that would make weird shadows or just like a strange object that I own to put in front of the camera.

I: What things did you end up taking pictures of?

P2: A little statue of Poseidon I own. I thought that would be cool. And a little little Lego Darth Vader helmet, because it's dark. So I was wondering what it would do with that.

I: So did you enjoy the outcome of those?

P2: I did.

I: The fourth prompt was to try and recreate a song that you like, how did that go?

P2: Not the best. I was trying to do the Imperial March, because I thought it was quite a basic melody, like a very obvious tune to recreate. So it was interesting to try and do that.

I: So how did you go about tackling this challenge?

P2: I was trying to think about the melody in my head and then kind of draw out on paper, using dots and lines and things like that, to try and get the app to use that for the melody.

I: Was that successful?

P2: Yeah, it was semi successful, I'd say.

I: How close did you get?

P2: There was a moment where you could half recognize what it was attempting to be. I think that that's probably more me than anything.

I: What did you find easy or challenging about this?

P2: I think the most challenging bit was just trying to get that melody down for the Imperial March. And then the easy thing was, once I'd realised that paper was the way to do something like that, It made it quite a lot easier.

I: So was the hard part conceptualising the melody in your head, or was the hard part communicating that melody to the app?

P2: I think it was communicating to the app just because I don't write music. And trying to tell it what I want to do was difficult.

I: Did you enjoy the outcome of the prompt?

P2: I did. It was funny seeing what "my" Imperial March was.

I: And then the last prompt was to use the app however you like to make something cool. What did you end up doing for this prompt?

P2: So for this, I took a photo of a little stuffed animal I have on my bed for the drumbeat and then I tried to play with the others to try to make some semblance of melody.

I: Were you using pen and paper for the other ones?

P2: Yeah, I was. So I took an interesting photo for one of them and then tried to make up a melody that would go with it.

I: Did you enjoy the outcome of that?

P2: Yeah, I thought it was really interesting, almost like a puzzle, to try and make something good.

I: What did you learn about music writing and, and melodies?

P2: It's harder than I thought, was my impression. But I learned that anything can be a melody, you just have to play with it enough that it sounds good.

I: What do you mean by play with it?

P2: Like adjusting the settings in the app and using the slider options to try and make the notes clearer and things like that.

I: So with the slider options. Do you feel overall that it helps you make something that you enjoyed?

P2: Yeah, I did.

I: Did it at all feel like the output was less of your creation? After having used these options?

P2: Not really. No, I thought. I thought it was just kind of an aid. It took something that I'd taken a photo of and tried to help me make it, more than anything.

I: From what you remember about sheet music, how did this way of writing music compare to that?

P2: Kind of was using my memory of sheet music, to try and place notes. To try and construct the melody I wanted.

I: Were you able to transfer that knowledge that you had to help you?

P2: Yeah.

I: In what ways were they similar and in what ways were they different?

P2: I think sheet music is harder to visualise, and obviously [the app is] something that plays an audio recording for you. So the app was kind of clearer, as you're making the melody what it's gonna sound like,

I: because it was paying it back to you?

P2: Yeah. And with sheet music you have to play each bit individually, and then build it up and see what it sounds like. So yeah, so I think I

prefer the app for that.

I: Last question iP4: Do you think the app could be useful in a musical setting?

P2: I do, Yeah.

I: What sort of setting?

P2: I think it would be a cool teaching tool because I know it helped me think about melodies more and how to construct them. So I think if you were trying to show people an example of how constructing music is done. You could use this app quite well.

I: That was the last question. Is there anything you'd like to add?

P2: I don't think so.

P3 Post-task Interview

I: What device did you use to use the app?

P2: My laptop.

I: Just your laptop?

P2: Yeah, I did try on my phone, I think the first day, but then I switched my laptop.

I: Why did you switch?

P2: I thought it was easier to like to use the UI on a bigger screen.

I: Okay. Can you elaborate on that?

P2: Just from like, just from my point of view, it seemed easier. With the layout, to have it all on the screen in laptop ratios.

I: How easy was it to access and start using the app?

P2: Very easy. Once you've given me the link to the app, it was pretty damn clear how to use it.

I: How engaged were you with the app? That's quite a broad question. So things you could say are like, did you miss a day? Or did you continue past the time that was suggested? Or that kind of thing?

P2: I didn't do it five consecutive days, just because I was coming back to uni and travelling and things like that. But when I did use it, I did use it for quite a while, I think probably between the recommended time. So like 15 minutes or so.

I: What was your favourite part of the app and why?

P2: ThI think it was the fact that when you took one photo, you could kind of build the photos, build the music in sequence from that origin one. So like, say you started with the drum, you could then choose one of the other three to like, build into that.

I: What was your least favourite part of the app?

P2: Sometimes when you took a photo, even if it was on white paper, sometimes it would recognize dark areas on the paper as part of it. So it was hard to get a clean line that you wanted.

I: Did you manage to make anything you were proud of?

P2: I was having a lot of fun with it. I wouldn't give out to the public what I was making. That's from my untrained skill.

I: Did the fact that you cannot save a tune change the way that you used it at all?

P2: I don't think so because I wasn't trying to make anything to distribute or show off. I think if I was trying to use it actually to create music for everyone to see, it would have made it a lot harder

I: Could you predict the melody that might be generated from a particular line?

P2: After a while of using a go easier, yeah. When I first started out it was a bit of guesswork. The more I got used to using it, the more I was able to see which lines would make which melody.

I: Did you enjoy this way of writing music?

P2: Yeah, I found that it kind of turned into a bit more of a game, a more interactive way of doing it. As opposed to like- I don't have much experience in writing music, of course. But I felt it was quite an easy way to do it. And for someone without much experience, it kind of gave the basics and an introduction to it in quite a nice way.

I: Did it make you think about music in a different way?

P2: Yeah to be fair, over the five days, when I was listening to music at the gym, or anything like that, I could start to start to pick out a bit more of the beats going on behind the music. So the drum instrument on the app, I think that was the clearest one to use. But when I was listening to songs, I'd be like, "Oh, that's a cool drum beat in the background."

I: Why do you think that drum instrument was the clearest to use?

P2: I didn't really know. The other ones were less obvious. With the drum, you kind of knew what to expect. And you knew how it would sound, in a way. And with the other ones, once you started using them, you knew what they were. But from the beginning, you didn't really know what they sound like.

I: At this point, I'm going to ask for some feedback for each individual prompt. The first prompt was to familiarise yourself with the app and just try and make something that captures the mood. Where were you when you did that one?

P2: I was at home.

I: What did you find easy or challenging about the first prompt?

P2: I think getting used to all of the settings and the different ways you could play with it.

I: Was that easy or challenging?

P2: Figuring out what everything did was a little bit challenging, but then it got easier.

I: Why do you think it was tricky?

P2: Because I'm not very experienced in music. So kind of having to look through and see what everything did to the rhythm and melody was interesting. Not in a bad challenging way. It was just interesting to see what everything was doing.

