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The Modernized Keyboard: Improving the Musician's Experience Through User-Centered Design

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The Modernized Keyboard:

Improving the Musician's Experience
Through User-Centered Design

by

Andrew James Magee

A Thesis in Partial Fulfillment of Requirements for the
Degree of Master of Fine Arts in Industrial Design

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I have met many people throughout my time at RIT. Most are artists, designers, musicians, engineers, all people striving to make the world a better place with their talents. You all inspire me to go for my dreams and live my life to the fullest.

Confucius on Music

*"**Music produces** a kind of **pleasure** which*
***human nature** cannot do without"*

*"When **music** and **courtesy** are better*
understood** and **appreciated**, there will be **no war."

*"To **educate somebody**, you should start with poems,*
*emphasize ceremonies, and finish with **music**."*

*"If one should desire to know whether a **kingdom***
*is well governed, **if its morals are good or bad**,*
*the **quality of its music** will furnish the **answer**."*

*"The **superior person** tries to **promote music** as a means to the*
perfection of the human culture. When such music prevails,
*and **people's minds are led towards the right ideals and aspirations**,*
we may see the appearance of a great nation."

Abstract

In 2016, a major part of being a gigging musician is traveling with your instrument.

For musicians with smaller instruments, such as the harmonica, traveling is no problem. Simply place it in your pocket and you are good to go anywhere with musical creation at your fingertips.

Medium-sized instruments, like the guitar, are somewhat of a hassle to travel with due to their size, but are also typically lightweight, so the traveling still somewhat tolerable.

But for musicians with large and heavy instruments, such as drums or a digital keyboard, traveling can be a nightmare.

My thesis explores the full experience of the modern-day keyboardist and provides a more convenient solution for traveling with their full-size instrument, while considering important aspects of the keyboard such as the number of keys, size of the keys, and resistance (or feel) of the keys when played.

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Introduction

This thesis explores many ideas related to music creation and perception. The study began with the broad research topic of music and was narrowed down to improving the experience of the modern-day, gigging keyboardist.

Chapters 1 begins the thesis with my musical background and why I chose the topic of music for my research. Chapter 2 covers some unique benefits that listening and playing music can have on the human body and mind, as well as why I think music is amazing. Chapter 3 discusses my process of arriving at my initial problem statement and some of the possible directions I researched before deciding on designing for keyboardists.

If you just want to get to the design questions related to my thesis study, you should begin at Chapter 4, where I describe the user I am designing for and the problem at hand.

I hope you enjoy this thesis and are inspired to create your own ideas about the future of human creativity and the tools for creation. The more we can encourage creative thought, the better our society will be.

Ch 1 **About Me**

1.1 **A Musical Childhood**

Creating music has been a personal interest for most of my life. The ability to play instruments has helped shape me into the person that I am today. It has helped me build strong relationships with other music lovers and allowed for a deeper understanding of their creative side through collaboration: writing songs or improvising.

I began playing instruments at the age of 8, starting with the alto saxophone. I took saxophone lessons from ages 8-12. Throughout this time I learned to read sheet music, a written method of notating songs. It took me quite a long time to understand it and fluidly translate the notes to my instrument, but finally once I got the hang of it, I decided that saxophone wasn't for me.

By the age of 12, I wanted to move on to a "cooler" instrument. What is more cool to a 12 year old than playing guitar? Yeah, I couldn't name anything else either.

Thus, from ages 12-17 I played the guitar. For the first year I took guitar lessons and learned independently from then on. I never learned to read sheet music for guitar, as it was difficult to learn the exact notes on a guitar neck. Instead I read guitar tabs, which are much more intuitive than traditional sheet music, but leave out some information, such as the timing required for the song. But, if you know the song already, then you can adapt the tab quickly.

Overlapping with my time I played guitar, I played the drums from ages 15-18. I also played percussion in my high school jazz band for two of those years. The jazz band included instruments like the marimba, shakers, woodblocks, and the beloved timpani drums.

The most exciting part was that ages 13-18 were filled with musical collaboration. Usually it was me and one other friend that would get together and play our instruments, either guitar, drums, or piano.

You would think that with all of this musical training, I would be a virtuoso by now!

However, when college rolled around, the instruments were left in my closet while I focused more on the academic and social aspects of my life. I still made music, but my tools of creation had evolved into a more compact solution.

The tightly packed three-person freshman dorm room was too small to bring any of my musical instruments. Instead I created music on my laptop, *which I easily carried around in my backpack*. It was much more convenient than carrying an instrument and could be taken to almost any environment, even the library!

But creating music on a laptop is much different than playing an instrument. The interaction to create the music on a laptop is not quite as engaging as strumming a guitar or hitting a drum. Instead, I would use a music creation software (either FL Studio 9, Garageband, or Logic) and tediously place each note for each instrument in each song. In total, I would place hundreds, even thousands of individual notes to arrange these songs.

Many of the songs I created were interesting and fulfilling to me, but after a while the laptop-music-making process began to lose its fun. Of course, I loved the final product of my work, but I hated the long process of placing each note.

As my love for computer-made-music faded, I chose to focus on other things in my life, mainly academic clubs on campus as well as obtaining my degree in Accounting. But little did I know, by focusing more on my mathematical side I was developing skills that would later help me gain a new perspective on my music making.

1.2 **Creativity & Math**

I was always a creative child. I would create my own toys in my basement out of objects that were seemingly unrelated: building a skatepark for my finger skateboards out of small Pokemon trading cards, making complex trifold duct tape wallets, or making a “tree throne” with an old skateboard and some other miscellaneous items up in a tree in my front yard.

As I grew older and it came time to choose a life path, I was discouraged from choosing an art-related college degree. After all, everyone has heard the story of the starving artist, still waiting to get his big break. I needed something more concrete that could give me the financial security and comfort that I wanted later in life.

I chose Accounting because I always loved working with numbers. I enjoyed math throughout elementary and high school and thought that a numbers-related major would be enjoyable for me.

After three years of Undergraduate School and an inspiring study abroad experience in Italy, I realized that I wasn’t enthusiastic about Accounting because it didn’t involved any creativity. How was I supposed to be the next Michelangelo or Da Vinci if I was stuck in a career that did not have any creative side to it?

“If I spend my entire life doing Accounting, something that doesn’t involve any creativity, and don’t chase my dreams, I will always be left wondering what amazing things I could have accomplished. My potential as an artist would be wasted.”

-Me at the beginning of my Senior Year of College, about to graduate with an Accounting degree. (Yes, I just quoted myself).

So with all this in mind, I began researching other fields that could accommodate my creative desires while still applying the knowledge I had gained from my business-related degree. It wasn't long until I stumbled upon the field of Industrial Design and it seemed to be everything I had ever hoped for.

I created a portfolio of drawings in about six months and applied for the Industrial Design Graduate Program at the Rochester Institute of Technology. To my delight, I was accepted into the program!

Industrial Design is the process of studying a real problem and people's experiences surrounding that problem, then brainstorming and testing solutions with the hopes that you will come up with a way to do something easier, faster, and more affordably.

The Industrial Design field combines two of my passions in life: mathematical thinking and creative problem solving.

The mathematical side: thinking about how each detail of the idea adds up to the whole product, specific dimensions for each detail, & the cost associated with each feature of the design.

The creative side: coming up with innovative solutions to problems in an elegant way that makes sense for all parties involved.

1.3 **Discovering the Piano**

In the summer of 2014, after completing my undergraduate degree and before coming to RIT, I had a vivid dream that I was a professional keyboardist on stage, performing for an audience. It was an experience I have never had before. I woke up that day, with the dream still fresh in my mind, and made the decision: I was going to learn how to play the keyboard and make my dream I had a reality.

Throughout my life I had dabbled on keyboards before, but never took the time to learn it thoroughly. Now I was serious about mastering the instrument, something that I knew would take many years. I was motivated by this idea I found online:

> "If a skill takes many years to develop, start developing those skills right away! Before you know it, the time will pass you by, so you might as well get something out of it."

Throughout the summer leading up to attending RIT I immersed myself in Youtube tutorials on how to play piano. I slowly built up my skills to a level that I could jam along with other musicians by listening to what they were playing and getting on the same groove, or as musicians call it, "playing by ear."

Eventually, when I felt that my skills had developed a bit and I was confident I would stick with the instrument, I took the plunge and bought a $1,000 professional-grade full-size, fully weighted workstation (equipped with the features of both a keyboard and a synthesizer): the Korg Kross 88, shown in Figure 1. This thing has all the bells and whistles I needed (as well as strings, organs, electric pianos, synthesizers, and drums).

Figure 1: Korg Kross 88 Workstation (Keyboard)

Unfortunately, the summer came to an end and I had to let my new instrument take the back seat while I focused on my studies. After all, I was going into a completely new field of study and I had *a lot* to learn.

1.4 **Stepping into Keyboardist's Shoes with Megalodonis**

Fast forwarding to the end of my first year in Industrial Design Graduate School, right before I began my thesis, I met Steve. Steve is a designer by day, the bass player by night.

He invited me to see his band, Megalodonis, perform. I went to watch band play in a very small, tightly-packed basement of the apartment that some of the band members lived in. It was unlike any concert I had been to before. The music was weird and interesting and the atmosphere was great, a very up-close and personal show, both literally and figuratively. I went home inspired to practice my new instrument: the keyboard.

After developing our friendship more in the last few weeks of school, I eventually asked Steve if he wanted to get together and play some music together. He said that the band was hosting open jam sessions every Friday during the summer, so I started attending them.

I would bring my keyboard to their house and setup in the same basement that I first saw them perform. The jam sessions actually went pretty well!

Although I was still in the process of learning how to play my keyboard, I was asked back to the jam sessions again and again. Eventually, I got a message that I never thought would be possible: "Hey AJ, do you want to play keyboards in our band?"

Obviously I said yes. It was an opportunity that I couldn't pass up. So for the year and a half I have been performing with Megalodonis as the keyboardist. I have learned many valuable lessons in the process. I have developed my skills and now know the ins and outs of being a (locally) gigging musician. But most importantly, I have personally experienced the problem I am solving with my thesis project.

Ch 2 **Why Study Music?**

2.1 **Music: A Universal Language**

Music is truly a universal language. Regardless of what spoken language someone understands, a beautiful melody can be understood across races, religions, cultures, and even across time periods.

Music has been around for thousands of years and it connects us to our ancestors even more than words do. “We cannot even say when it began, for music was in the world centuries before anyone invented writing” (Dearling 1996, 8). Languages are lost, but basic rhythms are not.

You don’t need to learn a language to understand a basic rhythm. A drum beat is a drum beat, no matter what your background is. Even some animals (besides humans of course) have been known to dance to songs!

Music is also amazing because it allows for multiple interpretations of the same work. Depending on your culture, or even your mood at the time, a melody or lyric could have a completely different meaning for you than for another person. This diversity of interpretation makes music interesting and meaningful to the person hearing it. The listener creates the story in their head that speaks to them the most. I believe that this is why abstract lyrics are so widely accepted. People create their own stories to go along with them, and the songs become more relatable.

It has the power to create emotions in people and bring them into another reality.

I am researching for one main reason: **music has the power to unite people** from different cultures and beliefs from all over the world.

2.2 **Healing Powers of Music**

Music has medical benefits. There have been many studies that indicate that listening to music can improve in the body's healing process. Music helps the body fight stress, sadness, and anxiety, relieves pain, improves mindfulness and cognitive functions. (Eevee 2014, 1).

Relaxation is naturally good for the human body and is essential for good health. When a body is stressed, or in the "fight-or-flight" state, the immune system and brain do not function as efficiently as they do when the body is relaxed.

"When you listen [to] pleasant original unfamiliar musical orchestrations, dopamine (which plays a major role in reward-motivated behavior) is released in the nucleus accumbens (which plays a significant role in cognitive processing of motivation, pleasure, and reward and reinforcement). This increases consciousness, lowers stress, turns off emotional negativity, and actually stimulates the memory circuits in your brain" (Waldman 2015, 1).

With all of this knowledge about the benefits of music on the mind and body, music therapy has become an accepted form of healing the body and mind. Music therapy is a form of healing that uses calming sounds to relax a patient, lowering their blood pressure and reducing stress in their body and mind.

The American Music Therapy Association describes music therapy as "the clinical and evidence-based use of music interventions to accomplish individualized goals within a therapeutic relationship…" (American Music Therapy Association 1998, par 2).

"Music therapy is now prescribed to people with heart ailments, brain disfunction, learning disabilities, depression, PTSD, Alzheimers, childhood development, and more" (Block 2016, 1).

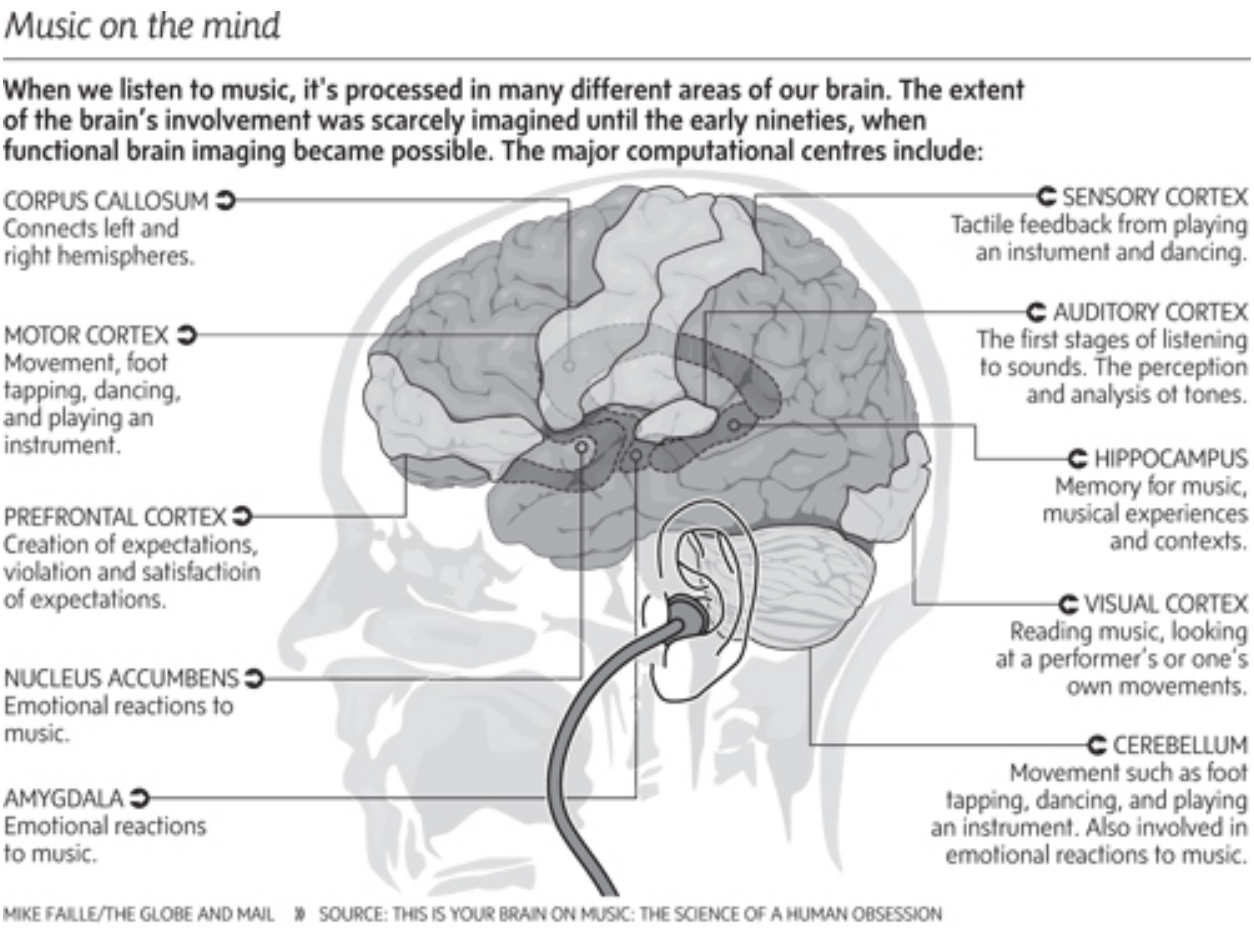


Figure 2: Music on the Mind

In Figure 2 you can see all of the parts of the brain that are activated when music is played, listened to, or danced to. We strengthen these parts of the brain whenever we use them, so listening or playing an instrument might be considered a mental workout in a way.

Listening to a song has the power to bring back powerful memories. People who are completely mute, who haven't been able to remember their own families, or even their own names, will listen to a song and sing every word out loud! It is truly a miracle what music can do for us. (Sacks 2007).

2.3 **Benefits of Playing an Instrument**

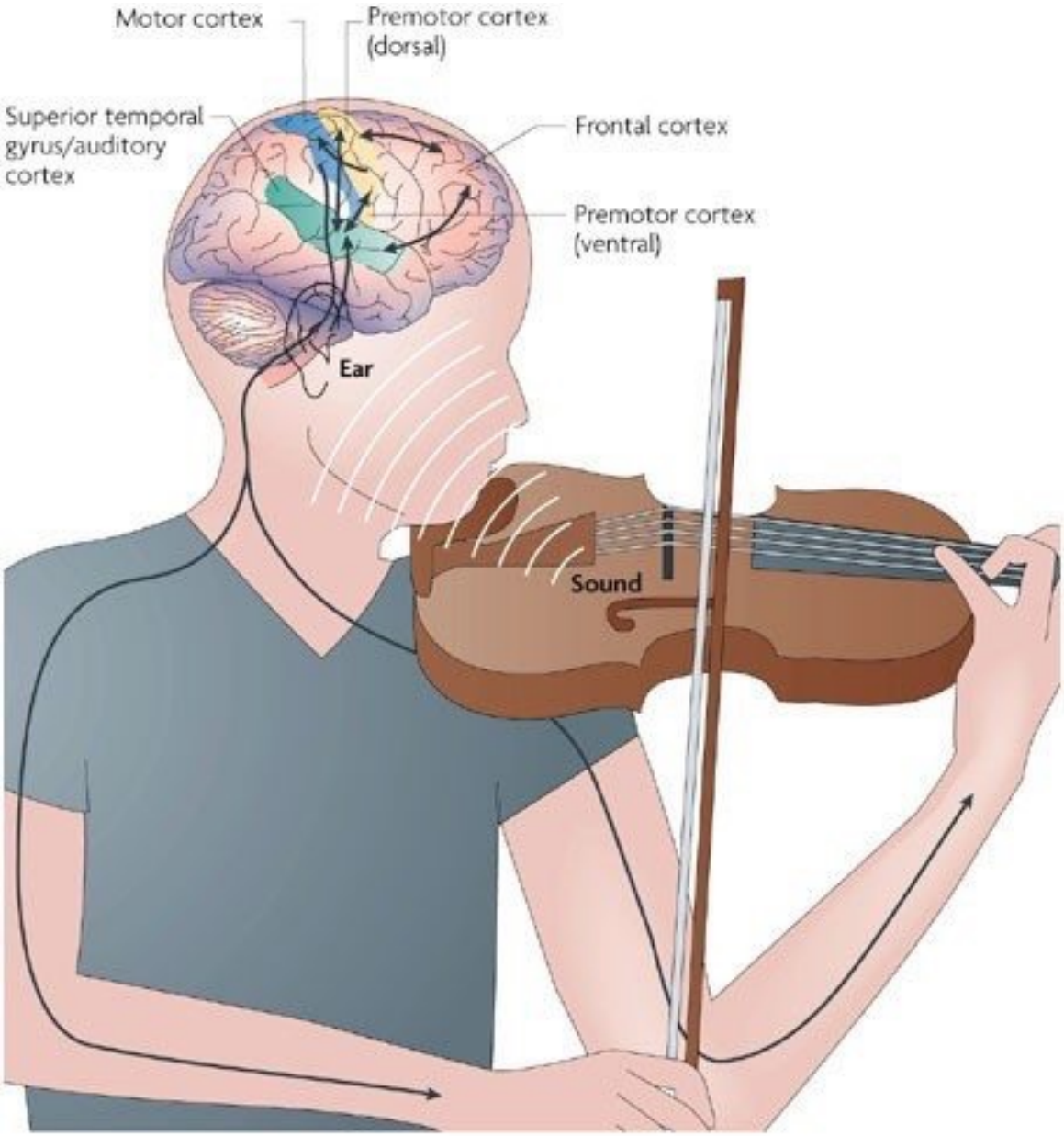


Figure 3: Instruments on the Brain

A study conducted at the University of Liverpool found that playing an instrument at a young age increases blood flow to the brain (Uniherald 2014, 1). “According to the findings, even half an hour of musical training is sufficient to increase the flow of blood in the brain’s left hemisphere, resulting in higher levels of early childhood development” (Block 2016, 1).

