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An evaluation of touch-based music sequencer apps on iPad

by

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in the
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Dr. Benjamin Swift

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Declaration of Authorship

I, Ke Ding, declare that this thesis titled, 'An evaluation of touch-based music sequencer apps on iPad' and the work presented in it are my own. I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University.
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated.
- Where I have consulted the published work of others, this is always clearly attributed.
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work.
- I have acknowledged all main sources of help.
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself.

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"We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run."

Roy Amara, leader at the Institute for the Future

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Abstract

ANU College of Engineering and Computer Science

by Ke Ding

With the repid development of technoldge, mobile devices have become the new ground for musicians to express themselves. With a variety of sensors, as well as the exponentional growth in the processing power, iPad offer an attracitve platform for music performing. Thousands of music applications have been developed for the iPad. Music sequencer applications, as one of the major category of music making applications, have seen a lot of derivation and innovation.

Acknowledgements

It has been a very interesting and challenging semester. I have many to thank for the support and guidence.

I would like to thank my supervisor Dr.Ben Swift for his patience and dedication throughout the project. My appreciation goes to Ben for his encouragement and selfless support. He always guided me when I was confused and pushed me at the time I needed most. I would like to thank Pro. Weifa Liang, as course convenor, he provided many useful guidence to the presentation and structure of academic report.

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Abbreviations

NIME	**N**ew **M**usical **I**nstrument **E**xpression
MPX-Q	**M**usicians's **P**erception of the E**x**periential **Q**uality
DMI	**D**igtal **M**usical **I**nstrument

Chapter 1

Introduction

With the rapid development of digital audio technolodge, people start to find out that computers are playing an increasingly important role in music. This new trend is providing unprecedented opportunities for people to create and manipulate sound. However, the flexibility of the digital technolodge is accompanied by confuse and uncertainty. As a result, thousands of new musicial forms built on computers have been created and released to the world. And it is natural to ask, what kinds of musical interfaces are taking better advantage of computers. To answer this question, researchers targeting at the better establised field of human-computer interaction [Wanderley and Orio, 2002]. Under the circumstance of new musical form explosion, a new community called NIME was born (see 1.1.1).

1.1 Background

1.1.1 The development of NIME

The New Interface for Musical Expression (NIME) is an international conference for musicians and researchers from all over the world to demonstrate their latest work on musical interface design [NIME, 2012]. It first started as a workshop at the Conference on Human Factors in Computing System (CHI) in 2001. After that, annually conferences have been held around the world. The hoster are research groups who devote themselves to interface design, human-computer interaction and computer music. The

latest conference was held at Griffith University in Brisbane, Queensland, Australia in 2016.

In the last sixteen years, NIME has explored different approaches on new musical interface design. The *reacTable* which was designed for live music performance on tabletop led a new trend on tangible music interface [Shaer and Hornecker, 2010]. Many researchers shifted their attention to this new media. Toolkit such as reacTiVision was developed to detect movement of performers and allow further development to turn any surface into a musical instrument [Kaltenbrunner and Bencina, 2007].

The success of *Smule* initiated a new era of mobile music [Wang, 2009]. After that, thousands of musical applications such as *MoMu, MadPad and Magic Fiddle* which were specifically designed for mobile devices were developed [Bryan et al., 2010, Kruge and Wang, 2011, Wang et al., 2011].

1.1.2 iPad: a new playground for musicians

The iPad, a tablet computer with touchscreen display, has quickly occupied the market all around world since it's first release in 2010 [Nguyen et al., 2015]. The emergence of iPad have provided a new platform for users to explore digital world [Müller et al., 2012]. After 7 generations, the usage of iPad has shifted from the extension of iPhone to a powerful pruductivity tool. In this shift, thousands of applications which was designed to utilise the larger touch screen has emerged. According to Daniel, there are over 1.5 million apps are currently hosted in the App Store and more than half of those apps are specifically designed for iPad [Nations, 2017].

Since the first release of iPad, there are practices to utilise the large tangible screen and wide variety of sensors of this cross-time product. Wang et al. designed *Magic Fiddle*, a new musical instrument, which combined the physical gesture of users and graphical display of iPad together. Martin et al. explored the possibility of using iPad as a percussive instrument and used iPad's network feature to ecourage cohesive improvisation [Martin et al., 2014].