I: Did it become clear what each option would do on experimentation?

P2: Yeah.

I: Do you think it was the visuals or the audio that made it more clear what was happening?

P2: I think it was the audio, because you could have it repeating as you were playing with the metronome and stuff like that. And with the speed, having it repeating as you were changing stuff was really useful.

I: Did you enjoy the outcome of the first day?

P2: Yeah, I mean, I thought it was a really good app to explore around and see where everything was.

I: The second prompt was to use the app while out and about or travelling. So where were you when you did that one?

P2: I think I was on a walk. That was the day I used my phone, I think.

I: What did you find easy or challenging about that?

P2: Because I was out and about it was a little bit more difficult to have a piece of paper to write anything on. But it was easier to take interesting photos to see what they did.

I: Okay, what sort of photos did you take?

P2: I was taking landscape photos or photos of the street and things like that.

I: Did you enjoy the outcome of this?

P2: Yeah, it was cool to see how the app reacted to less standard photos.

I: The third prompt was to take a picture of something weird for the basis of your sequence. Where were you when you did that one?

P2: In my room.

I: What did you find easy or challenging?

P2: Because I kind of experimented a bit on day two, when I was out and about, finding something weird and new to challenge the app to see what it did was a bit challenging. Obviously, once I'd decided what I was going to use it was easy, but it was trying to find something weird enough that the app would play with it a bit.

I: What do you mean by that?

P2: Well, I was trying to find anything that would make weird shadows or just like a strange object that I own to put in front of the camera.

I: What things did you end up taking pictures of?

P2: A little statue of Poseidon I own. I thought that would be cool. And a little little Lego Darth Vader helmet, because it's dark. So I was wondering what it would do with that.

I: So did you enjoy the outcome of those?

P2: I did.

I: The fourth prompt was to try and recreate a song that you like, how did that go?

P2: Not the best. I was trying to do the Imperial March, because I thought it was quite a basic melody, like a very obvious tune to recreate. So it was interesting to try and do that.

I: So how did you go about tackling this challenge?

P2: I was trying to think about the melody in my head and then kind of draw out on paper, using dots and lines and things like that, to try and get the app to use that for the melody.

I: Was that successful?

P2: Yeah, it was semi successful, I'd say.

I: How close did you get?

P2: There was a moment where you could half recognize what it was attempting to be. I think that that's probably more me than anything.

I: What did you find easy or challenging about this?

P2: I think the most challenging bit was just trying to get that melody down for the Imperial March. And then the easy thing was, once I'd realised that paper was the way to do something like that, It made it quite a lot easier.

I: So was the hard part conceptualising the melody in your head, or was the hard part communicating that melody to the app?

P2: I think it was communicating to the app just because I don't write music. And trying to tell it what I want to do was difficult.

I: Did you enjoy the outcome of the prompt?

P2: I did. It was funny seeing what "my" Imperial March was.

I: And then the last prompt was to use the app however you like to make something cool. What did you end up doing for this prompt?

P2: So for this, I took a photo of a little stuffed animal I have on my bed for the drumbeat and then I tried to play with the others to try to make some semblance of melody.

I: Were you using pen and paper for the other ones?

P2: Yeah, I was. So I took an interesting photo for one of them and then tried to make up a melody that would go with it.

I: What device or devices did you use to engage with the app?

P3: Well, I tried to use my phone, but that didn't work so well. So I also did it on my laptop.

I: Was it better on the laptop?

P3: It was a little bit - well. yes and no.

I: Can you explain?

P3: Well, [the laptop] didn't have any glitches. However, the user experience was definitely worse with having to put up my drawings to the laptop camera, rather than taking the pictures on my phone. Functional improvement but the user experience was worse.

I: How easy was it to access and start using the app?

P3: Very easy.

I: How engaged were you with that app? Did you use it for a long time? Did it capture attention? Did you get bored quickly? Did you miss a day, etc.

P3: I feel like I would have missed a day if you hadn't reminded me. Once it was open, and if I didn't have anything else that I was doing, it was quite engaging. I feel like some of the frustrations of using it made me not as engaged as I could have been.

I: What were those frustrations?

P3: I've talked to you about it before but - for the record - on my phone, and you think it's a problem with the memory, after a few minutes or 5 - 10 minutes of using it and putting in too many inputs, it started sounding all funny. Which meant I couldn't use it on my phone for more than about 5 - 10 minutes at a time, which definitely reduced my engagement. And then further from that, the consequence of having to awkwardly put my images up to my laptop screen also reduced my engagement because the functionality wasn't there.

I: What was your favourite part of the app, and why?

P3: I really enjoyed the fact that you can take pictures of random things and it translates it into sound, because I haven't seen that before. I think that's quite neat.

I: What was your least favourite part of the app and why?

P3: The fact that it doesn't work well on my phone is partly it. And I think the fact that you can't edit your sound very easily without taking a completely new picture is quite annoying for someone who has used some sorts of music programs before. I.e. it doesn't make a nice MIDI bar that you can slide around. If you want to change your tune, you have to try and draw out your image again but changing it slightly. If you want to change one note.

I: Did you manage to make anything you were proud of?

P3: No.

I: Did you have any fun or even slightly musical outcomes at all?

P3: Yes.

I: Okay. What did you do to get that outcome?

P3: I took pictures of regular shaped things and saw what sounds they made. I did one of my sash windows in my room, and for some reason the interval between them was quite a pleasant chord, which I was able to turn into something like a very short ringtone kind of song, which was quite pleasing. However, the fact that I couldn't slide around the drum beats, like I was saying, made me not like it as much as I could have. But it was still quite interesting.

I: Regarding the editing, was it? Was it most annoying for any particular instrument?

P3: Well, the notes were definitely the most [annoying]. So the synths. Yep, definitely more annoying for that.

I: Okay. Did the fact that you couldn't save anything within the app changed the way you use it?

P3: Yes. In conjunction with other reasons, I used the app for shorter intervals of time, more often than I would if I could save it. If I could save it I would use it for longer but fewer times.

I: Any point did you keep a drawing that you liked or made note of something you took a picture of that you liked, and then reuse it again on a different day?

P3: Oh, no, I didn't. I didn't even consider reusing one of my drawings to adapt from.

I: Do you think you could predict the melody that would be generated

from a particular line?

P3: Somewhat. I could to a medium accuracy predict the intervals between the notes after a while of using it. I was much less good at predicting the actual pitches of the note, like the actual starting pitch of where the melody would begin. If I wanted to start the melody on a particular note I couldn't do that very easily. That was much more difficult.

I: Do you like this way of writing music?

P3: For doing full songs, no. For little, sort of inspirational, like "Oh, that's a cool little melody", or "that's a funky chord", yes. It's much better for producing ideas than it is for writing a full song.

I: Did using the app make you think about music in a different way?

P3: I don't think so.

I: At this point, I'm going to look for a bit of feedback based on each prompt. And I'm gonna ask you a similar set of questions for each of them. So for the first day, the first prompt, I think you're asked to familiarise yourself with the app, and just make something that captures the mood. Where were you when you did it and what device did you use?