“We generally assume that learning a musical instrument can be beneficial for kids, but it’s actually useful in more ways than we might expect. One study showed that children who had three years or more musical instrument training performed better than those who didn’t learn an instrument in auditory discrimination abilities and fine motor skills. They also tested better on vocabulary and nonverbal reasoning skills, which involve understanding and analyzing visual information, such as identifying relationships, similarities and differences between shapes and patterns” (Cooper 2013, par 5).

The language part of our brain is activated when creating music. That makes sense though, doesn’t it? After all, playing a melody could be equated to speaking a sentence. The musician is creating this line that is meant to be experienced in a linear way and is very intentional in every note, similar to structuring a sentence when talking to a friend.

By promoting people to play instruments, we also encouraging them to develop their minds to the fullest potential.

2.4 **Why Do People Love Music?**

Do you ever wonder what makes people dance when they hear a song that they like? Why do humans even like music at all?

Well, firstly, humans naturally pay attention to sounds as a survival instinct. Before we had the comfort of our air-conditioned houses, we were out in the wild, just like every other animal on earth. Naturally, in order to survive, it helps to be aware of your surroundings. This awareness includes hearing the sounds that are happening around you. After all, you need to be ready when that bear tries to sneak up behind you.

And yet another survival instinct is predicting and recognizing patterns. Our brains naturally recognize patterns so that we do not need to interpret every little detail that happens in our lives. It allows us to understand what is going on more quickly and places objects, people, and experiences into categories. We can predict what will happen based on our past experiences. We can guess what someone is about to say because we have heard that phrase many times before.

As you may have already realized, the sensitivity to sound and pattern recognition are two main survival instincts that are **directly** related to our music enjoyment.

When something is about to happen, a human will try to predict it, whether its consciously or subconsciously. So when a song is repeating a musical phrase, which happens in almost all music, the person has something to latch on to and anticipate in the coming moments. They know what will happen next because its a pattern. It's safe for them.

They can also predict what will happen next in the song by associating it with the other things that they have heard that sound "good" to them. Maybe they know what the next note is because they have heard many other songs that have the same series of notes.

Music is interesting because of “tension and release”. Tension, or suspense, is created when the listener has a sound or idea that they predict will happen in the song, and that tension is released when that predicted thing finally occurs. This release is also known as a resolution because the music seems to resolve itself to where it wants to go. This is common in Jazz, where the musician will add many notes that seem to go “off the trail” of notes they would play, but then eventually get back on track to keep the listener grounded again.

This idea of tension and release is taken to the extreme in Dubstep music, with songs that create and build up the tension in the the section rightfully called the “build-up” and release that built-up tension at “the drop”, usually a louder more intense part with pumped up bass to get the listener to feel the release to the fullest extent. A dubstep song without “the drop” would seem incomplete and would leave listeners deeply unsatisfied because they were predicting and expecting “the drop” without ever getting it.

So why do people love music? Humans have evolved to pay attention to sounds and predict patterns as a survival instinct. We have used this instinct to our advantage by creating amazing musical patterns that appeal to our most inner beings. We can also play with our perception by creating music that builds up anticipation and satisfies that anticipation.

2.5 **Improving The World Through Music**

I have met many genuinely awesome people from the concerts that I attended. As most concert friendships go, one of the first things that we bonded about was the music.

This bond that happens at music gatherings is especially strong because the people feel that they are all there for the same purpose, to enjoy listening to their favorite band. People of all walks of life, who may disagree on a majority of “real-world” issues, are brought together to listen to the beauty of the music. People across the world, whom you would never think you would have anything in common with, could be listening to the exact same song, singing the exact same words, enjoying the exact same melodies and rhythms and you.

Figure 4: Music Around the World

Maybe it was the style of music I was listening to that made everyone seem so happy and together?

“Even short pieces of happy or sad music can affect us. One study showed that after hearing a short piece of music, participants were more likely to interpret a neutral expression as happy or sad, to match the tone of the music they heard. This also happened with other facial expressions, but was most notable for those that were close to neutral” (Cooper, 2013, par 1).

If we promoted more happy music, could that be enough to change the world for the better? Music is so special because it transcends boundaries and brings people together.

“Many studies have shown that emotion, or affect, might be one of the most significant factors that determine how and what we remember, and given that music is strongly associated with the modulation of emotional state, it can be expected that the study of musical memory will provide critical evidence about the nature of human memory in general” (Hallam, Ian, and Thaut 2009, 115).
So if we put these two observations together, music creates emotional states, and emotional states are directly linked to what and how we remember things. So by promoting music that creates positive emotions, are we promoting positive memories as well?

Interestingly, studies show there is a link between the characteristics that describe your personality and the music that you enjoy listening to:

*"**Blues** fans have high self-esteem, are creative, outgoing, gentle and at ease*

***Jazz** fans have high self-esteem, are creative, outgoing and at ease*

***Classical** music fans have high self-esteem, are creative, introvert and at ease*

***Rap** fans have high self-esteem and are outgoing*

***Opera** fans have high self-esteem, are creative and gentle*

***Country** and **western** fans are hardworking and outgoing*

***Reggae** fans have high self-esteem, are creative, not hardworking, outgoing, gentle and at ease*

***Dance** fans are creative and outgoing but not gentle*

***Indie** fans have low self-esteem, are creative, not hard working, and not gentle*

***Bollywood** fans are creative and outgoing*

***Rock/heavy metal** fans have low self-esteem, are creative, not hard-working, not outgoing, gentle, and at ease*

***Chart pop** fans have high self-esteem, are hardworking, outgoing and gentle, but are not creative and not at ease*

***Soul** fans have high self-esteem, are creative, outgoing, gentle, and at ease"*

(Cooper 2013, par 3).

Ch 3 **Research & Initial Ideation**

3.1 **The Mind Map**

When my thesis process began, I did not know specifically what I wanted to study. I did, however, know that I wanted to explore the wonderful world of music.

With the exciting experience of joining my first legitimate band, Megalodonis, I was ready to dive head first into the musical atmosphere and explore the possibilities of the future of music.

Without any direction, Stan Rickel, our Graduate Advisor, suggested that I make a mind map. Basically, a mind map is a spider-web diagram that lists every little thought that can be related to your subject.

So I downloaded a mind map program called SimpleMind. To begin, I placed one word in the center of the document: “Music”. From there I began to add my thoughts, questions, and possible thesis directions, unbiased to whether I would pursue that idea or not.

As you can imagine, the broad topic of “music” left with with a wide range of possibilities and questions. Figure 6 shows my original mind map.

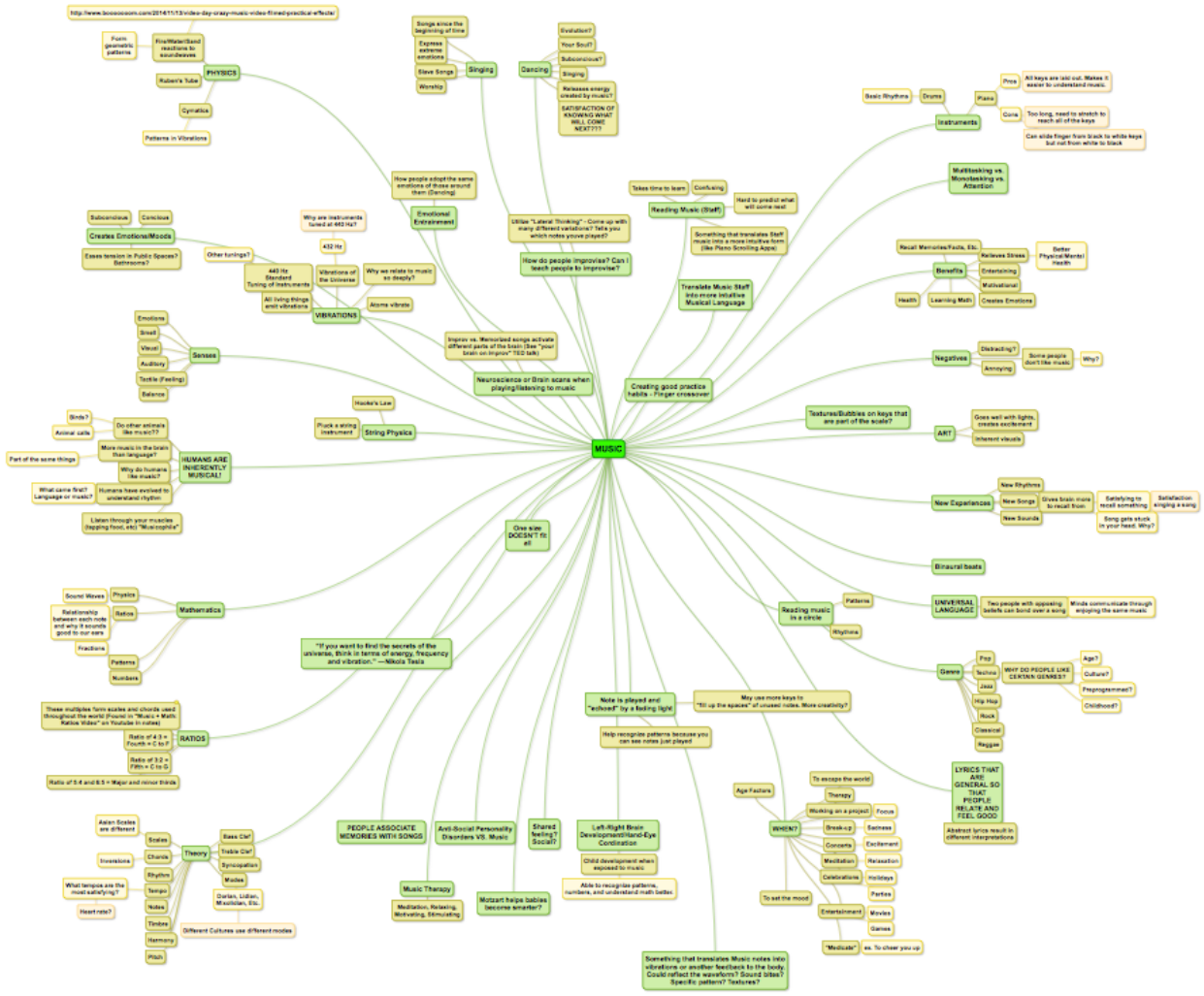


Figure 6: Music Mind Map

This mind map was slightly overwhelming, as it had almost every thought or question which had crossed my mind during the initial research process.

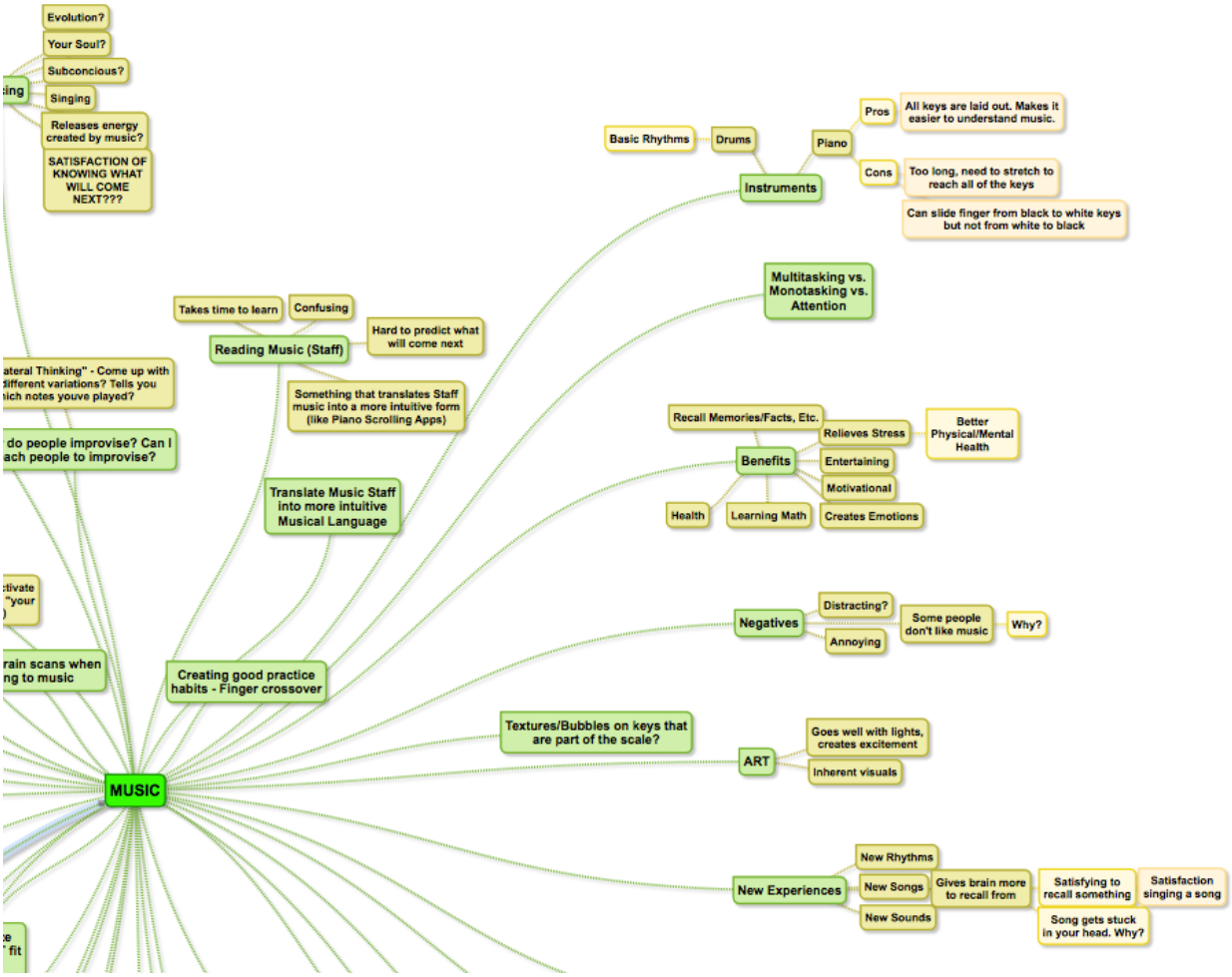


Figure 7: Zoomed Mind Map 1

In Figure 7 above you can see that I had a broad range of thoughts, from the benefits of playing an instrument to actual practices that I thought could be improved, such as reading sheet music from a staff, something that many musicians struggle with.

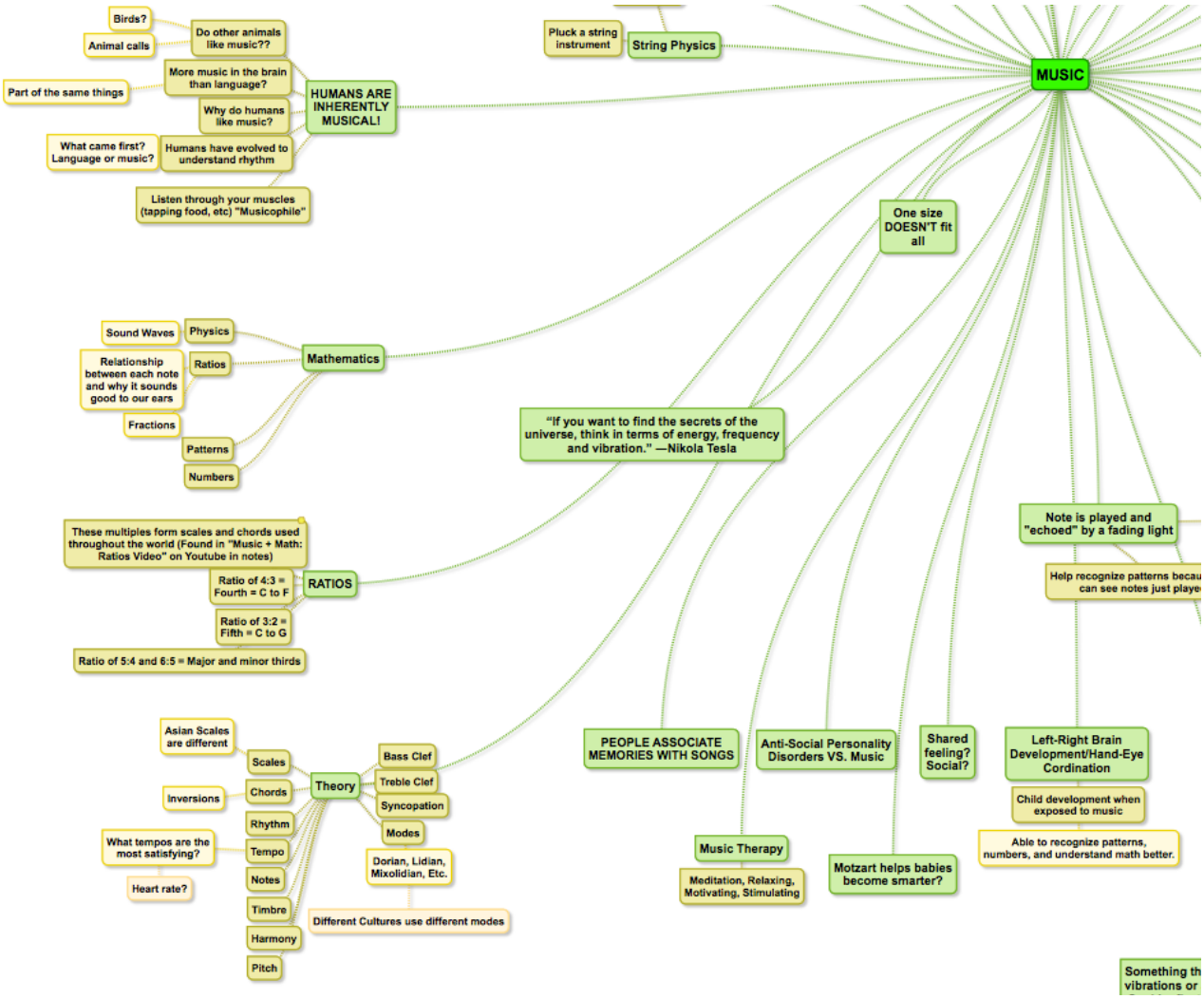


Figure 8: Zoomed Mind Map 2

My mind map also covered more complex concepts, such as the relationship between mathematics and music and the ratios that occur between two frequencies when played, shown in Figure 8.

3.2 **What to Study: The First Ideas**

Based off of my mind map, I began to decide what concept would be most interesting for me to study. I had many initial possibilities of a thesis research topic, but to start, I narrowed it down to a few of the ideas that resonated with me. Although I did not continue with any of these ideas directly, each topic influenced my decisions are sparked my creativity in the possibilities of music.

3.2a **Scrolling Notes Vs. Sheet Music**

The first idea was a system to adapt *sheet music* so that it is easier to understand.

The difficulty of reading sheet music is what holds back so many musicians from getting to that next level of skill. The main problem with sheet music is that there is a steep learning curve. It takes a long time to learn, almost as if you are reading a completely new language. Musicians start to learn to read sheet music, but eventually give up.

My idea for improving this method of notation was inspired by Guitar Hero, a video game that allows players to act as if they are playing guitar to real songs by pressing a button and strumming the guitar controller according to the scrolling notes that were falling down the screen.

In Guitar Hero, shown in Figure 9, it was the **anticipation of the notes** that makes it so special. The ability to anticipate what should be played next made it easy for beginners to play songs that they never dreamed were possible for them. It was intuitive for musicians and non-musicians.

Someone could walk up to a Guitar Hero game, without any background knowledge of reading sheet music, and know exactly what needs to happen in order to play the song.