1.2 Related Work

A lot of work have been down on evluating the interaction between users and mobile devices such as iPhone. However, there haven't been a paper specificly analyze musical instrument implemented on iPad. Stowell et al. evaluated the live music-making on computer through discourse analysis and turing test [Stowell et al., 2009]. A questionnaire-based evaluation method was proposed to evaluate the musical instruments, especially the new forms of instruments from NIME [Schmid, 2015].

Unexpectedly, music sequencers as the top three most popular instruments in iOS musical applications [Kell and Wanderley, 2014], has not attracted much attention. We can barely find papers related to recent years development of music sequencers application. The most related work was *Block Jam* (see figure 1.1), a sequencer with tangible interface consisited of several physical blocks [Newton-Dunn et al., 2003].

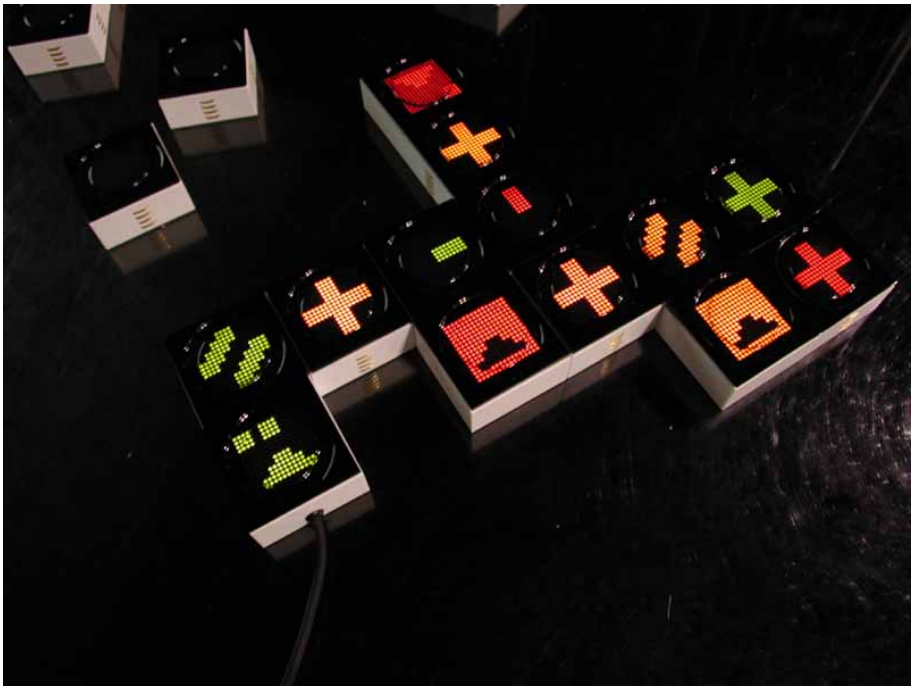

FIGURE 1.1: Block Jam: music sequencer consist of a cluster of blocks

1.3 Research goals and motivation

While musical interfaces have been studied for a long time, there have emerged thousands of novel twists on "grid-based"music sequencer. And to our knowledge there is currently

no paper investigate the situation of this certain kind of musical application on App Store. What's more, there is no consensus on using what's method to evaluate those newborn musical application on mobile devices. This work is a first attempt to classify the music sequencers on iPad and adopt the evaluation method(MPX-Q Questionnaire) designed for NIME community. This work is guided by the following goals:

- Create an interface taxonomy of current music sequencer apps on the iOS app store.
- Perform a HCI user study to measure user experience and musicians performance with different interface design approaches.
- Propose design guidlines for musicians, developers and researcher for creating musical interface in the future.

1.4 Structure

In the next chapter, literature relevant to the research topic was introduced, so as to establish a theoretical framework of the research (see Chapter 2). And the research project was divided into two consecutive studies. In the first study, we analyzed the music sequencer applications (designed for iPad) on App Store and create an interface taxonomy (see Chapter 3). Then base on the classification of music sequencer interfaces, we selected one most representative application from each category and conducted an user study to evlauate the effect of different interface design (see Chapter 4). In Chapter 5, we discussed the results and provided a conclusion of the study as well as the future work.

Chapter 2

Literature Review

2.1 Mobile Music

With the increasing popularity of mobile device such as smart phone and tablet, a new research field called Mobile Music emerged [Flores et al., 2010]. According to the definition by Gaye et al., *Mobile Music* wich employing portable technolodge does not only include the scope of playing music, but also involve music composing, synthesizing and sharing[Gaye et al., 2006].