P3: I was in my room at home and I used my phone.

I: What did you find easy or challenging about it?

P3: I found it very easy to get it working and to get a feel of what each different panel, what each different instrument did. It was very intuitive - the process of transferring your drawing - that was very easy. Difficulties included the crunchy funny noise issue after a while. The main thing we came up with from the first one.

I: Did you enjoy the outcome of the first day?

P3: I didn't enjoy the music that I made but I enjoyed the whole experience.

I: Moving on to the second day, I think I asked you to use it while out and about or travelling.

P3: This one I did while still at home, I just went outside. I took a picture of the car because I was doing something with the car and I made something based on that.

I: What did you find easy or challenging about using it outside?

P3: Well, same things as I mentioned. I found the sliding feature of when you focus on the lines that you want to use, worked less well with very shiny things like the car windows. But with a little bit of fiddling it worked out. For easier things, using it outside, obviously it's on your phone and you can just take your phone out of your pocket, take a picture of something. Or if you've got an idea, you can very quickly take out your pocket and it's very easy to do on the move, as opposed to a more complex program. I guess that's easy.

I: Did you enjoy the outcome of the second day?

P3: Again, I didn't enjoy musically the things that I made, but It was interesting.

I: The third prompt was to take a picture of something weird for your sequence.

P3: This was my sash window one, where I have the Venetian blinds at the top. So it's like window blinds and then sash windows with the keys and stuff on it.

I: What did you find easy and challenging on your third day?

P3: I found that the process of taking a picture and finding cool sounds very easy. And then challenges? As I mentioned, there's no functionality of sliding your note or editing your notes or your image after you've already taken the picture. Which meant that I couldn't get I couldn't get my song to sound quite like I wanted it to.

I: Did you enjoy the outcome of that day?

P3: Yes, musically, I enjoyed that one much more than the other two.

I: Can you think why?

P3: Well, I think I chose the right thing to use as my picture happened to make a very pleasing sound. I guess as a result of that, because it was pleasing to me to start with, I spent longer on it on that day than I did on the other two. So that probably made a difference, yeah.

I: Day four was to try to recreate a song that you like. How did this go?

P3: Very poorly. I couldn't really do this one at all. I'll be honest.

I: Did you do this at home as well?

P3: Yeah. At home as opposed to out and about

I: What did you find easy or challenging about trying to recreate a song?

P3: The fact that you don't know what notes your tune is necessarily going to start on when you take the picture makes it very tricky to make your song sound like the actual song. And on top of that, the fact that you can't, unless you use this app a lot, you can't predict the intervals very well either. Like, maybe either 60 or 70 percent, interval prediction accuracy. Which makes some semblance of the tune, but basically made a different song to what I was intending.

I: Did you enjoy the outcome?

P3: Musically no. But I found it an Interesting challenge.

I: Last prompt was Use the app however you'd like to make something cool. So how did you find that?

P3: I don't think I did this one specifically.

I: No. Did you use it at all after the other prompts?

P3: I used to after that. But not with the goal of being like "I want to make something cool". I was just messing about with it and going back on things I've already tried to do. As opposed to having the goal of trying to make something cool, because at this point, I figured I probably wouldn't end up with something that I would find musically satisfying.

I: How did you end up using it?

P3: Mostly, I'll be honest, I tried to make a recognizable real tune again. I did quite a lot of that. Which didn't go very well. Apart from that, I took pictures of lots of random things just to see what they would sound like, because that was just sort of quite interesting. Yeah, that's mostly how I ended up using it other than the other prompts.

I: Was the app as a whole easier or harder to use than at the start.

P3: Easier?

I: Significantly?

P3: Not significantly.

I: What do you think changed that made it slightly easier?

P3: I think I got better at predicting what melody would make out of my lines, the more I used it,

I: How would you compare this notation system to other ones that you've used? Like sheet music or tab, or piano roll?

P3: More interesting, but much less accurate. That's how I would describe it.

I: Would you rather try and write something down in sheet music notation or using this?

P3: If I wrote a melody that I wanted to write down, I would definitely use any other kind of notation.

I: How able were you to apply knowledge about other notation systems to this?

P3: Pretty well, I think. Not the sheet music or the tab. But when I was trying to recreate melodies I was comparing it to piano roll or some sort of MIDI notation, trying to imagine what that would look like to try and get the tune. So those two are quite transferable.

I: How do you think you would use that app, if you are going to set out to write music?

P3: If I was going to set out to write music, I would use the app more as inspiration.

I: Okay. Can you elaborate on that?

P3: So I really enjoy taking pictures of just random things and seeing what sound it would make. Or seeing what melody would happen. And then I would prefer to take that melody and put it into some other notation to play on another instrument so I could go and tweak the notes or tweak whatever chord it's making or that kind of thing.

I: And if you were a musician that had to write music, do you think you would use this as a tool?

P3: I think I might use it as a tool, but not for any kind of noting down of the music that I'm making.

I: That's the end of the questions. Is there anything else you would like to add?

P3: No, I don't think so. It was a very interesting experience. I've never played with anything quite like it.

I: Thank you very much. I'm going to end the recording.

P4 Post-task Interview

I: Which device did you use to use the app?

P4: My laptop and my phone.

I: Was it different per day? What made you change which you used?

P4: It just depended on if I had my laptop in front of me or my phone in front of me.

I: How easy was it to access and start using the app?

P4: Pretty easy, because I just went on to the chat, because you sent it to me on the chat and I just clicked on that and went on to it. And it was very quick to load up.

I: This is more of an open ended question. How engaged were you with the app? Were you sucked in? Were you engrossed? Did you miss a day because you didn't you didn't want to use it? Did you continue past the 10 minutes because you were enjoying it? That sort of thing.

P4: Yeah. So on Thursday, yeah, I used it for quite a while. I used it for a while because I was interested in how the different things worked and I wanted to experiment a bit. And so I did quite a few drawings on paper and then tried to make a tune. So I'd say that it was an engaging app, certainly to start with. But I don't know how well I would engage with it over a longer time period but certainly the premise and the technology, I thought, was very interesting.

I: What was your favourite part of the app and why?

P4: I guess the sort of creative freedom that you have with it. Because you could sort of do anything and I like the different instruments. I quite like that bit, the way it would just play what you've already done over each other. So there's no faffing about with trying to get it right, because it just plays it over as long as you've got it in the same beats and time.

I: What was your least favourite part of the app, and why?

P4: It was quite buggy, and it was laggy. So, I did actually find it hard to make a song. it was usually fine when I just put in one thing, then if I tried to mess about with the metronome, or the key of it, or stuff like that it cut out quite a lot and it became more jaggedy rather than smooth... instead of going, like [whoop] it would go like, [whoo-oo-oo-op]. Yeah, I think it was just laggy, to be honest with you.

I: Did you manage to make anything you were proud of?

P4: No, no, really. Not that I was proud of.