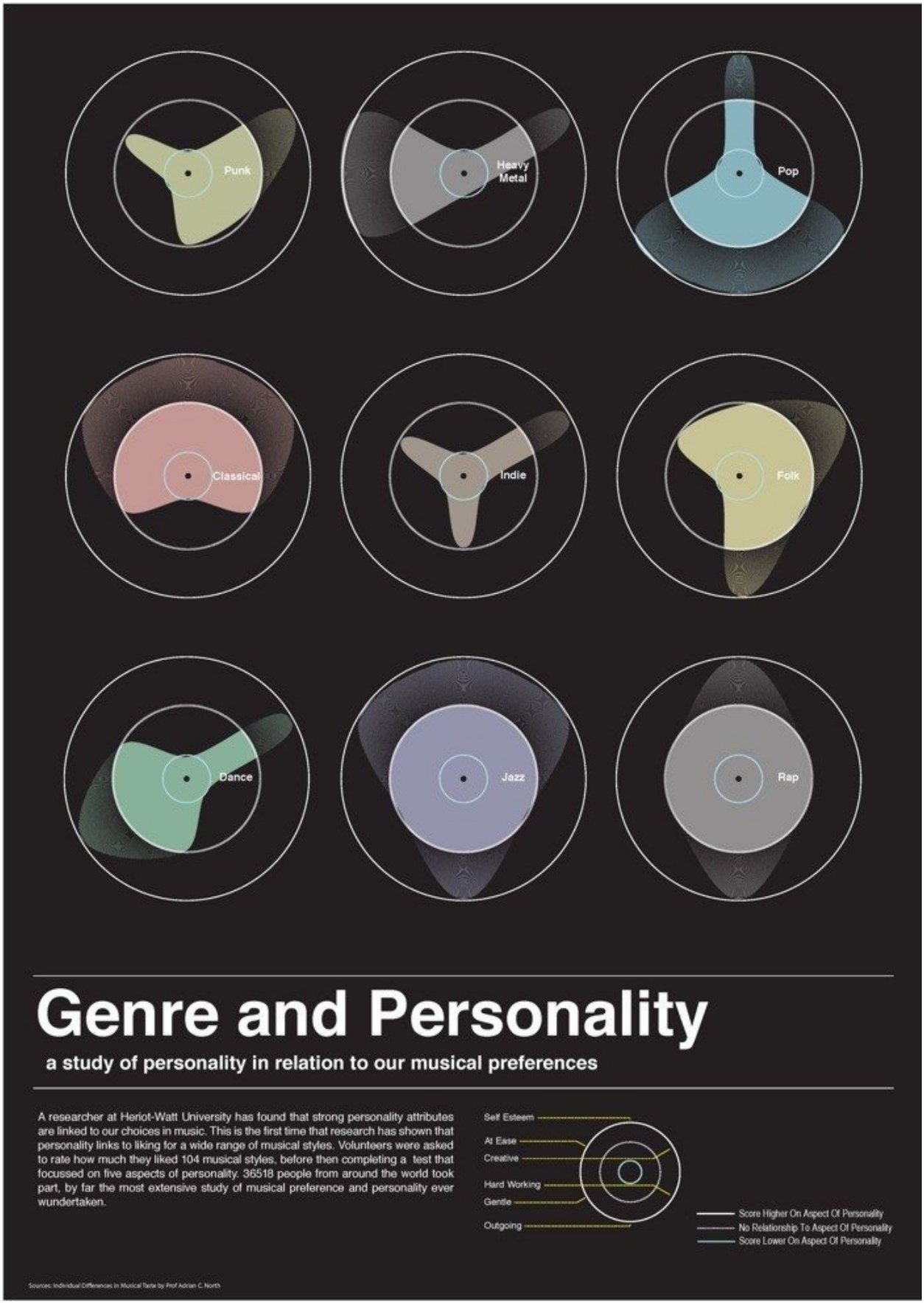


Figure 5: Music Genre and Personality

Of course, playing a fake plastic guitar on Guitar Hero is much different than playing a real guitar, but it was the simple concept of scrolling notes that made it accessible to music-lovers around the world.

This straightforward, intuitive layout was a major hit and revolutionized the video game industry, later inspiring games such as Rock Band, which is very similar to Guitar Hero in many ways and expanded to include bass and drums as well.

So how can we relate this idea of scrolling note visualizations to sheet music with real instruments?

In Western Music, there are 12 notes (Kumar 2016, par 2). On the piano, each key is a different note. We combine these notes in different ways to create chords, which creates the tension and emotion in the music.

In Figure 10 is the Grand Staff, the foundation of sheet music. The bottom section is called the Bass Staff, which covers the lower notes. The top section is called Treble Staff, which covers the higher notes. There are also other types of less popular staffs which I am not covering in this thesis.

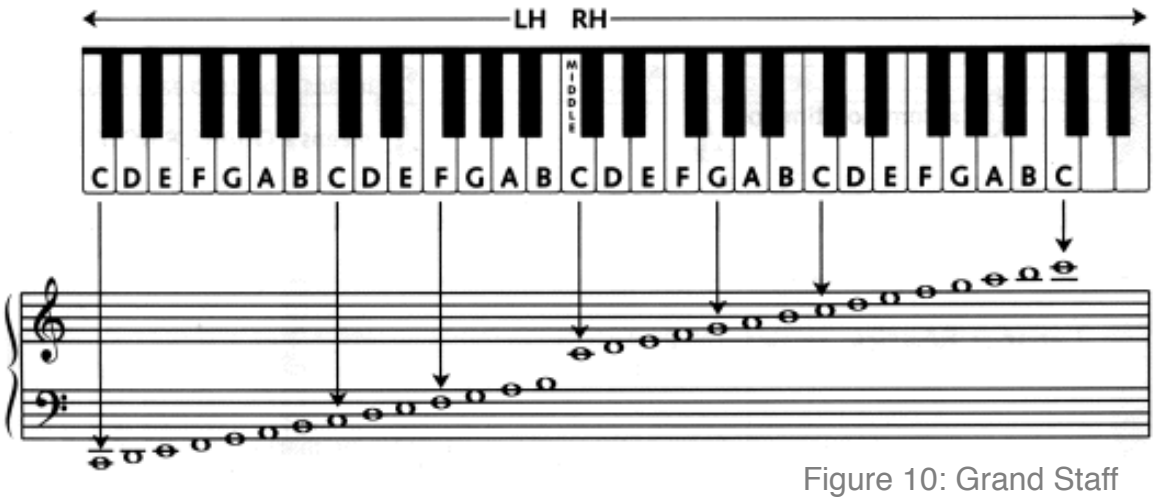


Figure 10: Grand Staff

On a piano, the musician would use their left hand to play the Bass Staff while their right hand plays the Treble Staff. Most instruments do not play both the Bass and Treble Staffs because their instrument does not have a range of notes wide enough to cover both staffs. Usually an instrument will use either the Bass or Treble Staff, but not both.

So for people playing piano or keyboards trying to read sheet music, they have it a little bit harder because two hands are playing at the same time. Usually the piano or keyboard player musician will have to learn the left and right hand individually at first. Then once they have a solid foundation for both hands, they will try to combine the two hands, one section at a time. But of course, that depends on the skill level of the pianist.

The main problem with sheet music is that there is a steep learning curve. Reading sheet music takes a long time to learn, **as if you are reading a completely new language.** There are different symbols for both the timing of the rhythm and the melody of the song.

But what if you didn't need to learn a new musical language to understand what needed to be played? What if reading music was as intuitive as the scrolling notes on Guitar Hero?

Well, after researching online, I found a solution that combined the scrolling notes with the piano in a system called P.I.A.N.O., shown in Figure 11. It works by projecting the notes onto a flat, white surface above the keys. I think it would be interesting to incorporate the same concept into a more portable solution. Something that could read sheet music, MIDI files, or any other format and convert it into scrolling notes down the piano. This solution helps the viewer anticipate what is to be played next and is intuitive for any skill level.

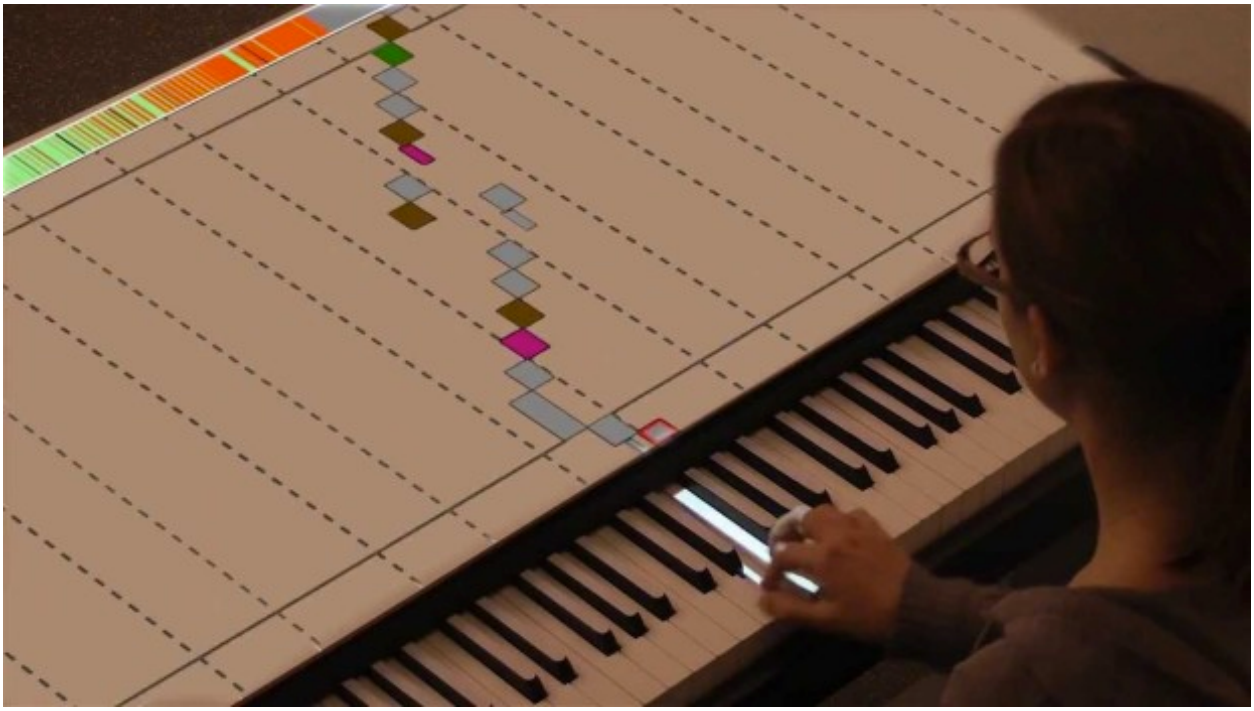


Figure 11: P.I.A.N.O. Projection Project

Also, each style of music, whether its blues, jazz, classical, or bluegrass, all share the same musical notation language. Also, the notes and timing that are on the page are not exactly how a musician might play it. Sometimes a musician will add their own little swing to the piece to give it that extra flair. Maybe a visualized system could help with the style of playing as well!

3.2b **Musical Information**

I was interested in enhancing the musician's experience by stimulating more of their senses and visualizing the music that was being played. I made the prediction that if musicians had more information about what they were playing, such as notes, chords, scales, harmonies, or rhythms that could be applied next in the song, they would be able to create more interesting songs that they would have otherwise. The process of visualizing the music would be enhanced by technology, but ultimately they would be making all of the decisions.

The instrument could visualize the different elements of the music. The added visual arts element would inspire and influence the piece being played, especially while improvising. The tension created between the notes would be visualized to help musicians gain a better understanding of what is actually going on within the music. Also, it could analyze the chord the musicians is beginning to play and give them suggested extensions of those chords.

Another idea: while playing on stage, each musician's sound would be running through to a system which indicates ***the key*** (for example, C major) that they are playing in. It is a simple and effective solution to keep everyone on the same page. Obviously the musician should be able to hear what everyone else is playing, but this would help clarify the key among all the noise, and would instantly be able to tell you if you were playing out of key. Sometimes, it is actually great to play "out of key" because it sounds more interesting. You can play different scales over the same chords and it would sound completely different.

How great is it to have an endless combination of patterns at your fingertips?

3.2c **Feeling the Music**

Deaf people have found a way to enjoy music without actually hearing it: they *feel* the music. At first this may sound odd, but everyone has the ability to feel the music if the bass is turned up loud enough. You may recall standing at a loud concert and feeling the vibrations of the bass pass through you.

So with this concept in mind, I asked the question: “if I were deaf, and even blind, how would I understand what is going on within a song?”

This transcends the idea of simply “feeling the bass”. The bass is the low frequencies and really waters down the song. I want someone that can only feel to understand exactly what is going on in the song, from the high-pitched shredding solos to the deep, low-pitched bassline.

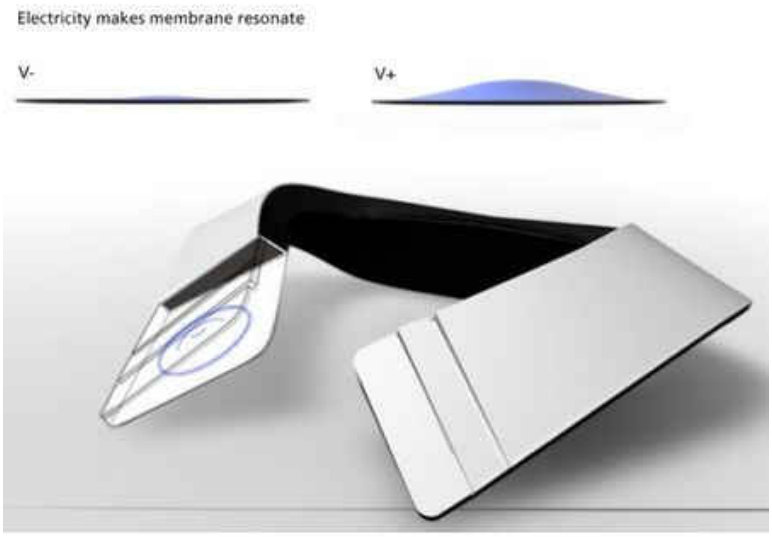


Figure 12: Music for Deaf People

While researching the topic of “feeling the music” I found a very cool music device that is meant for those who are deaf. This product known as “Music for Deaf People”, in Figure 12, is a collar that is worn by the listener which vibrates their chest and collar bone according to the music.

Maybe this would be enough information to help to understand the song better?

There is also the Subpac, shown in Figure 13. Subpac is a vest that vibrates to intensify the bass of the song, giving the user the feeling of a loud subwoofer without the loud sounds that could potentially damage hearing.

Figure 13: Subpac Music Vest

One incredible TED Talk “Can We Create New Senses for Humans” by David Eagleman talks about a vest that was created for deaf people. The sound from someone speaking is translated into vibrations that pulse through the vest. After about a month of wearing the vest and “listening” to speaking and feeling the vibrational feedback, the brain naturally adapts to the extra sense and incorporates it. A people who were once completely deaf were able to “hear” again and understand the words that were being spoken to them, all through this vibration vest Eagleman created. (Eagleman 2015).

What if these vibration systems were applied for musicians? Would a pianist understand the music better if there were vibrations pulsing throughout the piano bench? Or even vibrating the piano keys? What if musicians could send a short vibration pulse to the rest of the band when they want to move on to the next section of the song? Would this improve communication among musicians on stage?

3.2d **Rhythm in Sports**

Many popular sports require some sort of rhythm to perform at the top level. Running, Cycling, and Rowing are the three most obvious examples of rhythms at work. Obviously you want to keep at a certain pace rather than constantly speeding up and slowing down. A running rhythm helps your body get into a groove, or pattern that it repeats, more efficiently as time goes on. There are certain recommended beats per minute (or BPM) for slow, moderate, or fast running. These BPM's can be found in Figure 14.

Figure 14: Common Workout Tempos Vs. BPMs

As you can see in Figure 14, the tempo of the song usually depends on the style of music, with Jazz and Hip Hop being slower, and Techno and Drum and Bass being much faster and energetic.

“College students conducted a research and proved that the people who rode stationary bicycles were able to work harder while they were listening to fast music compared to those who weren’t listening to any music during the experiment. If you are like me and prefer running, listening to your favorite songs can help you beat your personal records and even strengthen your endurance. Long story short, music helps you perform better during your workouts and also makes them a lot more enjoyable” (Eevee 2014, par 7).

Also, “cyclists who listened to music required 7% less oxygen to do the same work as those who cycled in silence” (Cooper 2013, par 8).

What are the possibilities for combining workouts with songs or rhythms of certain BPMs? Could your music speed up or slow down based on the exercise you were doing and the pace you would want to keep?

Running or working out to a song with a rhythm helps the body to get into that natural rhythm as well. The appropriate song can energize the body, which makes for a better workout.

3.2e **Music & Math**

Another interesting idea was to create an instrument that combined the worlds of music and math. Literally every single thing that ever existed could be broken down and analyzed by mathematics, and music is no different. Each musical note has a corresponding frequency, or rate at which the air vibrates to create a pitch. These frequencies are written as hertz, for example, A4 (the 4th A from the Bottom) = 440Hz. (Wright 2009).

In Western music, an octave is broken up into 12 tones. Within these twelve tones lie endless combinations and possibilities. Each note is one semitone away from the next. But what is interesting about this is when you begin to visualize the waveforms of each tone. The relationships between the frequencies are what makes the music sound good or bad. Those that have more "basic ratios" of frequency relationship, for example a perfect fourth (2:3) or perfect fifth (3:4), sounds better to our ears, while others such was a minor 3rd (5:6) sounds like there is a lot more tension in the note.

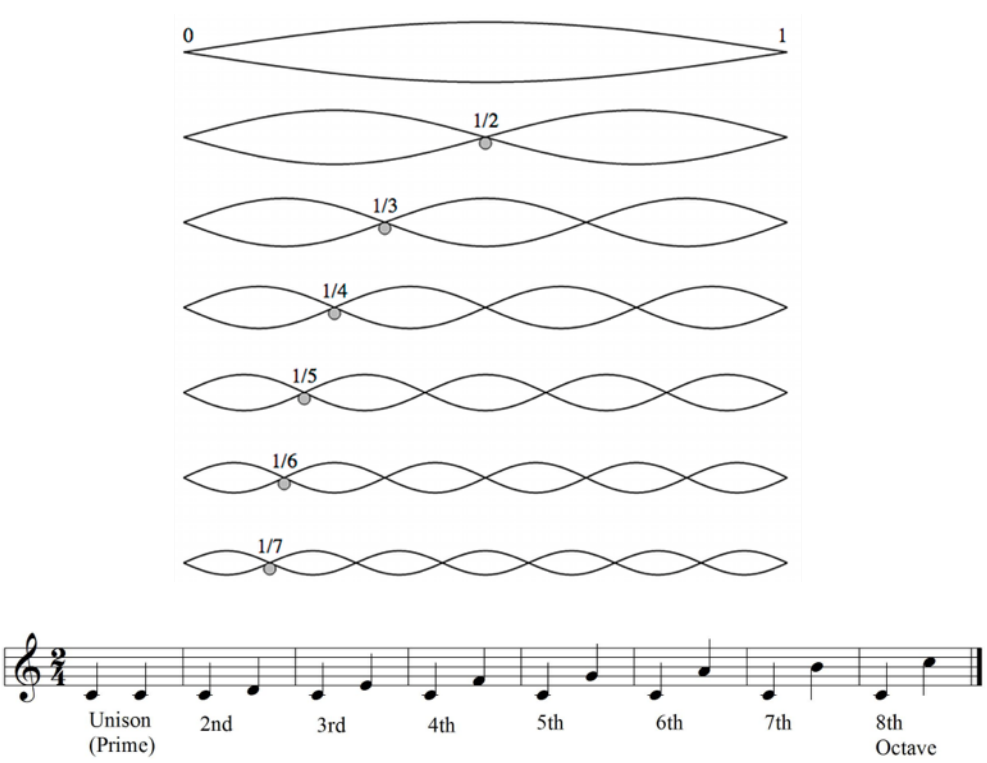


Figure 15: Frequency Waveform

3.2f **Visualizing Music**

I believe there is great potential for exploration in the “visualizing music” field. With technologies available today, such as MIDI, we can easily take each specific music data that a musician is playing and translate it into some sort of visual element.