I: Or, did you come up with something that you enjoyed?

P4: No. I think this is partly based on my level of musical experience - I found it hard to even make a tune. At one point I drew lines on paper trying to make a chord sequence, and actually that worked okay. So I couldn't control what I was making because it was just lines on paper. I wouldn't know how I would translate into actually choosing a chord and then being able to mark it down precisely on the paper and then take a picture of it.

I: Did the fact that you couldn't save anything in the app change the way you used it at all?

P4: I think because of that, I was less inclined to try and make a song, knowing that I couldn't save it. But in a way I quite like that it's something you can just fiddle with as well. You know, it's not something that you have to- you know, sometimes you just want to mess about with something. Try it out instead of having to go through all the making... But it would be nice to have that feature.

I: Did you ever reuse a drawing on one day that you liked and reuse it on another day?

P4: No, because that didn't really cross my mind. And I think also because I was writing on paper... and because I didn't have the ability to write my own actual song. I don't know how the app works completely. It meant that I was less inclined to want to write something down, and then use it later.

I: Could you predict the melody that would be generated from a drawing?

P4: Sometimes. So the main problem was that because what you're inputting isn't actually a drawing, it is a picture of a drawing. So often what would happen is, it would pick up on a shadow or something that you don't be in the thing. And then even when you try and adjust... To be honest, the adjusting thing to change the black and white of a photo usually worked quite well. But if you didn't have a line that was thick enough, then it wouldn't pick it up, which was an issue. So what was the question again?

I: Could you predict the melody that would be generated from a given line?

P4: Yeah, so if it was a straight line, that I knew that would just be a single note, and if there's three lines I knew it would sound like a chord, obviously going horizontally, and then if you have like a vertical line, it goes down the scale. Down, like [neeooo], and then up it would go [ooooop]. So I could predict it in that way, but I couldn't predict chords, like I said, or the exact notes. And also, sometimes I would take a picture and then think "oh, I can't hear that" because the actual stuff that was picked up in the picture was at the bottom of the thing, so it would only be in the lower bass stuff. And I found it hard to hear that a lot of time.

I: Did you like this way of writing music? Or, how did you feel about it?

P4: I like the idea of an image representing music, but I don't like the fact that you have to take a picture of it. Because that brings up quite a few issues.

I: What are those issues? Like you said before, shadows, thin lines. Anything else?

P4: Also the fact that, for example, when I'm using the laptop, I was holding it up to the [webcam], and it's quite hard to see the [screen] to take the picture. And it was hard to get it in the right register. If it was in a different setting, for example, you wrote something down, and they had a rig, or a set camera that would take a picture of it, then it would be useful. But I think that in terms of being used, sort of whenever you want, then it's less useful for that. Although I do think that it could still help for some uses.

I: Let's say that instead of taking a picture of a line, you could just draw it on your screen with your finger. If it was done that way, do you think it would be more useful or less useful?

P4: Probably more useful. Although obviously with a screen that obvi-

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ously still has its own limitation. Because if you have a fat finger then you might miss where you want to draw the line. With a small screen you can't really put that much in one line unless you could get it to scroll, zoom in and out on the place that you're doing it.

I: Did this whole way of writing music make you think about music in a different way?

P4: Yeah, it did really because it made me think about how you can basically write music in two dimensions, one dimension being time essentially the other dimension being pitch. So maybe seeing it two-dimensionally, and then also chords is like three lines horizontally. And then a vertical line is actually one sound. Although it's similar to the piano scroller thing. I was already a little bit familiar with that, but I've never used something like that before. So using that was interesting.

I: All right, I'm gonna go through each of the five prompts and ask you the same set of questions about each prompt. Did you do all the prompts?

P4: I did a few.

I: Okay, which ones did you do?

P4: I did the familiarising myself. I tried to make somebody that could capture the mood. I did do three and I tried to do four.

I: For the first prompt what was the setting like? Were you just at home on your laptop or what?

P4: Teah, so that was here. Yeah, that was in my room on the first day, on Wednesday

I: On your laptop or phone?

P4: Laptop.

I: What did you find easy or challenging?

P4: Well, familiarising myself was pretty easy. It was very clear how it worked. I really liked the layout, the user interface. I liked that because it was very clear to us. The buttons were nice and big. it was very obvious what everything meant. It was easy to familiarise myself with it. What was this question again?

I: What did you find easy or challenging?

P4: It was easy to familiarise myself with it. But then, trying to capture a mood, I could do that in terms of selecting A major or A minor. But I couldn't make make a plausible tune or melody on the first day

I: Did you enjoy the outcomes you came up with on the first day?

P4: Yeah, because I was very new to it and it was very interesting to hear what it was like to make something out of a picture. The first thing I did was take a picture of myself. It was interesting to hear all the different... it sort of sounded like some alien Doctor Who [oooOoowowowowodldoodoo], sort of thing.

I: Did you take a picture of something weird for your sequence?

P4: Yeah, so I took a picture of several things, actually. I did one of my bed sheets which is almost tartan. Yeah, that was interesting to hear the results. Because it's interesting to hear the natural pattern and to hear what it would sound like although there was still an issue that sometimes the picture wouldn't come out great. But then it's interesting, you think to yourself: "that's how this object or this picture could be interpreted".

I: Did you manage to make anything musical out of those weird inputs?

P4: Nothing I would call music. Just sound. And then it was actually on Thursday, when I used it the most, I drew a lot of different things on paper. So that's when I tried to make the chords. And I tried a wave and little dots to see all the different sounds it would come up with. but actually the drum part and couldn't get at all.

I: What do you mean you couldn't get it?

P4: Because well, firstly, I don't know how it worked. Because I could hear: crash, hi hat, snare and bass drum. I would assume they would go: bass at the bottom then snare back my hat then crash maybe?

I: Yeah.

P4: I didn't know when they were on the thing, so I couldn't make a tune at all, or even a beat.

I: And then the last prompt for trying to recreate a song, how did that go?

P4: I basically couldn't at all.

I: Yeah, I expected as much. What did you find challenging about that?

P4: I could try and write down the notes, then they'd be wrong. And then I have to write down something else. And it would just be unreasonably tedious to try and make a song in that way.

I: Which prompt was your favourite? And why?

P4: Taking the picture of something [weird], because that got my imagination going a bit better. Then I sort of started to look around for things I could actually take pictures of, like cool patterns that I have around me. And so I wanted to take pictures of those.

I: Do you think that app might be useful in a musical setting? In general? So instead of just having the app and trying to make things entirely within the app, do you think if the musician had this as part of their tool belt, do you think it might aid them in any way? Or indeed a non musician?

P4: Yeah, I think that it could in certain circumstances, but I certainly don't think it will be something that they will go to a lot, or at least I can't see a way that they would do that. Or maybe if the music you were writing was experimental,... It's plausible that someone can make an album out of that technology. And it would probably be quite an interesting listen. There are certainly albums like that. Not necessarily listen to, but something that I've heard of around. so I do think that it could definitely have its place. But in terms of making popular music I think that it could be used but I don't think it would be anyone's first port of call.