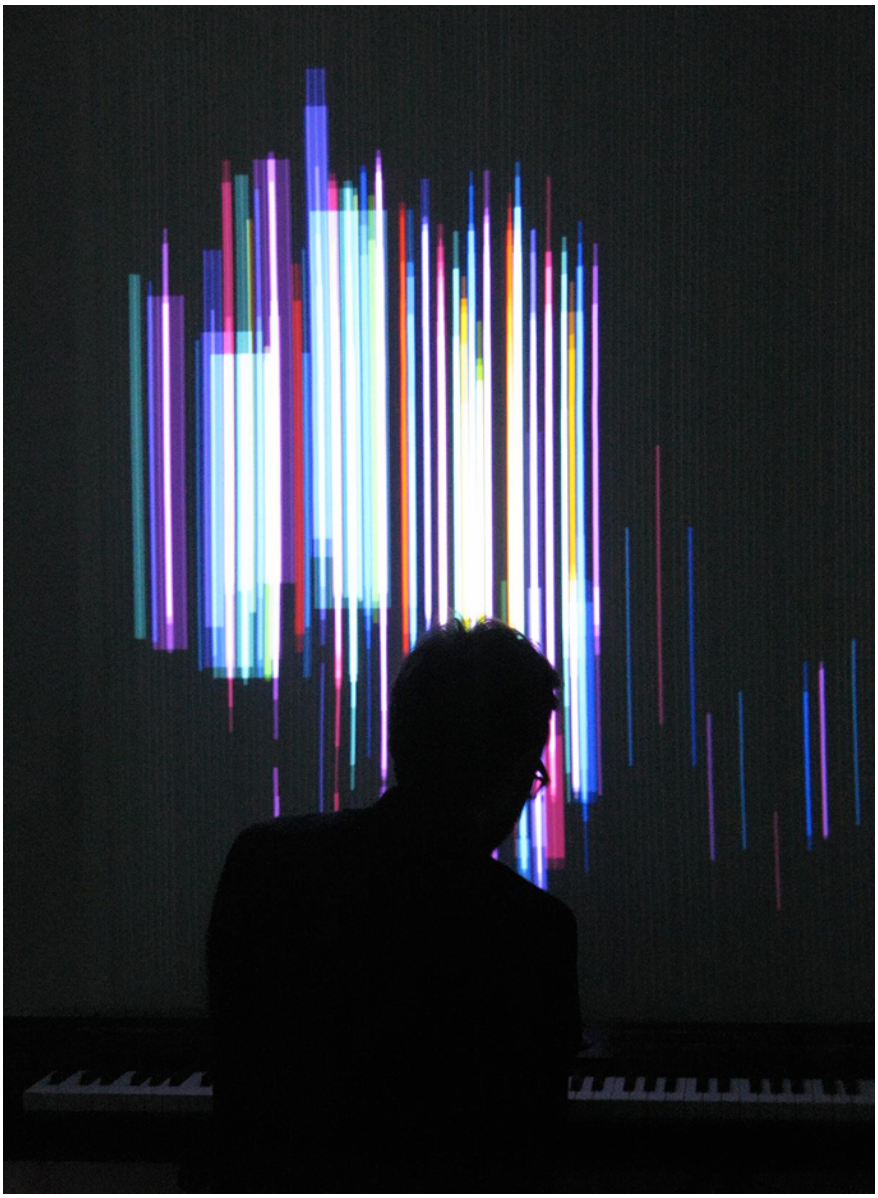


Figure 16: Projections Visualizing

Wouldn’t it be cool to experience a concert in which each note of each instrument was creating a visual image or animation? The instrument animations together would create a unique visual display that would fit together in the same way that their sounds are fitting together.

Music visualizers in the simplest forms have existed for quite a long time now. They are common in music programs, such as iTunes. However these visualizers are taking the frequencies of the overall song and translating it to a visual pattern. Instead, I would like to take each individual track of the song and give it a unique visualization. All of the visualizations would work together, almost like a color palette.

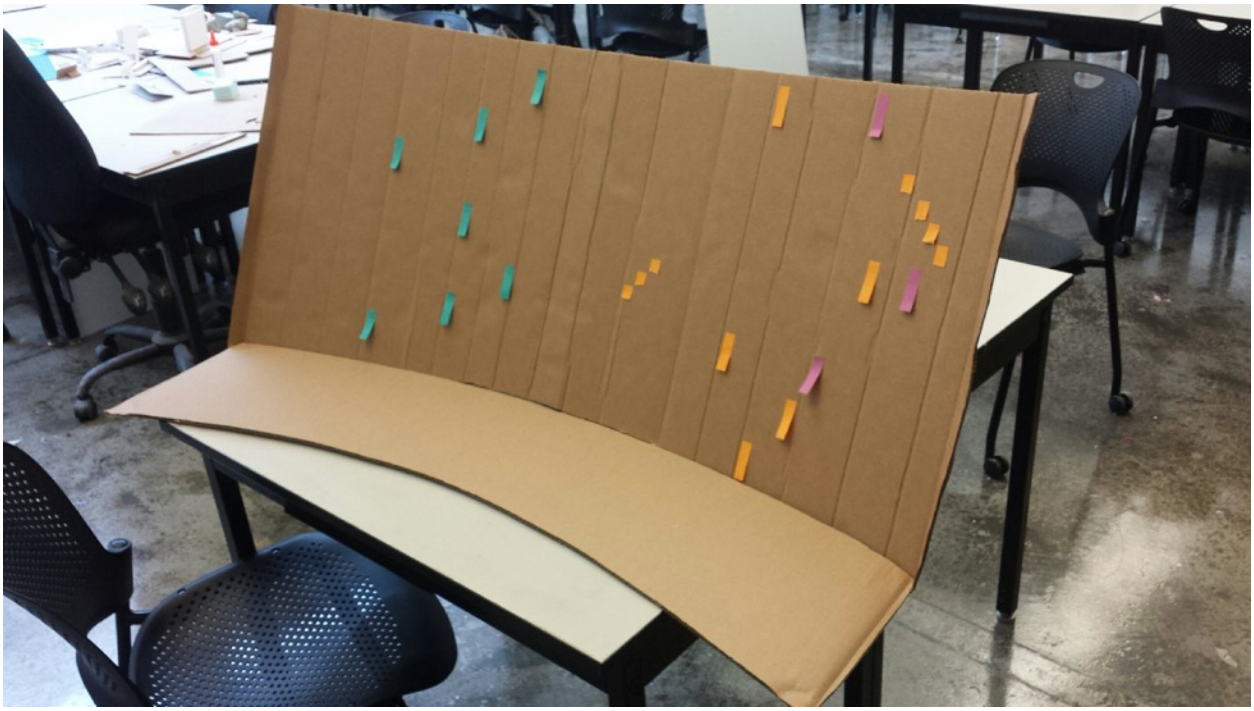


Figure 17: Curved Keyboard Projection Cardboard Mock-Up

Figure 17 shows one of my experiments I did with some cardboard and sticky notes. The bottom part is meant to represent a slightly curved keyboard and the top part is a display system with “falling notes”, similar to Guitar Hero. This can also be used in the same way to visualize the music in front of the musician, for the audience or for personal pleasure.

Taking these visualizations one step further, what is possible when we step into the world of Virtual Reality? See Chapter 12 for my predictions on the future of music creation.

3.2g **Cymatics**

Cymatics is defined as the study of waveforms and their visual representations. **(**TheFreeDictionary 2014, 1). This is one of my all time favorite topics and I was blown away when I discovered it.

When a frequency is crossed with physical matter, specifically natural elements such as sand or water, the pattern hidden within the frequency is visualized. Figure 18 will help you understand exactly what I'm talking about. This person is adjusting the frequency of the note by adjusting the knobs on their frequency generator. The metal plate, covered in sand, will vibrate to that frequency chosen by the user. Each specific frequency creates a different pattern in the sand. Cymatics visualizes the patterns that are always present in the vibrations, but remain unseen by human eyes.

Figure 18: Cymatics Sand Vibration Plate

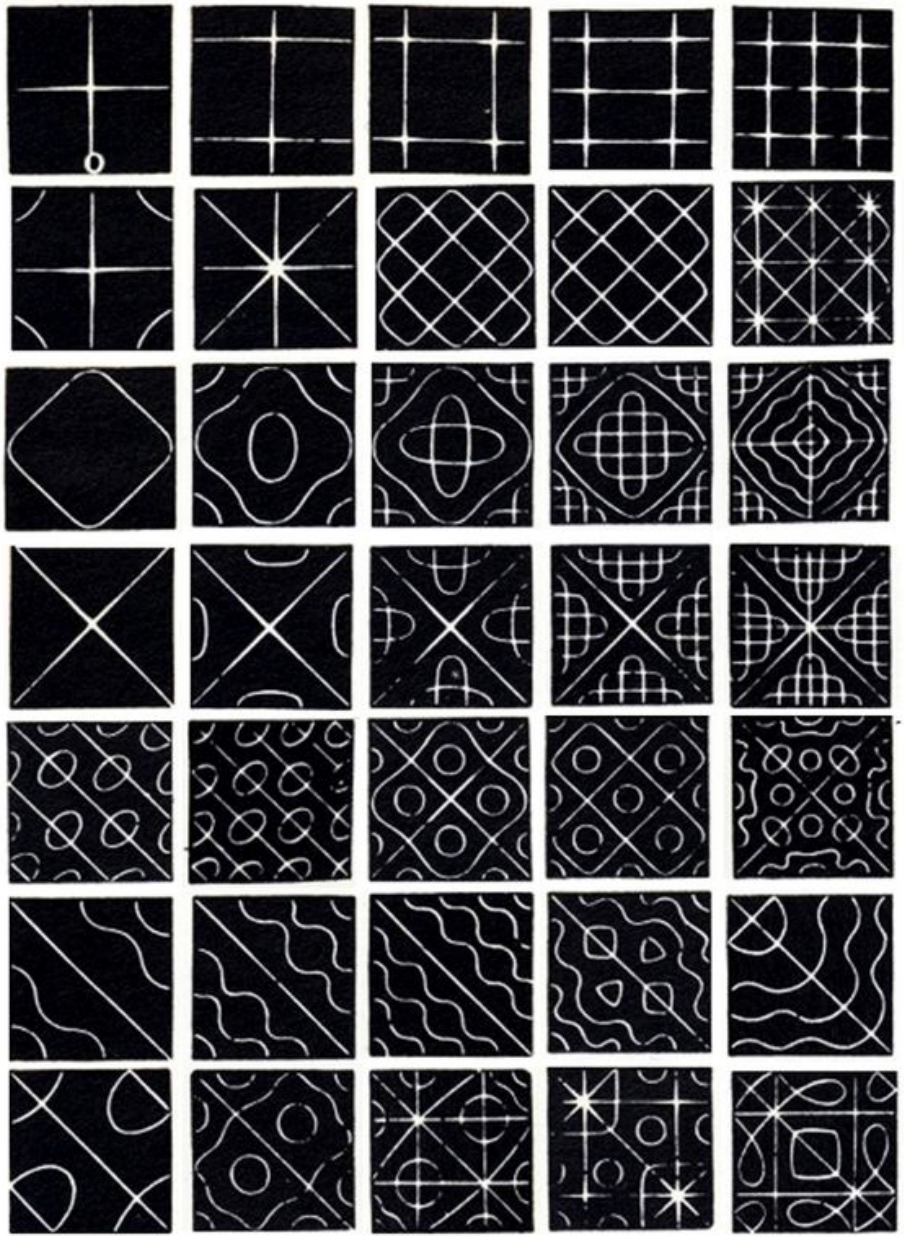


Figure 19: Cymatics Sand Patterns

Figure 19 displays just a few of the huge number of patterns that can be produced according to each frequency produced by an oscilloscope. It's pretty amazing what we can see when you start to visualize the hidden patterns in nature. It makes you wonder what other amazing things there are to discover.

3.3 **Musical Instruments**

As I researched about the broad topic of music, I was looking into **creating** music as well. I studied the musical instruments that are widely accepted by the world (drums, guitar, piano, bass, etc.) and those that are more experimental and only appeal to a small population of enthusiasts (rumitone, one-of-a-kind instruments, etc.). I was intrigued by the fact that some instruments have been considered amazing for centuries, while others were merely a fad for a few years or even months.

This raised an interesting question:

Why are some instruments widely accepted while others are left behind?

Well, one major part of playing an instrument is body movements. Some instruments have very expressive and natural body movements. Take playing the drums for example. When watching a drummer on stage the audience can see the exaggerated movement of hitting the drums and cymbals that it takes to create the sound, which makes for an entertaining show.

These exaggerated body movements help the audience perceive the music. Even if you could not hear a drummer playing, you could still see their quick movements and understand when they are bringing the energy to the performance. Is it the instruments that have the best “performance” movements the ones that stuck around?

Other instruments, such as the harmonica, are more difficult to see what is going on and really involves listening to get the full experience. The harmonica is small and usually blocked by the musicians hand, although even harmonica players can be very expressive with their body movements: leaning back and forward according to what they are playing.

3.4 **Initial Interviews**

3.4a **Who, What, Where, When, and Why?**

I conducted a number of interviews with musicians, music enthusiasts, and other people related to the music scene, such as music therapists or sound designers, to get some opinions on my potential thesis topics and choose a direction.

I began the interviews by gaining some insight about each person. What do they do for a living? What is their relationship with music? Do they play a musical instrument? How does music play a part in their lives?

Once I had a good understanding of the person's perspective, I would introduce the mind map I had been working on and some of the potential directions I could go. Naturally, each person had an interest in a different topic.

I had long conversations about topics on my mind map: from the conceptual talking points and visions of the future to the problems they were having with their own instruments. It seemed that most musicians were not interested in the conceptual talking points, but rather in improving the features of their physical instruments: the interface, size, and experience using it throughout their life.

I felt that it was appropriate to design an object rather than a software concept, seeing as I am in school for Industrial Design. I wanted to make a physical product and not rely on other people, such as visual animators or engineers, to get my thesis done. With this in mind, I strayed away from the "creating visualizations of music" and instead decided on "improving the experience of the keyboardist through user-centered design thinking."

3.4b **Main Interview Conclusions**

Upon completing my interviews, I realized that there was a concern among keyboardists about their experience with traveling. **Traveling with a full-size, 88-key keyboard is the major pain point for gigging musicians.**

I decided to improve the experience of modern day, on-the-go keyboardist by redesigning the keyboard. At the time, I was fairly familiar with the keyboard and believed that it could be improved in many innovative ways.

Also, unlike other instruments such as the guitar, I would not need to worry about the tension of strings (although I would have to study other complex subjects, like key resistance). Instead, I was able to focus on the areas, such as the size, feel, and experience of using a digital keyboard.

Ch 4 **User Profile & Context**

4.1 **The Modern-Day Keyboardist**

Name: Vincent (shown in Figure 20)

Bio: Gigging Keyboardist.

Travels with his keyboard by Walking, Car, Bus, Train, or Airplane.

Skill Level: Intermediate-Advanced.

Traveling: He drives back and forth from his house to band practice, jam sessions, and to concerts.

When his concerts are out of his home town, he takes the bus, train, or even airplane.

Figure 20: Vince Welnick - Grateful Dead Keyboardist

4.1a **The Experience of a Musician: Traveling & Performing**

There are two main constant aspects of working as a gigging musician: traveling and performing. Of course there are other parts of it, being social, meeting other musicians and fans, but even that is not completely necessary.

Overall, one thing remains constant: as a gigging musician you must have your instruments at your show for you to play. To get those instruments to the show, it is inevitable that they will have to move from one place to another.

Once you are a widely successful musician, hopefully you will pay someone to move your instruments for you. But for those keyboardists who do not have the luxury of having personal assistants, the burden of traveling remains a harsh reality.

4.1b **Why Does Vincent Need A More Portable Keyboard?**

Figure 21: Vince Welnick Performing

As a a gigging keyboardist in a band, Vincent is constantly traveling with his instrument.

He struggles with carrying his keyboard around with him because it is so heavy and bulky.

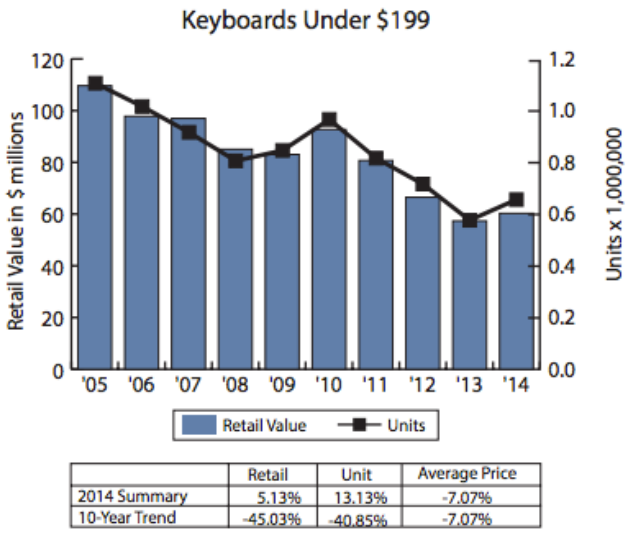
He wishes that he had a keyboard that was easy to travel with, but also maintains the professional sound, number of keys, and high-quality feel he has become accustomed to. We can see Vincent's robust musical setup in Figure 21.

Unfortunately for Vincent, and many other keyboardists around the world, currently there is no such portable, full-size keyboard on the market.

4.2 **Market / Numbers (How Widespread Is The Problem?)**

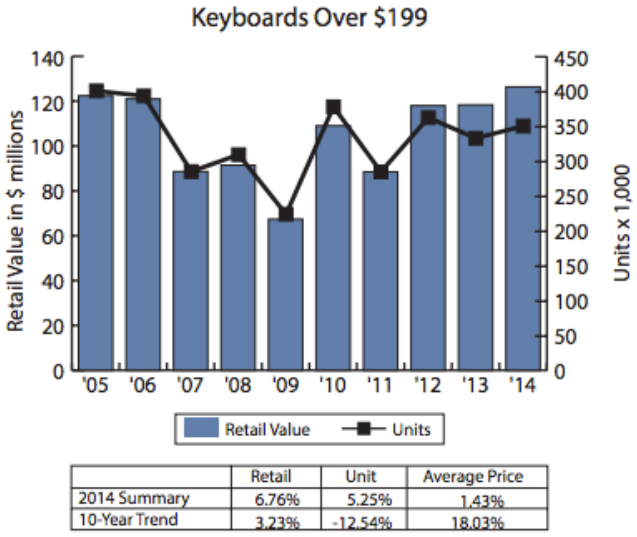
For my thesis, I am mainly focused on the over-$200 keyboard market, as gigging musicians will typically spend much more than $200 on their keyboards. Figures 22, 23, and 24 are from the National Association of Music Merchants Global Report 2015. They represent the retail value of keyboards in millions of dollars vs. the number of units sold in thousands or millions. By analyzing this data, it is clear to see if the raw number of keyboards sold is increasing or decreasing, and the retail value associated with it indicates if people are paying more or less for their instruments compared to past years.

According to the National Association of Music Merchants Global Report for 2015, there are roughly 1 million keyboards sold in a year. 650,000 of these keyboards cost under $200 while the other 350,000 cost over $200 (NAMM 2015, 34). There is also a large market for synthesizers, a cousin of the keyboard.



	Retail	Unit	Average Price
2014 Summary	5.13%	13.13%	-7.07%
10-Year Trend	-45.03%	-40.85%	-7.07%

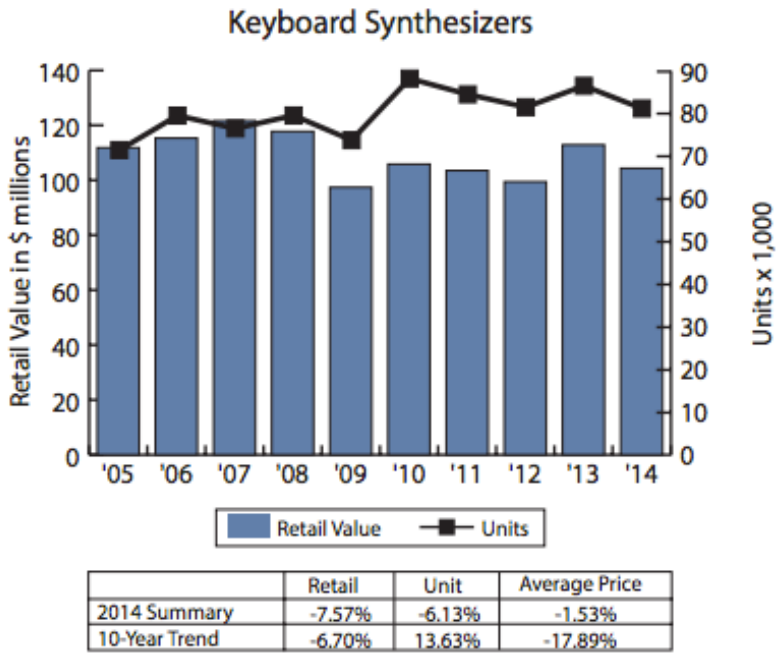
Figure 22: Keyboards Under $199 Market Graph



	Retail	Unit	Average Price
2014 Summary	6.76%	5.25%	1.43%
10-Year Trend	3.23%	-12.54%	18.03%

Figure 23: Keyboards Over $199 Market Graph

I also take into consideration the synthesizer market because musicians from this market are usually buying keyboard-based products as well.



	Retail	Unit	Average Price
2014 Summary	-7.57%	-6.13%	-1.53%
10-Year Trend	-6.70%	13.63%	-17.89%

Figure 24: Keyboards Synthesizer Market Graph

As you can see in Figure 24, the Synthesizer market has stayed steady in number of units sold while decreasing in retail value within the past years. This means that people are paying less for synthesizers than they did in the past due to improved efficiency of technology (NAMM 2015, 31).

4.3 **Personal Observations as a Keyboardist in Megalodonis**

When I joined Megalodonis as the keyboardist, I did not know what to expect. I had never performed for anybody before. Instead, for the past year I had been practicing piano in my basement by myself. No pressure, no traveling, just carefree music creation.

Once I joined the band, I needed to bring my instrument back and forth from band practice, jam sessions, and shows. Since I travel by car, this meant I needed to fit all my gear into a tight space. With time I was able to find a way to fit the keyboard, along with my amplifier, keyboard stand, and bench, into my 4-door sedan.

Eventually I became annoyed with my instrument. Yes, it was great for creating music, but it was horrible to bring anywhere. It was heavy and long, which makes traveling very difficult. Ultimately it was my bad personal experience that inspired me to come up with a better solution to the burden of keyboard travel.

I have documented my experience with pictures of myself traveling with my keyboard, shown throughout 4.4.

In Figure 25 you can see four of the seven members of Megalodonis in our first basement show!

Figure 25: First Megalodonis Basement Show

4.4 **The Experience of Traveling with a Keyboard**

A full-size keyboard (88 keys) is a very large object. The number and size of the keys make it so lengthy. Usually 88-key keyboards are about 5 feet long.

Any object that is 5 feet long is naturally difficult to travel with.

The internal components and materials of the keyboard add up in weight, making them very heavy and difficult to carry. Full-size weighted keyboards can range from 25-40 pounds. (Weighted refers to the key resistance type)

Figure 26: Me with my Korg Kross 88 and amplifier

25 pounds would be considered “extremely lightweight” for a keyboard, although by any other standard it would be considered fairly heavy. Korg claims the Kross 88 is extremely lightweight at 27.3 pounds. (Brouillette 2016, par 6).

Imagine if your laptop was 5 feet long and 25, 30, or even 40 pounds…

You probably wouldn’t want to carry it around that much.

Figure 27: Fitting through the Doorway with my Korg Kross 88 Keyboard

4.4a **Walking and Carrying**

The heaviness and bulkiness of the keyboard makes it very awkward to travel with.

One of the most basic and yet most difficult tasks is fitting through doorways.

Whenever I need to do this, I swing the door open and try to make it all the way through without the door coming back and hitting my instrument. I successfully fit through the door about half of the time.

Going through any tight spaces, like doorways or hallways, requires careful precision. I have scuff marks throughout my house from the times that I couldn't quite fit the instrument around the corner without hitting something.

It is also **awkward to walk up and down stairs**. Before ascending the stairs, the musician must tilt the keyboard to the same angle of the stairs. Not tilting the keyboard will result in hitting it against the stairs, making it impossible to walk up.

Figure 28: Walking up the Stairs with my Korg Kross 88 Keyboard

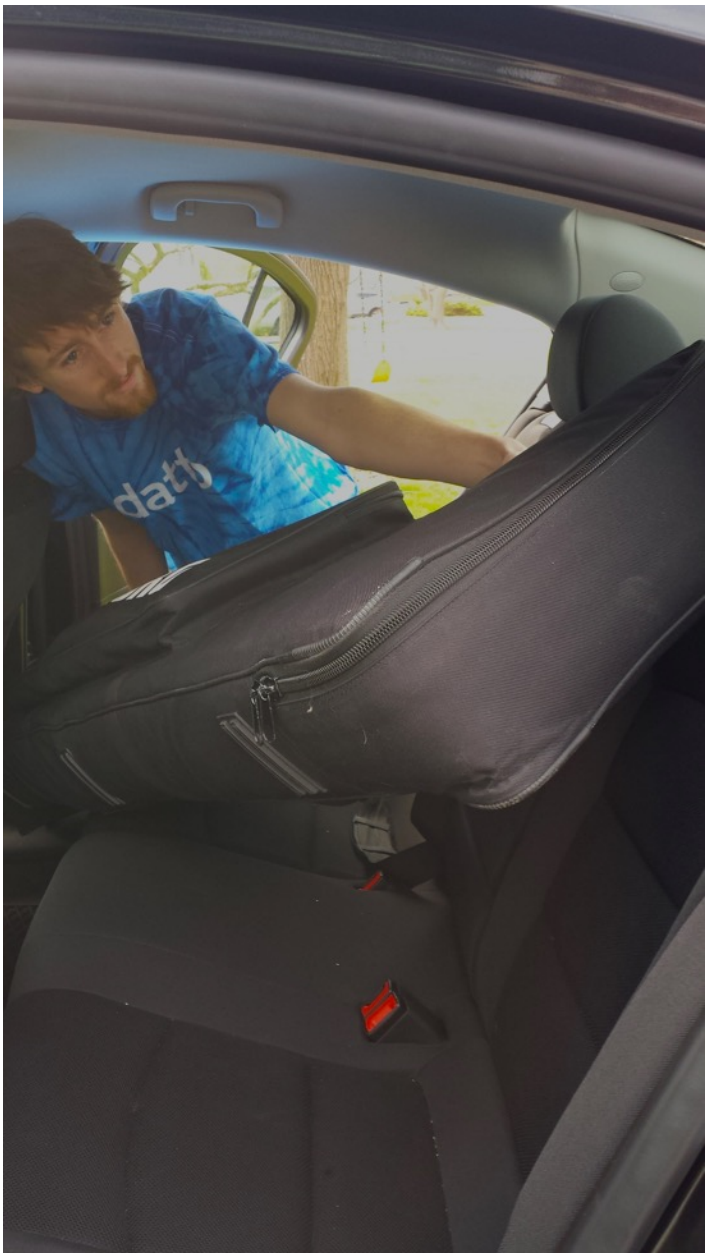


Figure 29: Traveling by Car
with my Korg Kross 88 Keyboard

4.4b **Driving in a Car**

A full-size keyboard is a struggle to fit into most cars. You have two main options: to fit the keyboard diagonally across your back seat and close the door before it slides back out, shown in Figure 29, or fold down your back seat and place it into the car through the trunk.

Either way, when traveling by car, **you are likely to sacrifice a seat or two for the keyboard.**

"Sorry man, I can't give you a ride. I'm driving one other person and my keyboard takes up the whole back seat."

-Me on many occasions.

4.3c **Taking the Bus or Train**

Similar to the hassle of fitting the keyboard into a car, the train or bus do not leave much room for the instrument either. A public bus or train with open space might leave a bit more room to hold your instrument next to you, but it will still be very difficult to bring the keyboard stand, and bench along as well.

4.4d **Traveling by Airplane**

Airplane travel and keyboards don't mix very well. Many musicians ask online forums: "how do I travel with my keyboard overseas?" Unfortunately for them, the answers are pretty unsatisfying.

Keyboardists have three main options for airplane travel: buy a $300 ATA case (or flight case) and check your instrument, buy another airline ticket for your keyboard to sit next to you, or ship it through the mail. As you can see in Figure 30, not every instrument makes it to the destination in one piece if the baggage is checked.

Figure 30: Keyboard Damaged During Airline Travel

North American Airlines	Dimensions (inches)	Linear Inches	Weight (lbs)
AeroMexico	22 x 14 x 9	45	22
Air Canada	21.5 x 15.5 x 9	46	22
Alaska	24 x 17 x 10	51	none
Allegiant Air	22 x 14 x 9	45	none
American	22 x 14 x 9	45	40
Delta	22 x 14 x 9	45	40
Hawaiian	22 x 14 x 9	45	25
JetBlue	24 x 16 x 10	50	none
Porter	22 x 16 x 9	47	20
Southwest	24 x 16 x 10	50	none
United	22 x 14 x 9	45	none
US Airways	22 x 14 x 9	45	none
Virgin America	24 x 16 x 10	50	30
WestJet	21 x 15 x 9	45	none

Figure 31: Airline Maximum Carry-on Baggage Dimensions

It would be ideal to be able to take your keyboard on the plane with you, but the length of the keyboard makes it too big to bring on the plane without paying extra fees for oversized carry-on baggage. Figure 31 shows the maximum carry-on bag dimensions for each airline, and as you can see, they are much smaller than the 5 foot (60 inch) keyboard. Normally there would be no way to bring a full size, 88-key keyboard onto a plane without paying extra fees for oversized baggage.

4.5 **Online Forums**

I read and engaged in online piano and keyboard forums to make sure I was solving a worthwhile problem. The following graphs show the percentage of forums responses with the same answer. From this information, and other forums across the internet, I am able to see what concerns musicians really have and what things they are talking about.

Forums are a great tool because they allow me to quietly observe the advice that musicians are giving to other musicians. Obviously, there needs to be caution when using public forums, as some of the answers could be completely wrong or even made up. I ensured the answers were an accurate consensus by cross-checking the feedback with many other forums and "question & answer" websites online.

People in the keyboard community are talking about the need for a more portable keyboard (PianoWorld 2014, 1). People are suggesting different things, but usually there is something wrong with it (most of the time its too long to fit for travel).

Some people have even gone so far as to hire someone to chop down their full-size keyboard so they can remain with the comfort of the instrument they have come to know, while allowing for the convenience of portability. Figure 32 shows a modified 53-key keyboard, once an 88-key keyboard.

Figure 32: Custom Chopped Down 88-Key Keyboard

4.5a **Reddit**

*“I am designing a professional 88 key keyboard. What are your **biggest complaints** about your instrument?”*

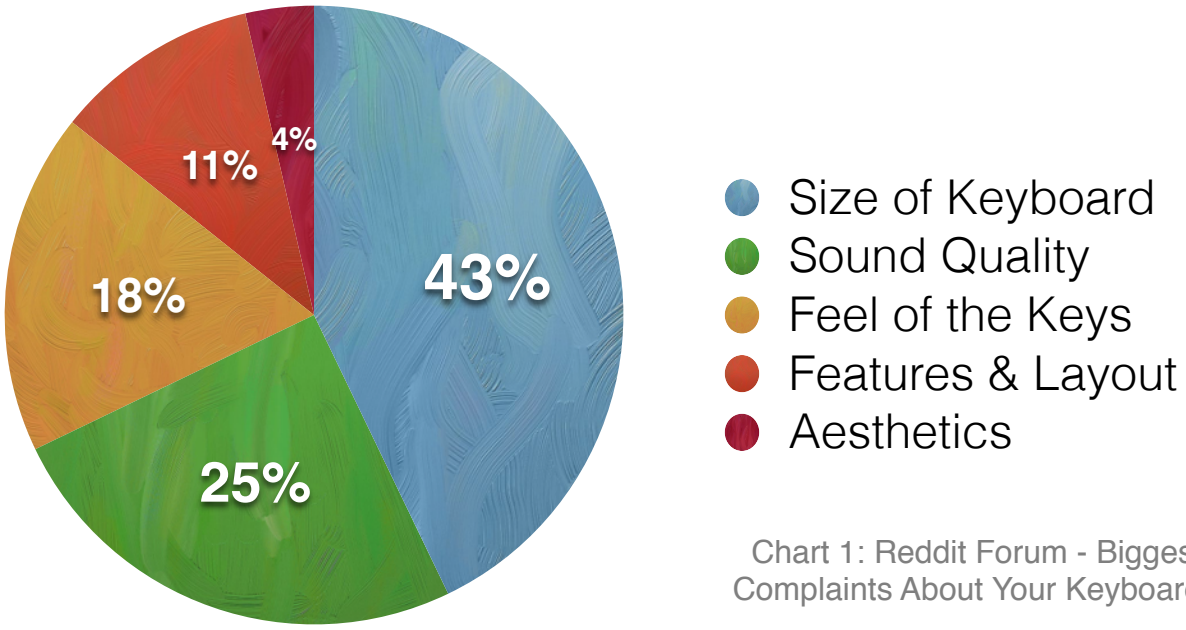


Chart 1: Reddit Forum - Biggest Complaints About Your Keyboard?

*“Heavy… making it hard for gigging. Super long too, especially in the case. Hard to fit anywhere in a car, **but that's what I get for insisting 88 keys**.”*

-Reddit User

4.5b **Piano World**

*"I am **traveling overseas**. The only way to get there is to fly on an airplane. **How can I bring my full-size keyboard with me?**"*

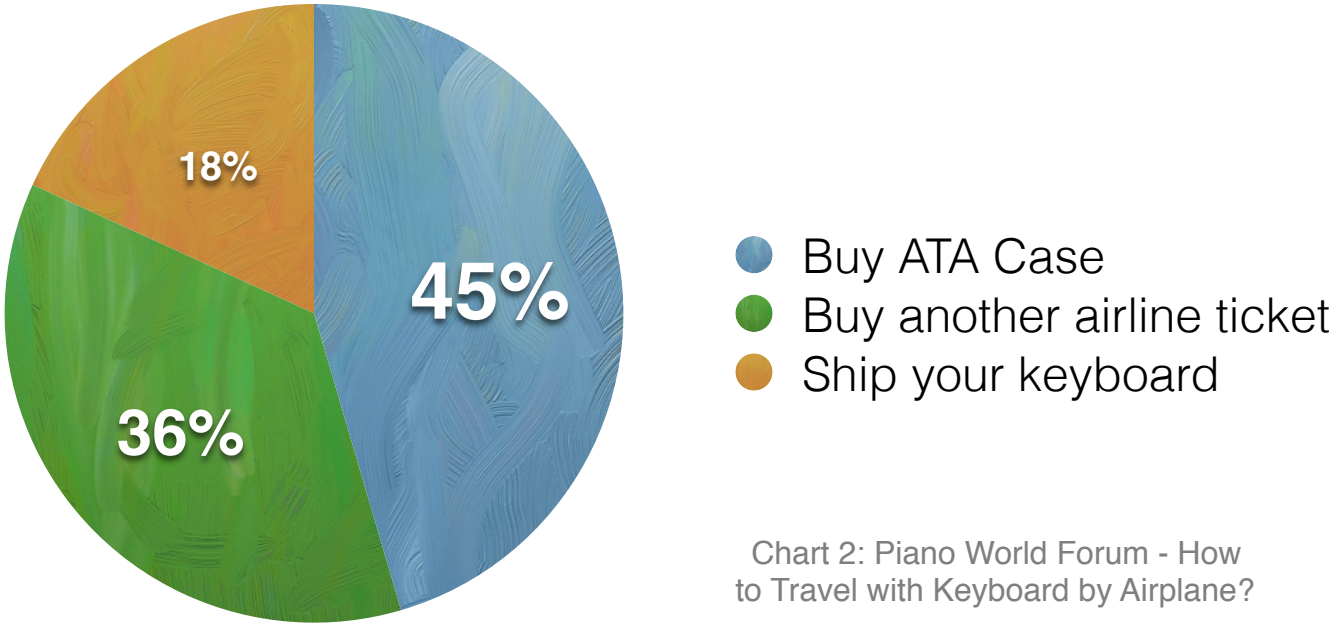


Chart 2: Piano World Forum - How to Travel with Keyboard by Airplane?

4.6 **Online Research / Inspiration**

I researched potential solutions to traveling with a keyboard. There was one keyboard, the Vax-77, shown in Figure 33, that folded in half for traveling purposes. This keyboard was talked about on forums, but the actual company discontinued making these special instruments.

Figure 33: Vax-77 Folding Keyboard

The Vax-77 was quite expensive, coming in at $3,000. It was also heavy, weighing 37 pounds. Yes, the length of the keyboard was shortened, but it remained heavy, thus still a pain to carry around.

Although the keyboard community was excited about the product, in the end it failed. Not enough people were willing to spend that much more money just to have the convenience of portability. And some would even argue that the Vax-77 was not much more portable at all due to its weight.

Another major inspiration for my project is the Teenage Engineering OP-1. This small $800 synthesizer is a beast. It's remarkable, timeless design makes for a comfortable and fun experience when playing the instrument. It is portable enough to conveniently fit into a backpack and is the perfect powerful on-the-go instrument.

Figure 34: Teenage Engineering OP-1

Many keyboardist want the to have the power of the OP-1 with the full size keys they are accustomed to so that they could get a good practice that would translate back to their full-size keyboard.

If the OP-1 were the size of a normal 88-key keyboard, it wouldn't be a big deal in the music industry. The reason the OP-1 is so amazing is because of the power packed into a small space. Without the portability factor, the OP-1 is just another synthesizer / looping station.

4.7 **How Should Keyboards be Designed?**

I have determined that a keyboardists routine consists of main things involving the keyboard:

1) Traveling with the keyboard (walking, driving, flying, etc).
2) Playing the keyboard, thus creating beautiful music (hopefully).

After researching the experiences of other keyboardists, and experiencing traveling with a keyboard, I realized there was a need for a more portable full-size keyboard.

4.8 **The Final Problem Statement**

Keyboardists have difficultly traveling with their full-size, 88-key keyboards due to the sheer size of the instrument.

The large size of a 88-key keyboard makes traveling (walking, riding in a car, bus, train, or airplane) an unpleasant burden for musicians.

Ch 5 **Design Goal & Initial Ideation**

5.1 **Design Goal**

My goal was based on the information I had gather through my own research. I noticed there was a major problem that keyboardists were facing when traveling with their instrument.

With this information in mind, I crafted the following statement:

My thesis goal is to design a full-size keyboard
that is better fit for the on-the-go,
face-paced lifestyle of the modern day keyboardist.

The modern day musician: someone who travels and has a need to create music on-the-go, as well as at home or in a studio space. They need to have quick and easy access to their instrument whenever they need it or feel the urge to play. They shouldn't be burdened by bringing their keyboard places. They should have full access to 88 keys and feel as though they are playing a professional-quality instrument.

If designed to be more portable, the keyboard has the potential to promote creativity by giving people a powerful musical tool, wherever they are.

5.2 **Initial Sketches: Improving Keyboard Portability**

I started by sketching out the first solutions that popped into my head that would solve the problem. Figure 35 shows a 4-section folding keyboard sketch.