P5 Post-task Interview

I: What device did you use for the app?

P5: I just use my phone. So like, it's my Galaxy S. So it's like a normal smartphone.

I: How easy was it to access and start using the app?

P5: It was very easy, because I got the link for the website. So I just clicked it and it just showed me right away and I just had to take the pictures to upload my drawings. So yeah, it was very easy to access it.

I: How engaged would you say you were with that app?

P5: I think it took some time to make myself more comfortable and just to like, familiarise myself with the app. After a few hours, I found it really interesting to just experiment with different drawings to see how I can actually, like, make something that I want. So yeah, I really enjoyed it, like every process.

I: What was your favourite part of the app?

P5: Oh, I really liked how easy it was to customise different scales and different pitch and time. It was very easy to navigate and it was very intuitive. And I also like how I can adjust each, like each texture of sound. So like, there were four main different tracks on the main screen of the app. At first, I actually thought it was a bit hard to combine those four different parts, because I'm more used to the interface with the parallel tracks which move at the same time, so it was a bit hard to combine those different windows at first. But as time goes by, I found it very interesting, because it just made me experiment more with the different elements.

I: What was your least favourite part?

P5: I think it might be better if there is a like saving function so that I can continue uploading the pictures or continuing editing later. Sometimes

I just wanted to save it, but then I had to start it from the start.

I: So that was a deliberate decision to not include the saving function. Did the fact that you couldn't save change the way that you used it?

P5: Yeah, it made me be more intuitive, and to be more casual, you know, things along and just think of, like analogies. So just like even more just to improvise more. Yeah. Just hard to do.

I: Did you manage to make anything you were proud of?

P5: Oh, I'm not sure. I think I'm still trying to be more comfortable with the app. It was very interesting to see, in terms of generating the sound from drawings or random visuals. But when I thought of certain melodies or had certain sounds that I wanted to make, it was really hard to make that as a drawing and put that into the app. I think it was sort of like a reverse process to visualise it first, you know, then into the app. So in terms of that, I couldn't.

I: Could you predict the melody that would be generated from a given line?

P5: I think I tested some lines before starting to make something. So I drew random lines just to see how it sounds. And I think it really worked well with the first three windows, but in terms of the drum part, even if the camera captured a clear line, I think it maybe ignored some of the points in the drawing.

I: Did you like this way of writing down music?

P5: Yeah, I mean, it was very insightful, because I'm not like a professional songwriter, but I usually think of something very concrete. So like starting from lyrics, or starting from meanings. But with your app, I had to think of some visualisations, or drawings first. So it was a very new approach to me. And also it really made me to think about the relationship between sound and visuals. So I thought about, like, there are some connections. Is it about some commonalities in elements of music and visualisation? Or does it come from our experience? Yeah, I thought about, like different social systems we have and how they're related.

I: I'm going to go through each prompt. Did you do all the prompts?

P5: Yeah.

I: I'm gonna go through each prompt, and then ask you the same set of questions for each one. For the first prompt, I asked you to familiarise yourself with the app, and make something that captures the mood. How did you go about doing that?

P5: As I said, it was very easy to navigate the app. And I really liked how I could like customise the scale in the sequence, the pitch and time, everything was very clear there. So I just found everything in the menu and yeah, I made some drawings and yeah, it was it was very easy to do.

I: Did you find anything challenging?

P5: It was a bit challenging to combine four different tracks, which are laid out in four divisions. It was a bit different from typical music editors you use which have parallel tracks. So it was a bit difficult at first but yeah, everything else like the menus and how you can customise it was very clear.

I: Where were you when you did the first day?

P5: I was in my room.

I: And did you enjoy the outcome from the first prompt?

P5: Yeah, I mean I really liked the different textures of the melodies. And also, I think I figured out how each track works. I really enjoyed different pictures of melodies and also drum parts.

I: The second prompt was to use the app while out and about or travelling. Where did you decide to do this?

P5: I used it on a bus.

I: So what was easy or challenging about that?

P5: I think it was easy and also inspirational, because I tried to capture scenes, and the outside. I really liked how I can just put the different images and turn it into the melodies right away. So yeah, I really liked that process.

I: What sort of things do you take a picture of on the bus?

P5: I took a picture of, you know, the line opposite on the bus. But also the scenes outside. It was moving very fast, so the picture was a blurry colour, but when I put it in the app it became clear, like black white images. So I liked that.

I: Did you enjoy the outcome from this prompt?

P5: I think it was where I realised that, if I can visualise something, then it can turn into sounds with the app. So yeah.

I: Did you enjoy the musical result of whatever you did?

P5: I just used the random images. Usually, it's very far from what I can imagine as a human. So how your app interpreted it was very interesting in that way. Because I couldn't predict the melodies.

I: Prompt number three was to use something other than pen and paper as the basis of your sequence. Where were you when you did this?

P5: I was in my room.

I: What did you decide to use?

P5: Actually, I just used different memos that I have. So I'm not sure if I followed the prompt exactly. I mean, I didn't use any pens or paper, but I used some existing notes that I made before. So there were letters and random images in a postcard. So yeah.

I: How did that turn out?

P5: I think it's also related to the second prompt. So like, what I initially thought about the images was very different from how your app actually captured it. So the result was something that I couldn't think of. And also in terms of the drum part, it was especially unpredictive.

I: Prompt number four was to try and recreate a song that you like. How did that go?

P5: I think I failed it. Clearly, because it was really hard to visualise what I actually wanted to make. So I understood how your app works, but in order to create a specific sound, I had to find some, like size of the drawings. And I had to divide it very precisely, but I couldn't do this. I like the process because it just made me understand how your app works and maybe like, what is the limit of it.

I: Did you enjoy the outcome of this prompt?

P5: Yeah, I mean, I really liked how far it is from what I wanted to do.

I: Last and final prompt was use the app however you'd like to make something cool. What did you end up doing there?

P5: I did the process of making different visualisations, and trying to find more examples that I can use. Because it is something that I usually don't do or don't even think of doing. I really like finding different examples to motivate myself to visualise it.

I: Different examples of what?

P5: Examples of visualisations, like any notes that I have, or any pictures that I can use. But also because I had to put it into the app, I had to think about how clear it is.

I: Okay, so you, you're mostly photographing pre-existing things?

P5: Yeah, I tried to find some interesting patterns or something like that. Also like finding something very unexpected. So even if it's just a normal picture of a cup, even there I can find some patterns.

I: What was your favourite prompt?

P5: Maybe the second one. So the fact that I can use it wherever I want. Since this is an app, it is portable, so I can just carry it to wherever I want and I can make the melodies right away from any simple drawings or random visuals.

I: So think about written sheet music and piano roll and other ways you've

used to write down music or give music to a computer? How does this compare to those?

P5: In terms of getting used to it, it was very intuitive and very friendly. I don't know much about the music notation itself. I feel like it was more accessible than traditional notation. But also, as I said, it was also very inspirational, the way that it connects two different modalities, like sound and visualisation.