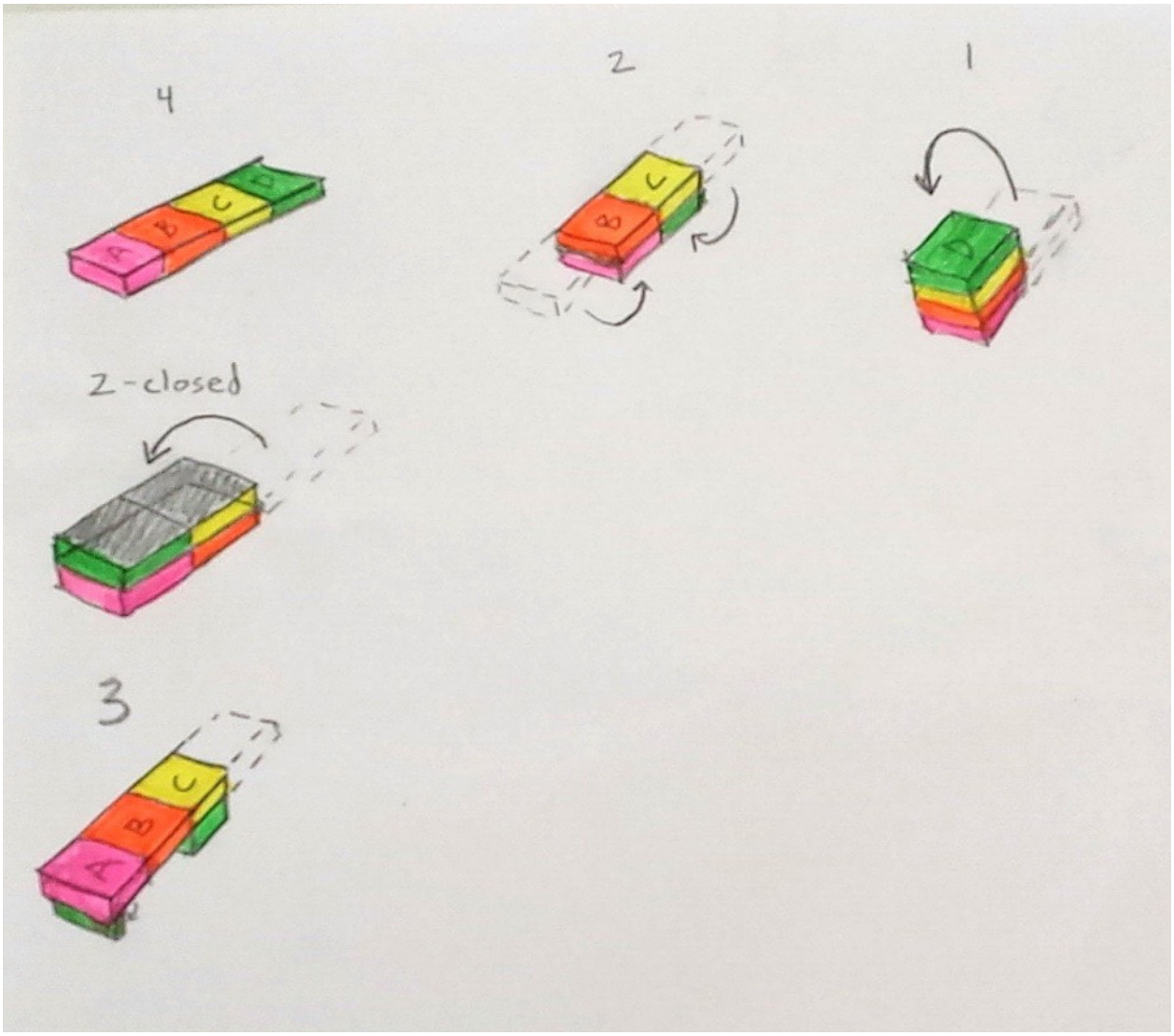


Figure 35: Folding Keyboard Concept Drawing

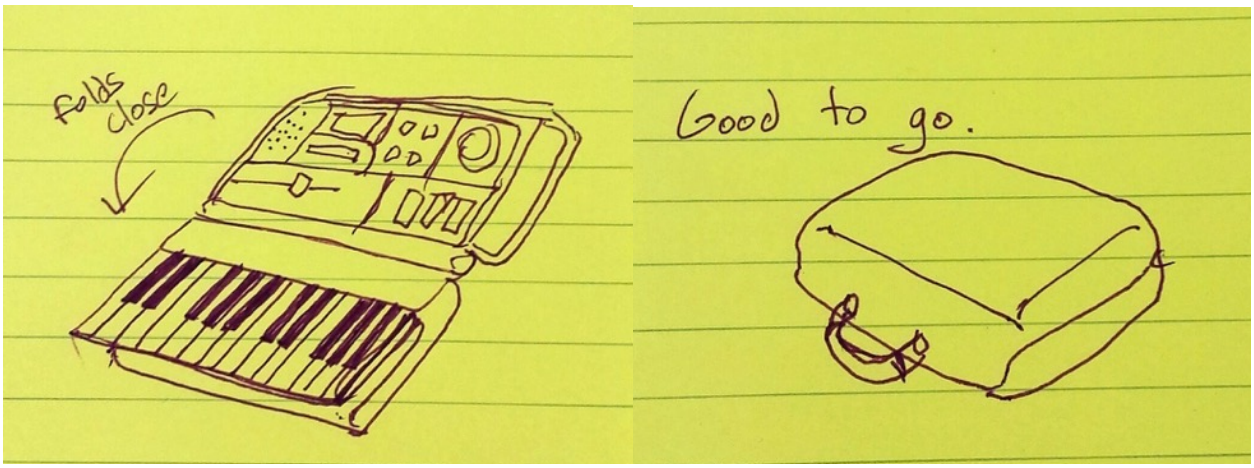


Figure 36: Suitcase Keyboard Concept Drawing

In Figure 36 there is the suitcase-keyboard / synthesizer. I was also considering the idea of modular controls so that the musician can choose the style of buttons, sliders, knobs, or any other interface option they would like. Figure 37 shows how a full size keyboard could fold at each 22-key section, and the key resistance could be removed to split up the weight for lighter travel options.

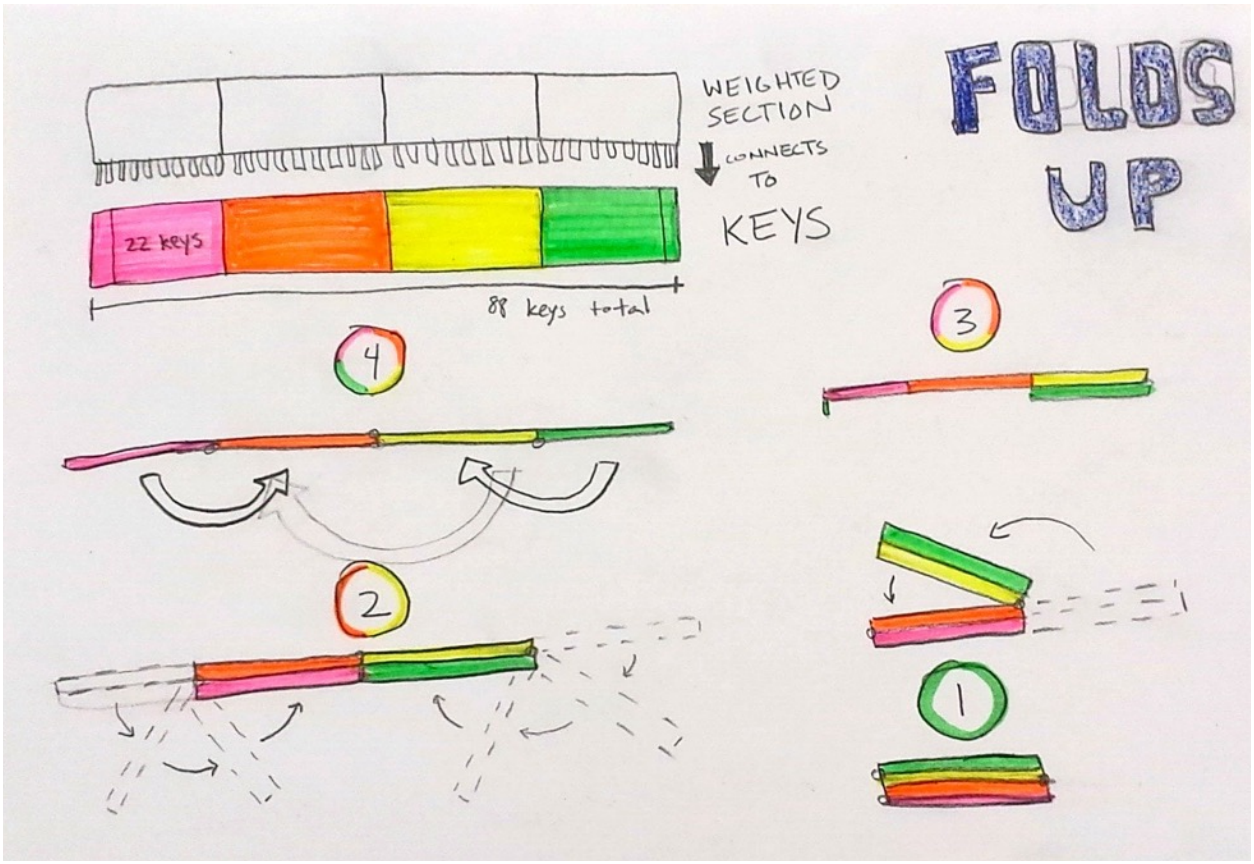


Figure 37: Folding Keyboard with Detachable Weights Concept Drawing

Ch 6 **Evolution of Products (Portability)**

6.1 **Technology Advances with Moore's Law**

Moore's law was created by Gordon Moore in 1965. It states that the number of transistors per square inch on integrated circuits will double every year (Investopia 2016, par 1).

So what does this mean for the Average Joe? This means that more technology can be packed into a smaller products, year after year.

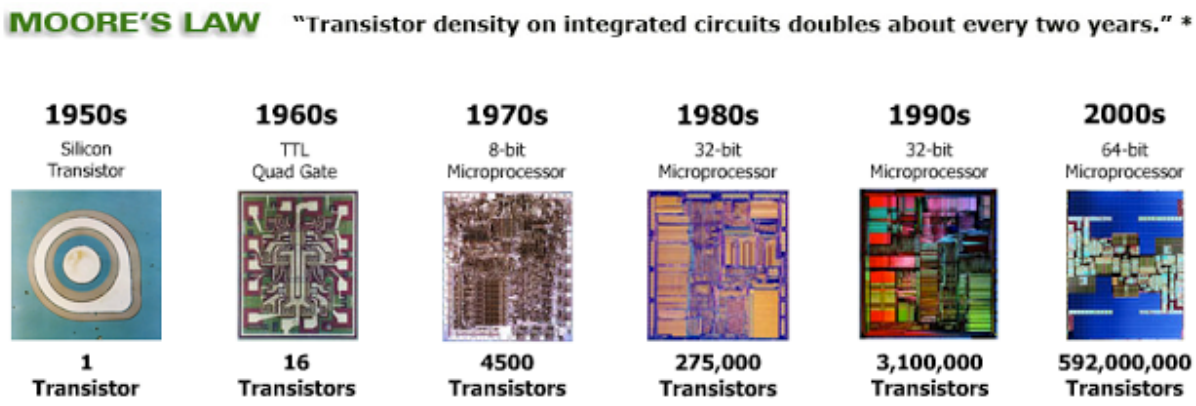


Figure 38: Moore's Law - Transistor Density Timeline

Figure 38 shows that more and more transistors are able to fit into the same small space year after year. Moore's Law has remained true for the past 70 years, but interestingly, we are almost reaching he limit of this law, as we cannot make transistors any smaller.

6.2 **Products Evolve To Become More Portable & Convenient**

There is a trend in products to become smaller and smaller until it reaches the most convenient size for its purpose. Televisions, telephones, and computers are the most notable examples of products that have evolved into a more slimmed down form, but have even more power and capabilities than in the past. Figure 39 shows the evolution of the computer: once a size of an entire room, now a slimmed down slate.

Figure 39: Evolution of the Computer

I do not think that the full size digital keyboard has reached its final stage of portability. The user experience of travel and convenience could be improved through innovations in design. If the musician is going through pains everyday traveling with their instrument, there has to be a better way.

6.3 **Simplicity is Timeless**

With the chaos of the digital age, where you can virtually be a hundred places at once, it is logical to simplify what is going on in your life. This simplicity can be applied to products as well.

Let's take Dieter Rams for example. He designed products for Braun that were simple and "nothing more than they needed to be." Amazingly, 30 years later, his designs are still considered some of the most elegant and timeless. He did not try to make things fancy by adding some cheesy graphic or form to the product in hopes that it would be a quick seller. Instead, Dieter Rams worked by the motto: "As little design as possible."

Figure 40: Dieter Rams' Iconic Record Player

Wacky trends will become outdated, but a simple, minimalist product will not. Figure 40 is an iconic record player designed by Dieter Rams, whose design philosophy inspired many others to become more simplistic and minimal. (Lovell 2015).

In addition, some other great minds recognize the importance of simplicity.

Chopin, a famous classical pianist, once said, “after one has played a vast quantity of notes and more notes, it is simplicity that emerges as the crowning reward of art.”

Leonardo Da Vinci, famous inventor and artist, once said, “simplicity is the ultimate form of sophistication.”

I tried to design my portable keyboard solution with minimalism in mind.

Ch 7 **Music Gear Benchmarking**

7.1 **Keyboard Options: 25, 49, 61, 73, or 88 keys**

Musical keyboards come in a variety of options. The number of keys offered on a keyboard is usually 25, 49, 61, 73, or 88 keys. An octave (from one note up until it repeats that note again, ex. from C to C) on a piano is 12 keys, shown in Figure 41.

Figure 41: One Octave on Piano Keys

It is a combination of these 12 notes that makes up **all** of Western Music we know and love today.

The number of 12 is important because that covers all the notes in an octave. The number of keys on the different variations of keyboards is based around this number 12.

25-key keyboard = Two 12-key octaves (24 keys total) + One extra higher C note.

49-key keyboard = Four 12-key octaves (48 keys total) + One extra higher C note.

61-key keyboard = Five 12-key octaves (60 keys total) + One extra higher C note.

73-key keyboard = Six 12-key octaves (72 keys total) + One extra higher C note.

88-key keyboard = Seven 12-key octaves (84 keys total) + One extra higher C note
+Three extra notes below the lowest C (B, B flat, and A).

7.2 **Full-size (88-key) Keyboards**

The full-size 88-key keyboard is the main focus of my research. A gigging keyboardist usually would have a high-quality instrument, complete with full-size keys, good key-resistance, and amazing sound options to choose from.

A high-quality, full-size keyboard with all of these features (full-size with accurate “piano-feeling” keys) usually starts around $700 and can go well beyond $5,000 (Google Shopping, 1).

All of the full-size keyboards that are marketed as “portable” are not actually that portable because they are still so lengthy. Even if the keyboard weighed only 5 pounds, it would still be difficult to travel with due to the large size.

More information regarding full-size keyboard travel can be found in 8.

7.3 **MIDI Keyboards**

Figure 42: Alesis QX25 MIDI Keyboard

MIDI keyboards are able to send data from the instrument to another device, such as a synthesizer, or to a music creation software on the user's laptop. This is especially helpful when making music with a laptop, as now the musician can use a piano style instrument instead of being confined to the mouse and keyboard. These keyboards usually are much cheaper because they do not have a built-in sound engine. Instead the keyboard relies on the sounds generated through the music program running on the external source.

Usually keyboardists buy MIDI keyboards that are smaller than 88 keys, usually 25, 37, or 49 keys. This is because these MIDI keyboards are usually tethered to a laptop or tablet for an external sound engine, so the musician wants something that can be easily carried around with their laptop, usually in their backpack. This is a major inspiration for my module idea, as there is already a market for small MIDI keyboards simply for their convenience. If musicians had the power to expand their smaller keyboard setup after they had purchased it, they would be very happy. MIDI keyboards are also especially popular among the DJ community for the convenient at home or on-the-go music creation.

7.4 **Synthesizers**

Synthesizers are similar to keyboards because they use the same piano-style layout of the keys. However, the power of the synthesizer is not in the keys, but rather in the ability to shape the sound however you'd like using a combination of waveforms, usually square, sawtooth, sine, and triangle. You get a different sound depending on the waveform. Looking at the waves gives you a little indicator or what the sound like! Sine is more soft and wobbly back and forth while triangle is very sharp and exact, mainly used in old school video game soundtracks. After the wave is selected, the musician adds filters to shape the sound even further. The synthesizer revolutionized the music in the world throughout the 1980s.

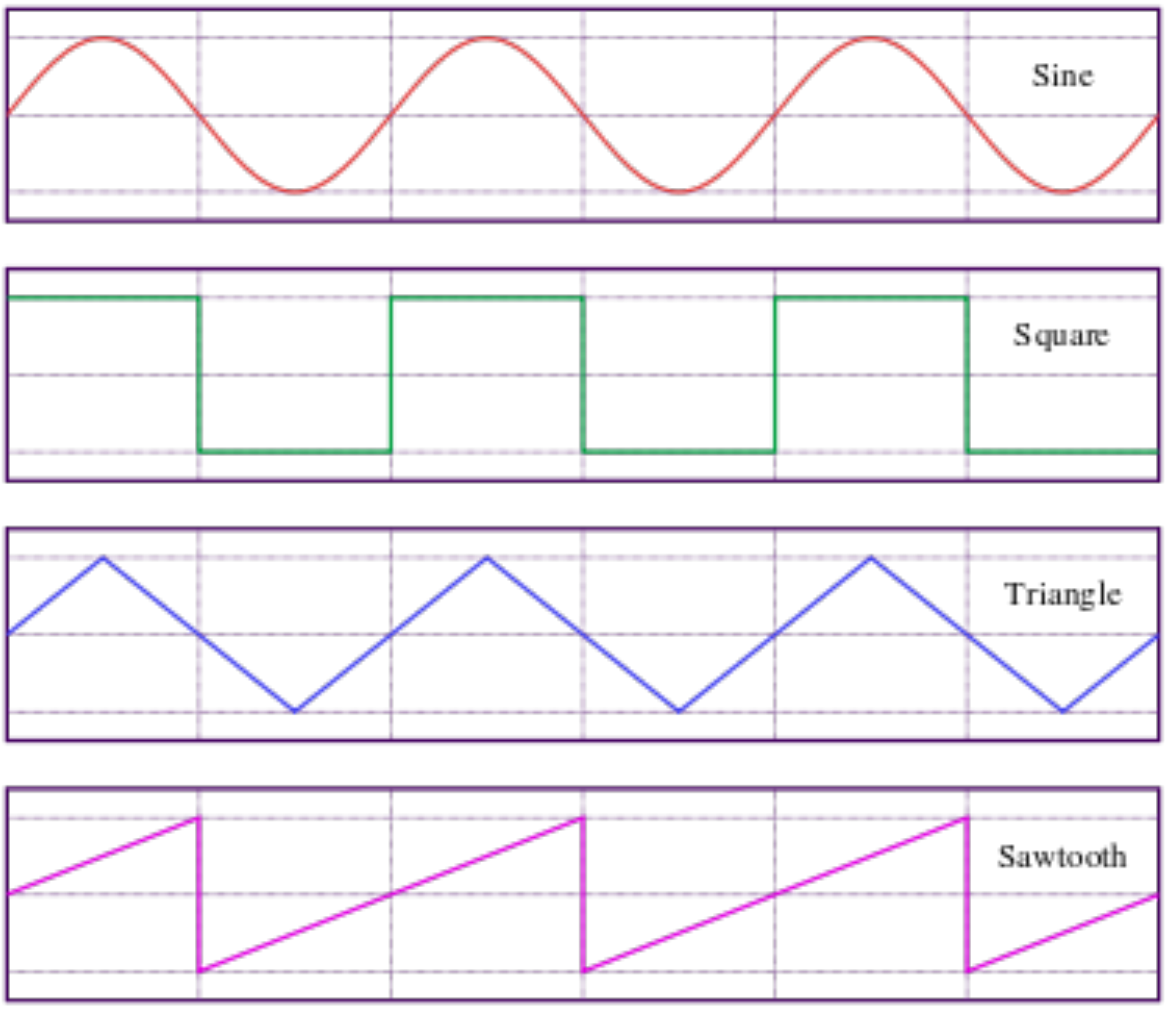


Figure 43: Types of Waveforms

These devices, originally used as a scientific tool to create frequencies, have taken over the radio waves and were considered “the sound of the future” when first invented as an instrument.

Figure 44 shows the Korg Minilogue, with built in waveform visualizer so the musician can better understand how they are changing the sound.

Figure 44: Korg Minilogue Synthesizer

7.5 **DJ Gear**

It seems that in the age of the laptop, every other person considers themselves a DJ. This might mean creating their own tracks on the laptop, or mixing together tracks that were already made to create that next popular dance mix. There is all sorts of DJ gear, from digital turntables to drum sequencers. This group of musicians uses instruments that have a lot of features packed into a small space, given that they have to travel with their instrument to each show when performing. This was a great inspiration for trying to determine what is needed and when it seems like there are too many controls and it becomes overwhelming, which happens quite often in these instruments.

And of course, it's always fun to have a glowing light setup when putting on a show. Keyboards could add this light-up feature to help keyboardists see what they are playing when in dark settings.