I: Were you able to apply knowledge of other musical systems you've used in the past to this?

P5: To be honest, I think I don't have, like, knowledge to apply. Maybe for someone who doesn't have much knowledge, like me, I think this app could be a starting point where you can think about the structure of music while you're using it.

I: Let's suppose you were, like setting out to write a song. Do you think you would use that app and, if so, how?

P5: I think I can use it to get the initial inspiration. If I have specific drawings that I want to turn into sounds.

I: And then would you continue using that app, or would you go use something else?

P5: If you can change it to a long interval, you could use it to write the whole song. But with the current app, it could be a starting point.

P6 Post-task Interview

I: What device did you use for the testing?
P6: My laptop.
I: Just a laptop?
P6: Oh, wait, on the one that I was moving I used my phone.
I: How easy was it to access and start using the app?
P6: Really easy. No complaints there.
I: How engaged were you with the app?
P6: I was actually kind of addicted to it.
I: Oh, okay.
P6: Yeah, it's like a really fun game, and you kind of feel a bit productive. So I did procrastinate a bit with it.
I: How long do you think you used it for each prompt?
P6: Like half an hour for each one?
I: What was your favourite part of the app?
P6: I like where you can put all four different bits and have them play all together. Rather than just having one line and one tune that you can write.
I: What was your least favourite part?
P6: If you take a picture of a line, it takes like some weird dots in the background, even on like a blank piece of paper. So it adds in these weird dots that I didn't always want so then there's like a weird odd note here and there above, like, the thing you're trying to focus on.
I: Okay. With those visible when you were, like cleaning up the picture?
P6: No, they weren't.
I: that is strange.
P6: So yeah, so I put like a blank piece of paper and then like draw something on it, and then it would just be the line. And then it would come out with dots in the background.
I: Okay, that's a bug that I've not heard about. So that's good to know.
P6: Maybe it was a dodgy camera.
I: It could be that. I don't know. Let's suppose the app worked perfectly. What was your least favourite part of what was meant to be in the app?
P6: I couldn't exactly write what I was hearing in my head. Because it was like a line drawn or whatever, it was always kind of vaguely in the right area, which was probably partly my fault. But like, if I'm writing like music, I know what a note is going to be and the difference between two. So I guess I wasn't always writing what I was hearing in my head.
I: How did you feel about that?
P6: I mean, it was fine. But I thought if I were to use it to actually try and write tunes for other people, it wouldn't be very helpful because it would be playing different things. And it also could be that I just need to practice more and get better at it.
I: Did you manage to make anything you were proud of?
P6: Proud? No. But I was definitely entertained.
I: Were any of the musical outputs something that were pleasing to your ear?
P6: Oh, yeah, there was. So when I tried to rewrite the tune that I had in my head, that was actually very close. It's the closest I got to writing what I was hearing in my head. So that was nice.
I: Oh, well done. That's quite difficult. Did the fact that you cannot save the tune, change the way that you use the app?
P6: Actually, yeah. Because I knew that I could just scrap it whenever, so I never really tried to fine tune anything or make it particularly presentable. They were all a bit drafty and scrappy. Which I also liked, because then it meant I was more experimental, because I wasn't like "this has to be nice." It's like, just clear it and then it's fine.
I: At any point, did you find an idea that you liked, or draw a picture that you'd like the sound of and then reuse it on a different day?
P6: No, I didn't.
I: In general, do you think you could predict the melody that would be generated from a particular line?
P6: Kind of. I think if you have, like, where it's gonna start pitch wise. Yeah, definitely. Because you just follow that line.
I: Did you like this way of writing down music?
P6: I found it fun, but I don't think I would use it to write. I didn't find it helpful as someone who'd grown up writing notation music. Because I grew up writing music, then I know exactly what it's gonna sound like when it's written on the page. So if I need to write down something that's in my head, or if I want to play something, if it's on a piece of paper it's just so much faster for me because I've learned to use notation. It feels more kind of guessy to do it with lines and stuff, I think just because I'm more used to and [the app is] more vague.
I: Did it make you think about music in a different way?
P6: Yeah, actually, it did. It made me realise how, how it wasn't accessible to so many people. Because I mean, if you're blind, you could use this method much more easily. Or if you'd have access to being taught music and stuff. Like for people who learn by ear, maybe this is a better way for them to write things down, because it's just following shapes rather than following specific notes.
I: I'm going to go through each prompt and ask you the same set of questions about them. Did you do all the prompts?
P6: Yes, I did.
I: So the first prompt was to get to know the app, familiarise yourself with it and make something that captures the mood. Where abouts were you when you did that one?
P6: What do you mean where I was emotionally or physically?
I: Physically.
P6: I was in my room.
I: Okay. Did you find it easy or challenging?
P6: That I found challenging, but just because I was getting to know the app.

I: What about it was challenging?
P6: Well, just working out, like, what button does what and how much it speeds up, or how much it shortens it, or how much the pitch changes. Just like getting used to that.
I: How long did it take you to figure out what things did?
P6: I mean after like two tunes, like 10 minutes, maybe. It wasn't like I was sweating over it.
I: Did you enjoy the outcome of the first day?
P6: Yeah, I did.
I: Because of the experience, because of the musical outcomes.
P6: Kind of both. I mean, it was fun, firstly just to get to know the app, and also, to see what I'd made, even if it wasn't exactly what I was trying to do, it still kind of worked.
I: And were you mostly drawing stuff on paper for the first day?
P6: Yeah, it was.
I: The second prompt was to make a song while out and about while or travelling. So where were you when you did that one?
P6: I was walking across the downs.
I: So what did you find easy or challenging about this one?
P6: Firstly, I didn't have my headphones so hearing it was kind of difficult. And also not really having control over what you're going to do so you just have to make do with what's around you, then control it like that. So I mean app-wise it wasn't any different. It was more like growing my creativity, I suppose.
I: What did you end up photographing
P6: A leaf and then like a twig. Just outside stuff.
I: Did you like how they sounded?
P6: It was better than I expected. It was very jaggedy - it didn't really fit as a tune. Still fun.
I: So overall, you enjoyed the prompt?
P6: Yeah, it's a fun challenge.
I: The third prompt was to take a picture of something weird for your sequence. Where were you when you did that one?
P6: I was in my kitchen. And I had a weirdly shaped carrot with like four legs.
I: Fantastic. How did that go?
P6: That actually sounded quite good. It was weird because I took it from three different angles. So I use the carrot for the whole thing. And it actually sounded quite good.
I: Was there anything particularly easy or challenging about this prompt?
P6: Finding something weird at first, but then I bought carrots and that was fine. But other than that, no. Not challenging, I don't think.
I: The fourth prompt was to try and recreate a song that you'd like. How did that go for you?
P6: That one, I think went the best. Weird, right? Because if I tried to write a tune that doesn't exist, I couldn't do it. But then when I was writing a tune that did exist, I think it was easier because it made me think more about the pattern of the tune rather than like what the tune sounded like. It made you think differently about it.
I: Did you manage to get something that was quite close to what you wanted?
P6: I think I did. I mean, I don't think I got the pitch completely right. Like if it were possible to squint your ears at something, then I think it would sound like it.
I: Did you enjoy the outcome of this prompt?
P6: Yeah, I did. That was really satisfying.
I: And the last prompt was to use the app however you'd like to make something cool. What did you end up doing?
P6: I ended up half using a picture of something and then trying to draw lines to fit stuff around that. So I was kind of half using my own brain, half using something else.
I: What do you take a picture of?
P6: One of those pens with like four clicky bits on the side.
I: Was it easy or hard to find stuff that would fit with the sounds that came out of the pen?
P6: So at one point I took the end off and taped the four bits that came out so they were sticking out different ways. That was really hard to find stuff to fit because it didn't really make any sense. But when I put it all together, it was actually quite easy. Like weird blips at the beginning. And you could change where the blips were depending on which pen was pushed in.
I: Did you enjoy the outcome of the final day?
P6: Yeah, it was fun to listen to and to just play with.
I: So at the end, like on your last day of using it, was it easier or harder to use the app then at the start?
P6: Oh, so much easier. Why is that? I think from the prompts, making us do lots of different things, and doing kind of weird things with it, you just get to know the app and find ways to make, say, like the leaf and the twig fit together. You have to use lots of different things and experiment with it. So by the end, I kind of really knew my way around it. I could think, "oh, if I put it in that that will make it that much faster. So it will fit."
I: Which controls in the app were you mostly using?
P6: The speed - The bit that makes it either longer or shorter. And then also the pitch.
I: Did you end up doing anything cool with the scale options?
P6: No, I found just because a lot of the shapes were weird, it was best to keep it within the same scale. I tried at the beginning, and then I just kind of thought like, "this is just notes."
I: Which prompt was your favourite and why?
P6: Taking a picture of something weird, because I think it was the nicest tune that I managed to make out of it. And I also got to use the same thing, but in like three different ways, which I thought was quite cool.
I: So after using the app and writing music with the lines and such, how would you compare it to other music notation systems that you've used?
P6: I mean purely just because I was raised with notation, and that's second nature to me, I found it a lot harder to get what I specifically want. Yeah. But I can see how in a scenario of learning by ear or if you have a disability, that it can really be useful for thinking about tunes more structurally? I think it makes you learn a tune better because you can think "oh, yeah you can see that it's a descending" - whatever - much more easily than you can if you're not used to reading notation,
I: Were you able to apply your knowledge about notation to this.
P6: I don't think so.
I: Let's suppose you are setting out to write a bit of music. Do you think you might use this tool, and if so, how?
P6: I definitely think if I was going to write a folk tune that it would be nice to use it more as a model rather than as a full tune. So kind of use it as a skeleton. I'd be like "I want these shapes to be here in the tune." More as like, improv prompts, rather than a full tune. It's quite hard to be specific with it.
I: So you would use it to as a jumping off point for something else?
P6: Yeah, I think so. If you're having a session, or whatever, and you've given everyone these different prompts with these lines just using the shapes of it. I think I would use it like that. Because otherwise I'd be

annoyed that they weren't playing exactly what I wanted to because I find that hard to write with the lines.

I: That was the last question. Is there anything you'd like to add?

P6: I don't think so. I think those are quite fleshy questions. They got to the bottom of everything. I had a lot of fun using it though.

P7 Post-task Interview

I: What device or devices did you use to access the app?

P7: Pretty much my phone, which is a Moto G8. I tried it briefly on my computer, my laptop, but I struggled to do that because my laptop cameras a really weird angle, which is my laptop's fault.

I: What do you mean by a weird angle?

P7: like you press down the middle key at the top of the keyboard and it's like a camera. It points up at, like, 45 degrees so it was quite hard to hold something square on to it.

I: How easy was it to access and start using the app?

P7: Yeah. Cool. I clicked the link, and then pressed "run app". And then got orientated with it pretty quickly, which is quite good, because I struggled to work out like how Minecraft works, you know?

I: Okay, more of a broad question: How engaged were you with that app? So that could mean like, did you miss a day? Or did you continue past the suggested time?

P7: Oh, I had a good time with it. I think I might have missed a day in doing it. But I found that pretty quickly, I'd just be like, in the park and see something and be like, "Oh, I wonder how that would sound". That's pretty good. You can definitely get into a roll with it and do it for a while.

I: What was your favourite part of the app and why?

P7: I liked trying the same thing with different scales. And I liked putting a bunch of things on top of each other, although it sometimes struggled if you put too many complicated things on at once. But I like that you could do that.

I: What was your least favourite part of the app? And why?

P7: Sometimes if you put too much into it, particularly the drum kit, the sound would get more kind of machiney after you told it to stop, which I didn't love, because it sounds bad.

I: So that's not a feature of the app. Let's suppose it worked perfectly. What was like the least good part of what was meant to be in the app?

P7: I think all the things that were meant to be in it I enjoyed. You know, there's always more things you can suggest or things like that. But I think they're all just, like, extra things or things but didn't entirely work perfectly. So I don't think there's anything I really disliked but it was meant to be there.

I: Did you manage to make anything that you were proud of?

P7: Yeah, I think so! Me and my friend were at a pond and made a thing using a bunch of pictures of different places at the pond. I mean, it sounded kind of cluttered, but it was really fun. I was like, "I'd keep that if we could keep it". I think at first if you were looking for a perfect piece of music, you probably aren't going to get something. But you could definitely find something where it's like, "oh, that was fun and is listen-inable". I didn't expect to be enjoying the pictures that it made. But I thought they often went with the sound in a fun way. If you were using all four boxes the combination between the pictures and the sounds were good.

I: Cool. The fact that you cannot save a tune, change the way that you use that app at all.

P7: Oh, interesting. I remember thinking I would like to save a tune. But yeah, given that you're not really looking for something that you're going to save, you're just kind of having a fun time with it.

I: Did you ever find an idea that you liked and then reuse it on a different day?

P7: I tried doing that but it was slightly difficult because you had to take the picture right then. And even if you had the same drawing, it would sound different, because you'd never get the camera angle to be the same. But yeah, I did use the same bit of paper again, because I kind of knew that was a known quantity, and I wanted to try putting something else onto it, but it would be a bit different because of that.

I: Did you find that you could predict the melody that would be generated from a particular line?

P7: I mean, you could see when something goes up and down. But I think you'd have to have quite impressive ability to spatially see what the gaps were, if you know what I mean, and pitch to be able to do that properly. And also you don't know where the start of the scale is going to be.

I: Did you like this way of writing music?

P7: Yeah, I thought it was fun.

I: Why?