Figure 45: DJ Digital Turntables

Ch 8 **Experiments & Tests - Key Questions to Consider**

8.1 **Dimensions of an 88-key keyboard**

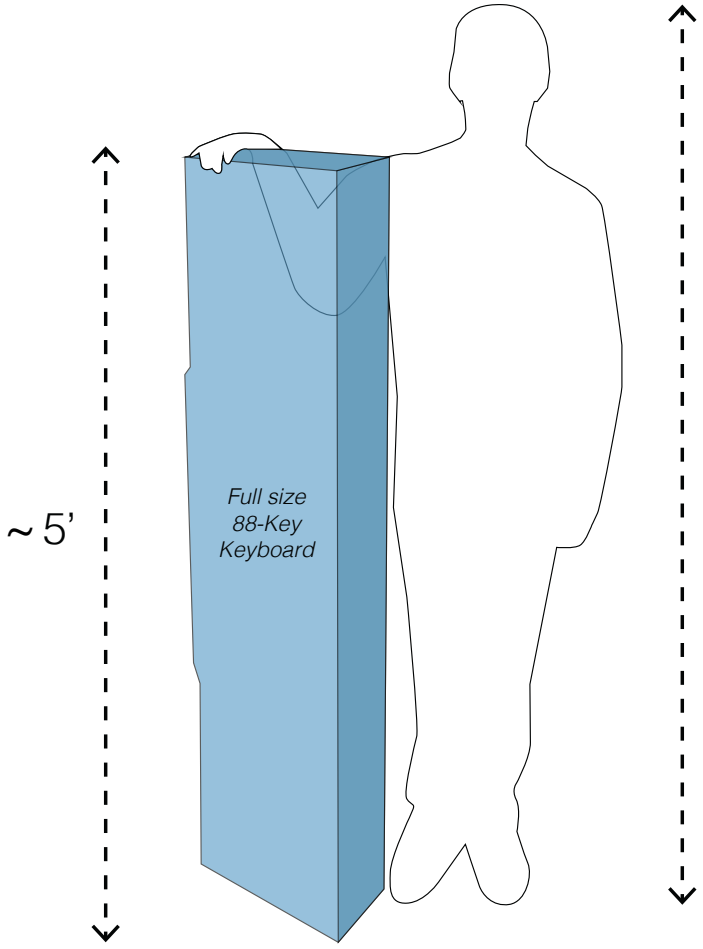


Figure 46 shows the dimensions of my keyboard vs. me. It is clear that my keyboard is as tall as I am.

Figure 46: Dimensions of My Korg Kross 88 Keyboard Vs. Me

8.2 **How to make a full-size keyboard more portable?**

A full-size keyboard is 88 keys. The main issue is that the keyboard is much too big and bulky to travel with.

Figure 47: Dimensions of Korg Kross 88

As you can tell in Figure 47, the keyboard has some pretty awkward dimensions. The problem is the length of the keyboard. Since the keyboard is so long, the user is forced to carry it parallel to the ground, similar to how you would carry a heavy wooden board.

It is possible to make the keyboard smaller by using keys that are smaller than standard size keys. The problem with this is that many musicians prefer the full size keys.
So, without changing the size of the keys, is it possible to design a keyboard with 88 keys to be smaller? Yes of course it's possible, but not in the static, single-piece format that keyboards are produced in today. Achieving portability will require some design innovations.

8.3 **Folding Vs. Modular**

I listed out my potential options for making the keyboard more portable. I came up with two main options: Foldable and Modular.

Foldable:

1 Fold (Halves) - Two sections, 44 keys each.

2 Fold (Thirds) - Three sections, 30 keys each.

3 Fold (Fourths) - Four sections, 22 keys each.

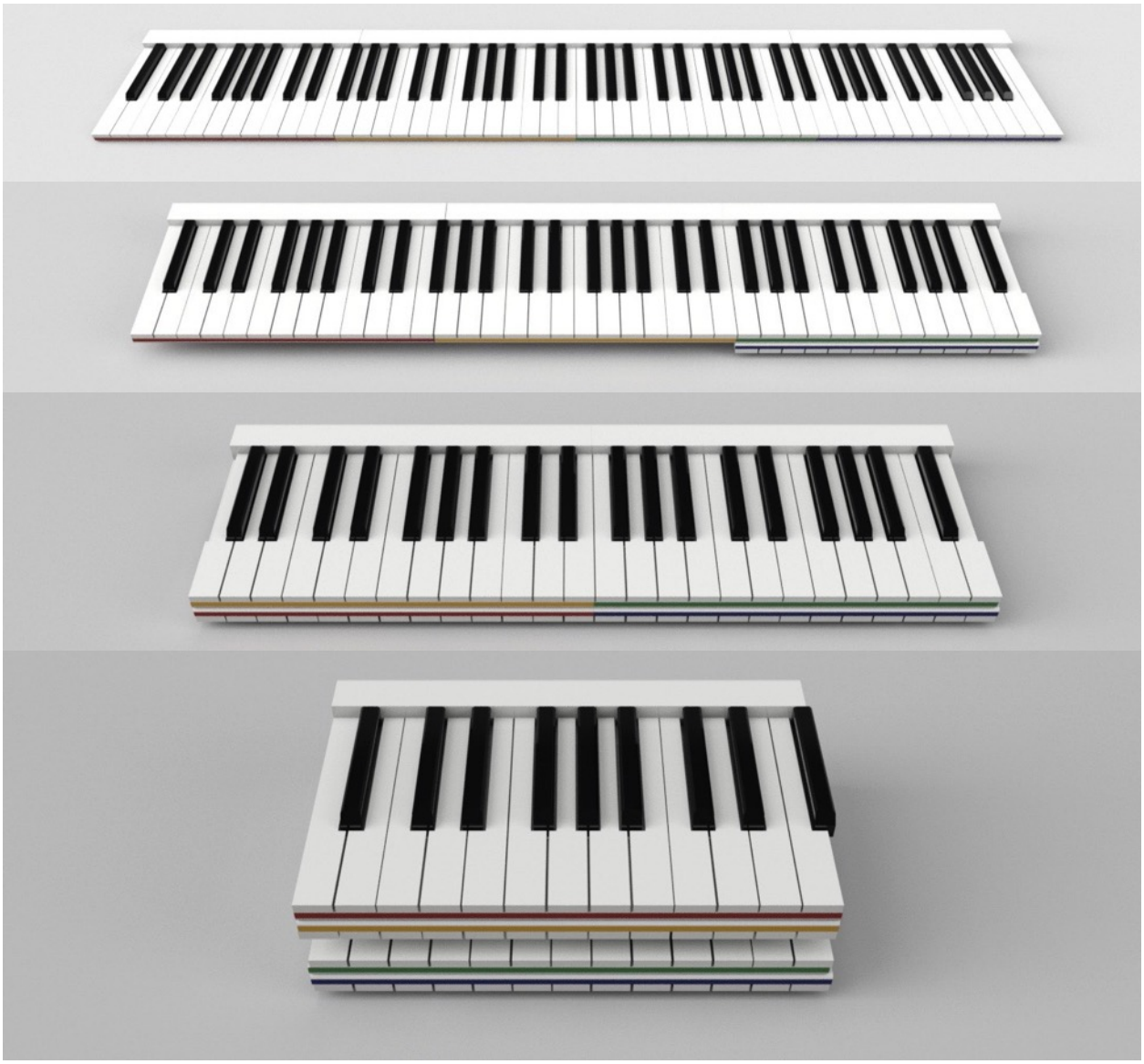


Figure 48: Folding Keyboard Concept

Modular System:

Slot and twist lock

Clamp lock that adjusts

Magnetic clips

Slot in from back

Slot and twist tighten

Screw in

8.4 **Modular Connection System**

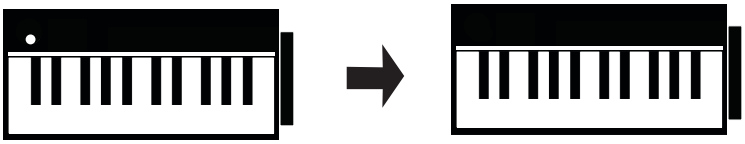


Figure 49: Modular Keyboard Icon

Figure 49 is an icon I created to better show my concept. At first I split the 88 keys into four modules, at 22 keys per module. Unfortunately it proved to be a little weird, as the split would happen between a white and black key and did not seem like an elegant solution.

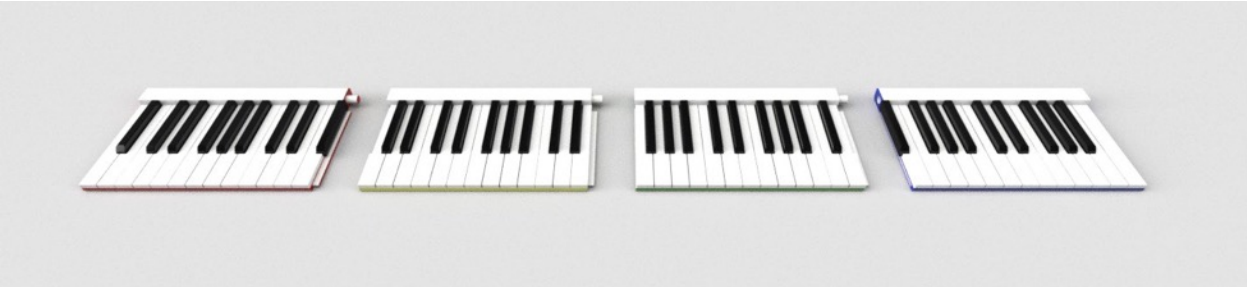


Figure 50: Modular Keyboard Concept

I studied different types of connection systems to figure out how the modules could somehow come together and stay strong in a static keyboard format. This was a major challenge because the modules want to bend in an arch unless they are strongly tightened together.

As references for the module connection, I researched woodworking joints, aluminum connectors, modular furniture, magnets, and everything else I could think of.

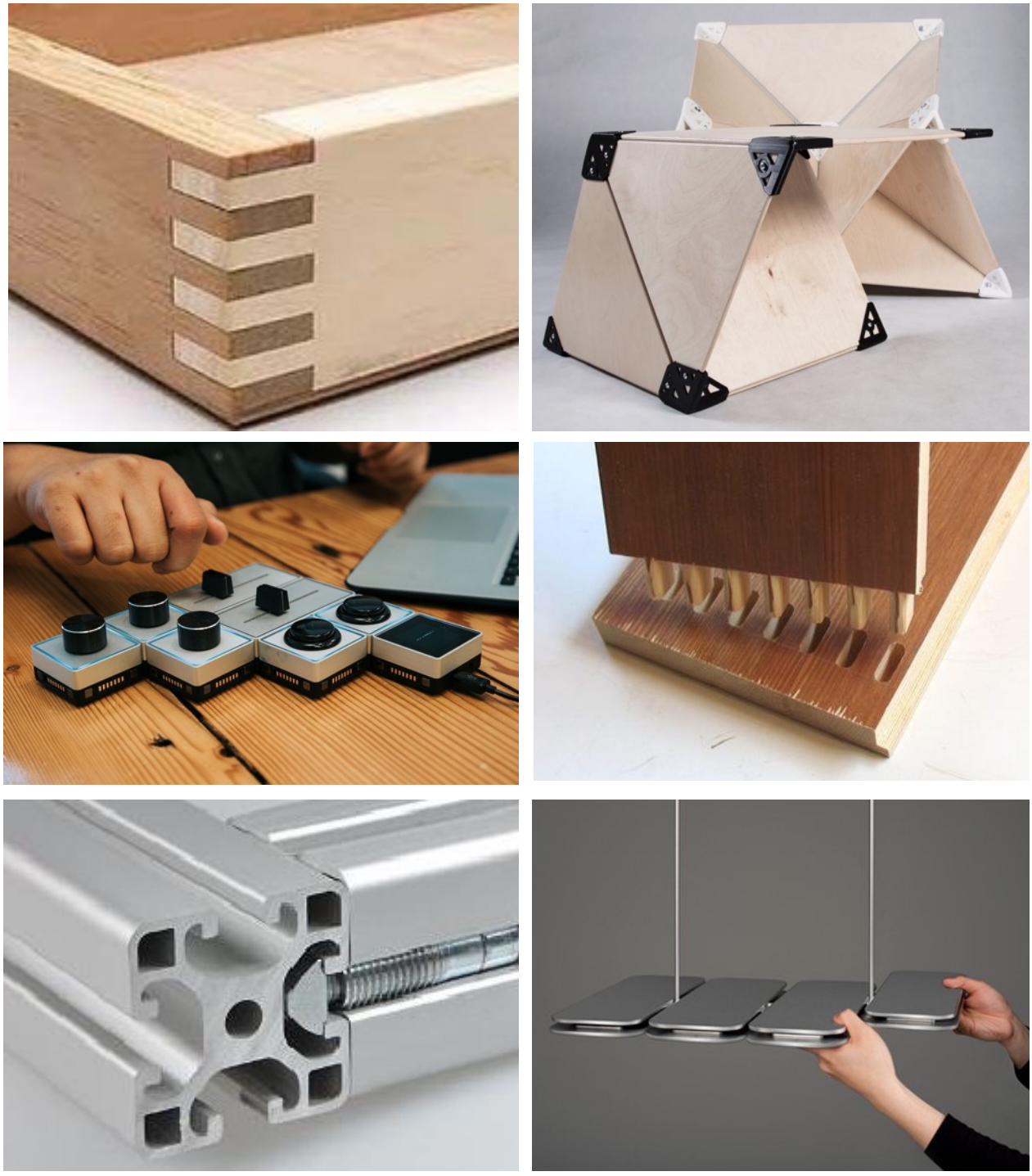


Figure 51: Modular Connection System References

8.5 **Key Resistance (Determines the Feel of the Keyboard)**

Key resistance refers to the amount of pressure it takes to press down a key. There are 3 main types of mechanisms for key resistance: unweighted or synth action, semi-weighted action, and fully-weighted action. Each type of resistance uses a different method to create the "feel" of the keyboard. Many keyboard manufacturers have patents on their unique resistance and keep them as trade secrets. They want their keyboards to feel the best, as that is a major consideration people take into account when purchasing a keyboard. Each resistance or key action can be defined as follows:

Unweighted or Synth Action: "Synth Action keyboards are typically constructed of plastic keys and use springs, rather than weights, to return the key to its initial position. Synth Action keyboards produce a quicker and lighter feel than weighted keyboards, and they work well for certain types of music and for playing the sounds of instruments other than the piano (which many digital pianos have). Many straight-up synth musicians prefer the feel and playability of a synth action keyboard over a more expensive hammer-weighted action for these reasons" (Sweetwater 2004, 1).

Semi-Weighted Action: "Semi-weighted keyboards combine the spring-loaded mechanism of synth actions with the addition of light weights attached to each key, similar to those found in weighted action or hammer action keyboards. The result is a key that has light-to-moderate resistance when you press it, with a rebound to the "up" position that is a little slower than the springiness of a synth action. Semi-weighted actions appeal to players who don't need or want the full resistance of a weighted action" (Sweetwater 2004, 1).

Fully-Weighted or Hammer Action: "During manufacturing weights are added to the plastic keys, usually by glueing pieces of metal to the underside of the part of the key where a players fingers make contact. The extra mass, combined with stronger springs causes the key to be harder to set in motion down, and depending on the spring and how much weight is added will change the speed and force with which it returns to rest.

The result is a keyboard action that feels or “plays” much more like mechanical piano keys, which is sometimes preferred among players. A further development in keyboards is the use of hammer action key assemblies, where the key actually moves a mechanical hammer, making it feel even more like a real piano key” (Sweetwater 2003, 1).

There is also a distinction between “graded” and “non-graded” hammer action keyboards. The graded action feels heavier with more resistance on the lower keys while the higher keys are lighter with less resistance. On a nongraded hammer action keyboard, all the keys have the same amount of resistance

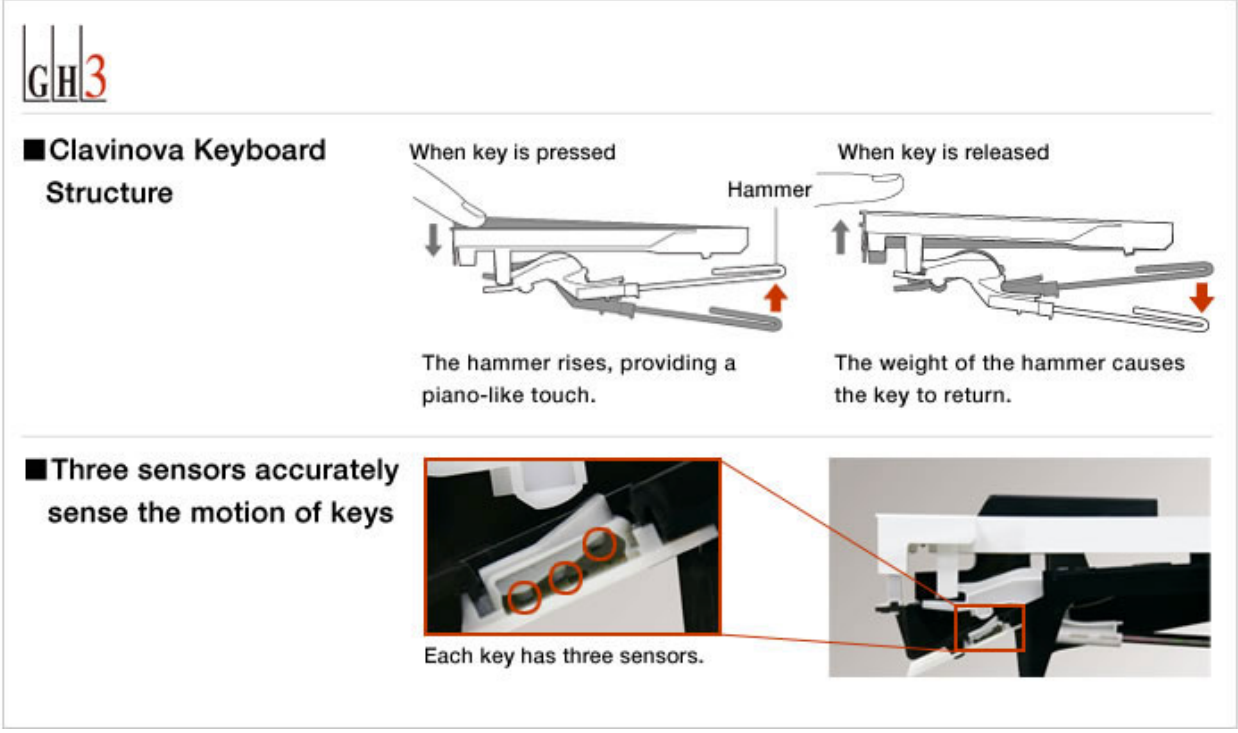


Figure 52: Yamaha GH3 Weighted Mechanism

In Figure 52 you can see the Yamaha GH3 weighted key mechanism, which were put in all of the Yamaha Clavinova digital pianos. These digital pianos were widely praised for its accurate feeling of a real acoustic piano. You can see the counterweight is what gives the feeling of raising a real “hammer” (what hits and plays the strings) on an acoustic piano.

Figure 53: Testing Various Resistance Materials

I tried many key resistance methods to determine if there was a lightweight alternative material that could provide the right amount of resistance, as seen in Figure 53. I tested different types of foam, rubber bands and stretchy material, as well as air bags for air resistance. None of them were truly accurate to that of a piano and I was unsure about the wearing of the materials over time. I did not have the resources or experience to create a fully-functioning weighted key mechanism, so I chose to stick with some industry standards.

At one point I considered a detachable weighted-key option, but that seemed like a long engineering endeavor that I would not finish within my year of thesis research. For my final solution, I decided semi-weighted keys were the perfect balance between good key resistance and the lightweight convenience I was looking for.

8.6 **Control Layout (What Buttons Are Needed?)**

There are a number of different parameters that could be changed that will affect the music being created. These parameters alter the sounds and rhythms produced by the keyboard.

In the spirit of Dieter Rams, and in an effort to not overwhelm the user with options, I posed the question:

What is the minimal control layout needed to play the keyboard?

I have concluded that the musician will need the following as a minimum to produce their music:

1) **Power Button or Switch**	On / Off
2) **DC Power Cord Input**	For DC Power Adaptor
3) **Volume Knob or Slider**	Up / Down

Just these three items alone would be enough to turn on the instrument and play a preprogrammed piano sound with the ability to adjust the volume. But not many people want to just play one sound. Usually even the most basic of keyboards will have at least a few sounds: a piano, electric piano, and organ.So in addition to the three basic controls, I wanted to give users the ability to choose their own sounds.