P7: It was just different. I've not done something like that before. It sort of made you look around the room going like "What would that be like? What would that sound like?" I didn't try to integrate it in any kind of writing that you might be doing outside of the app. But I think if you did, it will be things like little sequences of melodic intervals that you might not have thought of. Or maybe if you're like somebody who uses samples or drum beats, you might be able to take from it in a more direct way. But I don't personally, so I probably wouldn't.

I: Did using the app make you think about music in a different way?

P7: I think it made me think about things, or images in a different way, more than music.

I: At this point, I'm going to ask about each prompt. Did you do all the prompts?

P7: Yeah I did.

I: I'm gonna ask a similar set of questions for each prompt. So for the first one, I asked you to familiarise yourself and just make something that captures the mood. So the first question is, Where were you when you did that?

P7: I was at my desk in my room.

I: Did you find it easy or challenging?

P7: It took me a minute to figure out how to use it, and how to get a good picture. I don't think it was anything that would make you go, "Oh, I'm not gonna bother doing this." Like it was pretty simple to pick up.

I: And did you enjoy the outcome of what you made?

P7: Yeah, I think that outcome was always- you'd enjoy it in a way that was pretty connected to the things that it came from, and the process of making it as much as it was to the sound of the thing. But yeah, it definitely made something where I was like "Oh, that's neat! I didn't say you could do that."

I: In terms of actually what it sounded like, were you pleased with the result?

P7: Yeah, I think so.

I: Prompt number two was "make something while out and about" So where did you do that one?

P7: I didn't do it second, but I did do it. At said pond, I took a picture of a bunch of tadpoles, which made a really fun drum thing. I've learned that if you wanted to take a picture of something quite chaotic, it was best to put it in the drum, because otherwise it would make something kind of screechie and chaotic melody wise. But if you put it in the drum,

you know, because it would make individual sounds for each thing that it spotted. Yeah, I was in the park with a bunch of naturey things.

I: Did you find that easy or challenging?

P7: I think if the first time I tried to use it was outside, that would have been slightly more difficult. But I'd generally figured out how to make a picture that it would like by then so it was alright.

I: And you enjoyed the outcome of that one, did you?

P7: Yeah, that was fun.

I: The next prompt was to use something other than pen and paper for the basis of the sequence. So you've kind of done that ready in the outside one. Did you do anything else?

P7: I think I used things that were not pen and paper more often. Just because I thought it was fun to see what sounds different things would make. And also, I didn't have a thick pen, so It wasn't as easy to make a good paper [drawing]. Yeah, I think that was one of my favourite things about it actually - taking pictures of these and seeing how they sounded.

I: What was your favourite thing that you took a picture of?

P7: I mean, the tadpoles were neat. I have some weird things I made out of wool. That was fun to hear in audio format. Tangled pair of headphones. That was pretty fun.

I: So the prompt after that was to try to recreate a song that you like. Did you do that one?

P7: Yeah.

I: Where were you when you did that?

P7: I was in my room again. That one I tried to do with the pen and paper. The first three notes were stepwise and they actually came out, just doing like "line line line". And then I could make something that follows the shape of the melody, and then I had fun drawing things that were approximately the shape of the melody just to see how they would sound but I couldn't get anything that was exactly like the sound of the tune.

I: What did you find easier or challenging about this prompt?

P7: It was pretty difficult!

I: Why do you think it was difficult to recreate something?

P7: I guess if you really wanted to do it in a serious way you could mark out some squares - you could get some squared paper and do that kind of thing. But I don't know why you'd do that. When I was trying to get the melody the best [scale] was the chromatic option. Because it wouldn't start the melody on a different bit of the scale for the other ones. But the thing about the chromatic option is, unless your lines are incredibly precise, you're more likely to get random stray notes.

I: Did you enjoy the outcome of when you tried to recreate something?

P7: I think it gave the most usable melody, if you were looking for melodies. So yeah, that worked.

I: This is a by the wayside question. Did you realise that for choosing the scales, you could pick whatever scale you wanted by tapping the note names?

P7: No. I think I tried to do that the first time I used it. And maybe I'd already overloaded it or something, because I don't think it worked. But no, I did not at any point do that. It remained in A.

I: Last prompt was "use the app however you'd like to make something cool".

P7: I did that quite a lot.

I: When you did that, what was your approach to using that app?

P7: Like I say, a lot of "how would this object or image sound?" Or like, "let's see what happens if I put a sprig of rosemary in this square, and the wiggly lines in this square, and some headphones in this square" you know, more of that than anything else. Once or twice, I made things where I drew, like, pointy things in the upper space for this square and wiggly things in the lower space for this square to try and make something where you could hear the different lines. At that point, I was annoyed by the balance of it. That would be a good feature, to be able to change how loud and how quiet each square was.

I: Which prompt was your favourite and why?

P7: Oh, the one that encouraged you to take it outside, because I hadn't done that yet. And I don't think I would have tried to recreate a melody without it telling me to do that.

I: When you were using the app at the end, was it easier or harder to use when compared with the beginning?

P7: Oh, easier.

I: How so?

P7: A: I knew what the buttons did, apart from the fact that you could change the scale. And B: I knew what kind of picture would make something listenable.

I: What do you find the most personable things?

P7: I appreciate that's a subjective thing. Generally, there not being too much noise in the picture around the thing that you wanted to hear. And, like I was saying, if you have something scattered, I thought it worked quite well in the drum box rather than a melody box unless you were going for a very "neeneenenene" kind of sound.

I: How would you compare this to other ways of writing music that you've used in the past?

P7: Particularly compared to other electronic things - So that's like the first time you want to use something like logic, or something like that. I really enjoyed how easy it was to just make something fun quickly and pick it up.

I: How would you compare it in relation to sheet music, or piano roll?

P7: In terms of wanting to make a specific melody, Piano Roll is probably still easier. But it's definitely way faster than sheet music for trying to just get something made and have a nice time doing it.

I: Were you able to apply the knowledge you have about different notation systems when it came to using this?

P7: I mean, I know what the different scales mean. I guess the general principle of different boxes happening at the same time is something that something that one might assume would be obvious, but it's something that is like "no, you have to figure out how it works". So that was trans-ferrable.

I: In terms of the actual writing down of a thing on a bit of paper, or your intuitions of how a photograph would be turned into a melody - Could you transfer any of your knowledge there?

P7: I think probably. I think that must have been the case, given that it didn't feel completely alien to use. Kind of hard to tell.

I: Let's suppose you are setting out to write a bit of music. Do you think you would use this app? And if so, how might you use it?

P7: I think definitely, if you were- Like the piece we did where all four squares came from something in the pond - if you wanted to do something inspired by something, you could definitely use it in a fun way for that. Or just "I'd like a melody. Can I have one, please?" That'd be a fun way to generate the melody. I think it would be more likely to be for some kind of exercise based- Not that that wouldn't make a piece that you'd be proud of at the end of it, but more like something where you'd be like, "I think I will do a writing experiment today", than general writing. Although that said, sometimes you just can't think of a tune.

I: Cool. That is the end of questions. Is there anything you would like to add?

P7: Nah I think that's pretty good.

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