It would also be nice to have different sound settings to give the user a few options:

4) **Sound Options Button, Knob, or Slider**	2 or 3 Sound Settings (Piano, Organ, Electric Piano)
5) **SD / USB Card Slot**	Add more sound via SD / USB
6) **MIDI Slot (IN, OUT, THRU)**	Connect to computer or other instruments

8.7 **Materials**

Keyboards are mainly made with two types of materials. Either they are highly-durable plastic or some type of sheet metal like aluminum. The plastic is more lightweight than the metal, but the aluminum is more durable and feels more sturdy. Both have their pros and cons and either could be a viable material for manufacturing.

A material to look out for in the future is graphene. This material is possible thanks to advances nanotechnology which allow us to essentially fold a single layer of graphite back onto itself, creating an amazingly strong carbon nanotube. These carbon nanotubes are combined to create graphing. This material is almost 200 times stronger than steel and has extremely high conductivity with a high current density, “a million times that of copper electric circuits” (Howes and Laughlin 2012, 217). It could be a good material for the strength of the modules, to hold together tightly and not bend.

8.8 **Creating the Minimum Viable Product**

The “minimum viable product”, or MVP, refers to the idea that there is a point at which your product will be successful (or people will be willing to pay for it) with the least amount of features necessary. For some companies, such as Apple, the MVP of an iPod could be very complex and require years of work. For other more simple companies, the MVP may just mean a website with a bare-bone structure without all of the bells and whistles. The idea of the MVP is that you get your product out there to start generating funds, and then you improve it with every year.

For my MVP, I created many prototypes, starting from the thinnest, most bare-bone keyboard possible.

8.9 **Paper, Cardboard, and Wood Models**

I created a few models to achieve the design of my keyboard. It all started with a Digital Keyboard that my friend, Dave, gave to me in the beginning of the semester. After many hours of playing it, I finally mustered up the courage to take out the piano keys and rubber resistance to use in my paper, cardboard, and wood models to come.

Thanks again for the keyboard, Dave. It's in a better place now.

Figure 54: Final Moments With The Keyboard

Figure 55: Taking Out The Keys From The Keyboard

Figure 56: Paper and Cardboard Keyboard Model

Figure 57: Wood Keyboard Model

Figure 58: 3D Printed Module Connectors

Figure 59: Final Keyboard Model out of PLA Plastic, Wood, and Styrene with Rubber Resistance (Synth Action)

In the end I decided on a slot and lock connection system, with ridges along the slot so that the keyboard does not shift back and forth when connected. Figure 59 shows my final model that would connect together. With further development, I would add an auto locking system with a release button on the bottom of the next module.

Ch 9 **Final Solution: Modules**

9.1 **The Modular Keyboard**

I decided that the Modular Keyboard, shown in Figure 60, was the best design solution because it gave the musician the most flexibility and control over their instrument. No more carrying around this huge instrument whenever they travel. Instead, the user can choose the number of keys they want to bring with them (in sections of 24 keys).

Figure 60: Modular Keyboard Solution

There is no need for two separate keyboards: one for at-home playing and one for travel. Unless the key resistance is the exact same between the two keyboards, which is very rare and unlikely, then the musician will not get a consistent practice. A keyboardist could practice on an unweighted keyboard, but when it comes time to transition to their more serious, weighted instrument, they will need to adjust a bit. The weighted keyboard is harder to press than the unweighted. Overall, the dynamics in feel of the instruments are much different. This solution provides consistency to the musicians experience so they can fully develop their skills.

9.2 **Durability & Protection**

This keyboard needs to be durable and built to last. The modular system will need structural strength to hold up against the pressure of playing. I envision each module can be placed into a backpack, without the need for any external or separate protective case. The keyboard should be durable enough to be hit around in the backpack while maintaining its quality and structure.

It is important for these professional keyboards to be durable because they are meant to last many years of gigging. Since people are spending so much money on these keyboards (usually over $750) they expect it to be of high quality.

Keyboards can learn a lot about durability from the cell phone industry. Today you can purchase a phone that is both shockproof and waterproof with unbreakable glass. If these same protection techniques and materials were applied to a keyboard, people would feel more comfortable traveling with their instrument because they would know it is safe from getting damaged on-the-go.

Figure 61: Waterproof and Shock Resistant Toughphone

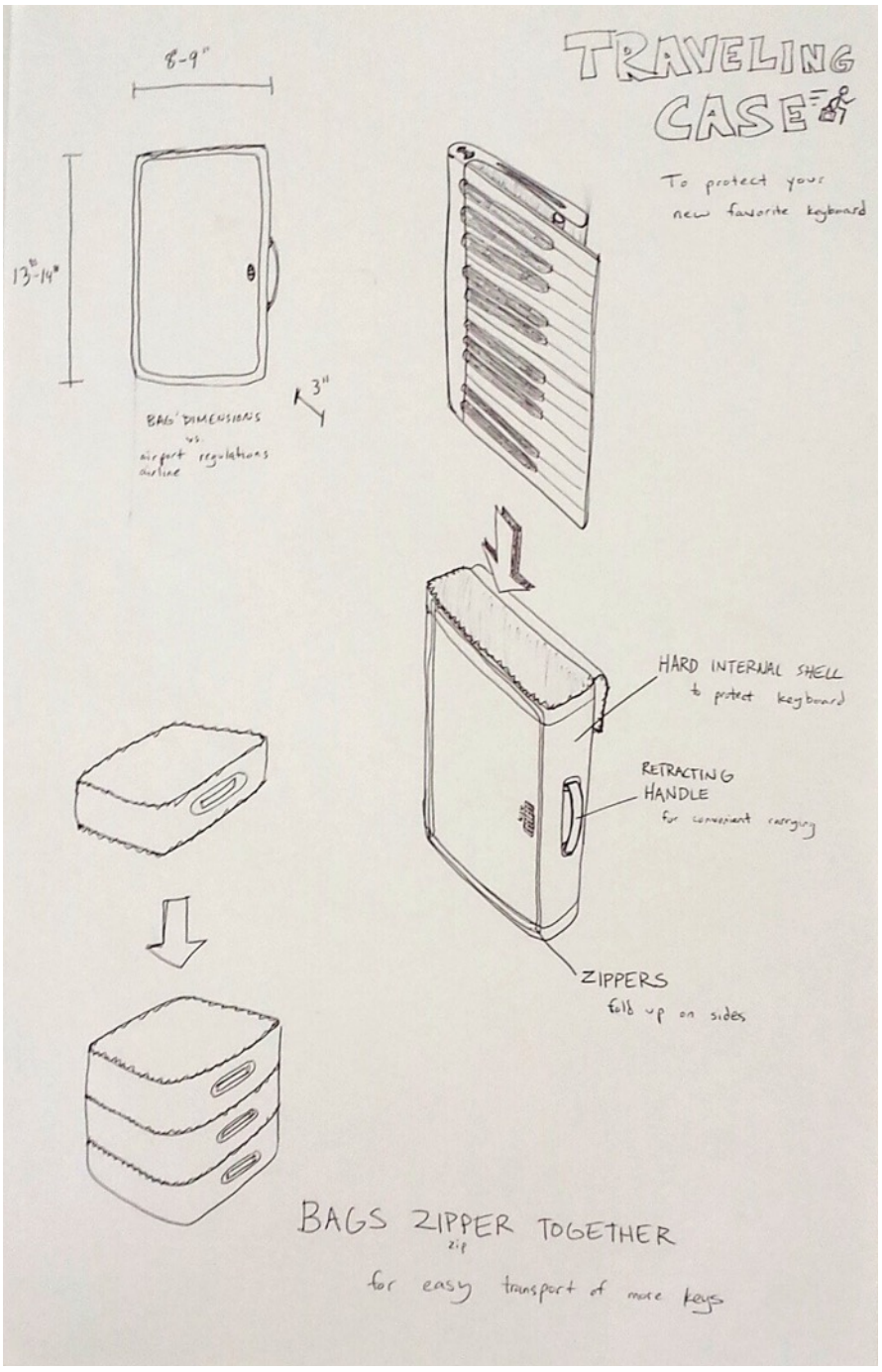


Figure 62: Modular Keyboard Carrying Case Concept

9.3 **Traveling Options**

Although the modules are durable enough to stand by themselves, it always help to have a case when traveling. A highly-flexible modular system calls for a highly-flexible carrying system. I envision one that each one of the modules are individually placed into a module-size case. These cases can attach together in different orientations to achieve the best shape for the musician's traveling needs.

Figure 62 shows a concept of the bags zipping together, but they could also be held together by magnets, or all in one bag that expands depending on how many modules are in it.

Ch 10 **Benefits of a Modular Keyboard**

10.1 **Portability**

The main benefit of a modular keyboard system is the **portability**. Now the keyboard can be broken down into **sections that can fit comfortably in a backpack** wherever you need to go. The keyboard can even be split up while traveling, with two sections in one bag, and two sections in another.

Figure 63: Modular Keyboard Connection

By splitting the keyboard into sections, it can be fit into spaces much more conveniently, whether its in a car, bus, airplane, or even just walking through a doorway or up a flight of stairs.

Figure 64: Modular Keyboard in Backpack

10.2 **Flexibility**

A modular system allows for more flexible experiences with the instrument. Now the keyboardist can choose how many keys they need for each specific situation. In an airplane seat, one module of 24 keys would be good. In the back seat of a car or on the bus, two or even three modules would be possible. At home or at a live show, four or more modules could be used. The number of keys is only limited by the amount of space that is available.

Figure 65: Flexibility of a Modular Keyboard

10.3 **Accessibility**

Breaking the keyboard down into sections makes it more accessible for a musician to buy into the system at a reasonable price. It also allows for them to upgrade and expand their instrument in the future if they decide they want more. This could be especially attractive to beginners, who usually start with a cheaper, toy-like keyboard and will eventually need to purchase a high quality keyboard if they are serious about the instrument.

Figure 66: Easy Storage of a Modular Keyboard

It also makes the instrument more accessible to be used whenever they need it, as a few modules can be easily fit into a backpack for quick and convenient travel.

And finally, a modular solution allows for more accessible design solutions to be implemented into an existing system. Someone with weak fingers could get a special type of low-resistance keyboard that could be seamlessly integrated into their workflow.

10.4 **Customization**

Keys come in all sizes and resistances. The modular system would allow the user to decide what key resistances they would like, and can even have a keyboard that has more than one resistance type. For example, maybe I would want the bottom notes to be a weighted resistance to get that piano feel in my left hand while the right hand plays unweighted keys which are easier to press down and can be potentially played faster.

Customization can also come in the form of different colors, chosen by the user.

This project has room to expand to incorporate different styles of modules: dedicated to keyboards, synthesizers, beat-making, looping, visualizing, and more! Most of the topics I studied in the beginning of this thesis, but did not pursue, could be incorporated into this instrument.

Overall, the musician's experience should be customized to fit their needs. If they need to travel by carrying their instrument, then so be it. Their instrument should be convenient to carry while walking. They need to travel by car? No problem. Travel by airplane? Not an issue.

The experience of traveling with your instrument should be a pleasurable one that encourages you to create wherever you are.

Ch 11 **What's Next?**

11.1 **Future Improvements to the Keyboard**

This modular keyboard concept is a minimum viable product, meaning that it is the minimum amount of features needed to sell the product and get it to market. It is no more than is needed. However, this idea will only appeal to a certain group that is content with having those limited features.

Some musicians prefer to have a large bank of sounds built into their instrument, with no need to hook up to a computer.

The features on this keyboard were included for one purpose, to give the keyboardist what they need to create beautiful music. However, there are many other fun features that could be included in an instrument like this, such as a looper (which allows the user to repeat a musical phrase and layer music over that phrase) or different parameter adjustments (which allow the user to shape the sound to their heart's desire).

For the next steps, I plan to explore these concepts of additional features without losing the elegance or simplicity of the design.

I also plan to create a working prototype of this keyboard that users would be able to use and provide their feedback on what they like and dislike.

11.2 **User Testing & Refinement**

I will have two prototypes for user testing. Prototype #1 will be four modules that connect into a larger keyboard. The feel, size, and experience of putting together this keyboard will be there, but the electronics to make the music will not be.

For Prototype #1, I will be testing the experience of:

1) connecting the keyboard modules together
2) putting pressure on the keys (as if the musician was playing)
3) breaking the modules down
4) and traveling with it in different scenarios.

With this information I will have a better understanding of what works best for keyboardists' when traveling and using this instrument on-the-go. I will gather feedback from a large number of participants and make improvements to the design based on their feedback.

Next, prototype #2 will be created with working electronics inside.

Ch 12 **My Vision of the Future of Music**

12.1 **Adding a Visual Element**

When playing an instrument, the musician has a main indicator of what they are playing: the sound they are creating. They also have a secondary indicator: the hand or body position on their instrument. I consider this secondary because for some instruments, such as the guitar, a hand position might be the same for multiple chords, but the sounds will change depending where on the guitar neck the notes are played.

Also, sometimes you are not looking at your hands. As a performing musician, you do not want to be looking down at your hands at all times. You want to be looking out and engaging the audience with your performance!

Sound uses our hearing when we listen and even feeling when we can feel the vibrations of the sound. Imagine if we could add another seamless sense to music, something that humans love: sight. If we could visualize music in a systematic way such that the same thing would happen every time you played that note (or differently depending on how you play it), that would allow that visual to BECOME part of that instrument. With an added visual element, music would potentially become more impactful to the audience.

Visual artists and musicians could collaborate to create a masterpiece. Different visual “themes” could be applied to the music depending on the feel that the musician wants.

12.2 **Tactile Information on the Instrument**

Figure 67: Braille Keyboard

Since the musician cannot always be looking at their hands, especially on a piano, where the hands are separated and cannot be seen all at once, it would be nice to have some sort of tactile indicator so that the person could *feel* the music. This could come in handy when creating tension and resolution within songs. Maybe the texture of a piano key could become more bumpy as tension is created between the notes. When that tension is resolved, the texture would become smooth again. Tactile feedback could also come in the form of vibrations, or a braille-style of texture.

In a more simple idea, the tactile information could come by adding different unique textures to each knob, slider, and button on the instrument. The musician could understand what parameter they are changing simply based on touch alone. This could be helpful for musician playing in low-light environments or those that have low vision, or even the blind.

12.3 **Music in Virtual Reality**

I am completing my thesis at a time when the technologies for Virtual Reality are available. Virtual Reality, also referred to as VR, has been a concept for a long time now. In 1930 a Science Fiction writer predicted a future with Virtual Reality. Since then, there has been a race to create this concept. But the concept was ahead of the technology. If the headset lagged at all, the user would get very motion sick. There were also some other problems that needed to be worked out, such as not making the user too tall, too small, or intersecting with the virtual objects around them. These were all things that are scary to a person immersed in VR. It was not until the past few years that technology has given the opportunity for VR headsets that work quite well.

We are at the tipping point. 2017 and beyond will yield high quality VR headsets that will immerse the viewers deeper and deeper into the digital world. Eventually, in theory, VR sets will be so good that it will be impossible to distinguish between reality and the digital reality. People will live completely digital lives. Maybe we are in a simulation right now!? Ok, back to the music topic.

How could the concert experience evolve with the application of VR or even AR (Augmented reality)? Maybe you would walk into the venue and be given a VR headset (or AR headset). Upon putting on the headset, the entire environment would be transformed into an amazing world that changes with every note of the music.

Or maybe VR will lead us to a world where we don't physically attend concerts, but simply tune into them. You could still be "hanging out with your friends at the concert", while actually in the comfort of your own house.

The future of musical instruments can also be explored with AR and VR, as playing virtual instruments will become more popular as we immerse into the digital world.

Figure 68: Music in Virtual Reality

12.4 **Future of Music Collaboration**

The future of music collaboration is working with people from across the world over the internet. Today, people share many things across the internet: their social media pages, items to buy, artwork, information. The internet has made it possible for communication and collaboration with people from around the world.

With all this sharing and collaborating going on, I have to wonder: why isn't internet music collaboration popular? Maybe it's because some people consider creating music more of a personal, "by myself" sort of activity. Yes it is nice to have other people's input, but for something like writing a song, their input may not be needed.

But what about the people that DO want to collaborate with others? While interviewing musicians for this thesis, I met Dave. Dave is in his 40's, has a wife and two kids, and made money as a DJ throughout the 1990's. As his life began to be filled up with tasks, he found less and less time to make music. He still wanted to create beats, but didn't have the time to mix the tracks to make them sound just right. Luckily, Dave met a man named Yuto online. Yuto heard one of Dave's tracks he posted to a music-sharing website called SoundCloud. Yuto reached out to Dave to collaborate on some music, and after a month of sending tracks back and forth, a friendship was born. Now Dave and Yuto create unique tracks, with Dave sending his original work over, and Yuto mastering the track, but also sometimes chopping it up and rearranging it to create a work that Dave would never have thought was possible.

Dave told me about how interesting it was to hear his track, with parts that he deliberately created to be a certain way, chopped up and reorganized by Yuto to create something completely new, with a few reminders of the old track scattered throughout it.

As Dave collaborated with Yuto, the internet will allow more and more people to collaborate musically, regardless of location.

12.5 **Gamify the Music**

Music will become more fun, experimental, video-game-like interactions.

Teenage Engineering is a musical instrument company that has elegantly designed instruments with a unique twist. The OP-1, in Figure 69, is all based around the idea of using a cassette tape deck (as you can see with the visual on the screen).

All of the functions are inspired by the tape deck system and the OP-1 even requires you to perform analog-type tasks to use it, such as rewinding the tape and stopping it at the moment you want to record.

Figure 69: Teenage Engineering OP-1

The OP-1 also has “secret modes” that come up when you press a combinations of buttons, almost like a cheat code in a video game. Some of these button combinations activate actual games that you can play on the instrument, such as an old school helicopter game called ChopLifter.

The Teenage Engineering Pocket Operator Synthesizers, in Figure 70, create a fun visual experience, with each different operator showing a unique animation. As you adjust the parameters of the sound, the animation is affected.

Figure 70: Teenage Engineering Pocket Operators

Ch 13 **Conclusion**

13.1 **Closing Statement**

In the field of Industrial Design, it seems that a design is never truly finished. Yes, you may reach a point when the design is ready to be revealed for the public, but it can almost always be improved. New materials and technologies are constantly being introduced to the world that could be implemented into my modular keyboard design.

13.2 **What I've Learned**

Throughout this thesis I have learned many valuable lessons:

1. If you plan something out to take a certain amount of time, it might take more time, so don't procrastinate! (Not that I procrastinated…)

2. People love talking about things that interest them. And even the people that are seemingly unrelated to your topic might still have very valuable insight.

3. Music is fun. It promotes happiness throughout the world and has the potential to help people in every kind of situation. I hope to be creating music for as long as I can.

Ch 14 **Summer Startup: Flux Keyboards**

14.1 **My 2016 Summer Experience**

Over the summer I had the pleasure of working with Austin DePalma on this project. We were accepted into the Saunders Startup Program at RIT so that we could develop the idea further and create a business model for it.

Throughout the summer we interviewed over 100 potential customers for our product: The Flux Modular Keyboard. The people we interviewed were musicians, many of whom we met at the GearFest Musical Instrument Conference. We drove to GearFest so we could check out the instruments that each company, or competitor, has to offer, as well as meet people and learn more about their preferences when it comes to buying a keyboard, organ, or synthesizer.

We realized that people do not want to do a lot of menu-digging, and prefer to have dedicated controls for each major function. They want to have an instrument that is portable, but most importantly, it needs to be intuitive, feel “nice”, and has professional quality sounds.

Throughout the summer we developed a business plan and next steps for the project. First, we made a pivot to a keyboard that would be modular both in size, and in controls. Then we ditched the portability factor and focused mainly on the customization of controls. We wanted to give musicians the convenience of having many different types of instruments, both software and hardware, incorporated into a physical platform. **By the end of the summer, I had a much better understanding about my potential target market. Face-to-face customer interviews were the most valuable research method.**

Although this thesis paper marks the end of my graduate studies, I will continue to make improvements to this design and bring further innovations to the musical experience.

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