In the last sixteen years, there is a growing number of researchers start concerning the development of applications in mobile devices. This new trend was first highlighted by John after analysing 98 NIME procedding papers related to mobile music during the period from 2002 to 2012[John, 2013].

The expanding capabilities of mobile devices inspired researchers to exploit the new features.The wireless network ability of mobile device is the first area attract researchers' attention. TunA is the first practice of building connection among PDA users though wireless network[Bassoli et al.]. By accessing the playlists of nearby users, TunA help users in same network to exchange their music. Tanaka extended Bassoli et al.'s work from music sharing towards collaborative musical creation [Tanaka, 2004]. Tanaka propsed a system which exploits ad-hoc wireless networks to allow a community of people using their PDA to work on the same piece of music [Tanaka, 2004]. Some research started from a different approach by investigating the possibility of utilizing the touch screen on the mobile devices. Geiger designed a paradigm for using touch screen on mobile device

like iPaq [Geiger, 2003, 2006]. MoGMI, which stand for Mobile Gesture Music Instrument, is a research project focused on using the accelorometer inside the mobile phone to perform music. Through examing three different axis mapping models, Dekel and Dekel explored how to turn mobile phone into a standard instrument. Smule Ocarina is the most successful mobile musical artifact, which take advantanges of the global popularity of iPhone [Wang, 2014]. It leveraged the microphone to take input from breath, and combined with command from the multitouch screen to mimic the physical interaction of ocarina. Besides, Smule Ocarina also utilizing the GPS module to connect users all around the world and create a new social experience [Wang, 2009].

2.2 Musical Interaction Patterns

Musical interaction patterns, also konw as design patterns, are common solutions for developers to design a specific interface,like music sequencer. Flores et al. stated since designer can reuse the proven discipline in their work, design patterns can assisit multi-disciplinary design, improve communication between designers and facilaitae knowledage transfer between teams with different background [Flores et al., 2010]. In Flores et al.'s work, following four most common music interaction patters on mobile devices were given: 1). Natural Interaction. 2). Event Sequencing. 3). Process Control 4). Sound Mixing. In which, event sequencing was the second most popular interaction patterns. The general decription of event sequencing pattern was illustrated as: by editing the sequence of musical event which maybe individual notes, several piece of samples or parameters that can modify the sound of music [Flores et al., 2010]. In Kell and Wanderley's paper, sequencer was put into an independent category of musical application on App Store, and it's nature of mapping was briefly discussed.

2.3 Evaluation of digital musical instruments

Digital musical instruments (DMIs) refer to instruments whose sound are generated digitally. It is not uncommon to ask what does evaluation means in the context of digital musical instruments. But as Stowell et al. mentioned, evluating the expressivness and creativity of an musical interface were very difficult [Stowell et al., 2008]. Stowell et al.'s paper followed by providing a methodology based on discourse analysis. An evaluation

framework was given by O'modhrain, in which DMIs were evaluated from four inter-dependent prosepective: audience, performer, designer and manufacturer [O'modhrain, 2011]. Also, three general design goals were listed at O'modhrain's paper, which were *Enjoyment, Playability and Robustness*. Barbosa et al. proposed a process to evaluate DMIs from a performer's view [Barbosa et al., 2011]. A case study conducted by Jordà and Mealla was focued on the expressiveness and mapping of DMIs. Recently, by reviewed 89 papers published in NIME from 2012 to 2014, Barbosa et al. pushed forward the discussion to how to better use the evaluation tools to improve the design of DMIs [Barbosa et al., 2015].

Chapter 3

Study 1: Classification of music sequencer

A big scale study was conducted to create an interface taxonomy of current music sequencer apps on the iOS App Store. In total, 55 music sequencer applications on App Store have been examined (see Appendix B). Several search criteria are implemented to locate music sequencer on the App Store (see Section3.1.1). After analyzing those music sequencer apps, we proposed classification criteria based on the design of the user interface (see Section 3.1.2). The 55 music sequencer applications were classify into 3 major groups according to the classification criteria (see Section3.2).

3.1 Method

In total, 71 musical iOS applications associated with music sequencer had been downloaded from App Store. After examined and discussed with my supervisor Ben Swift, 16 applications were removed from the study list either because the application can hardly be classified as music sequencer or because the application was not designed for iPad. The rest 55 music sequencer applications were studied in detailed.

3.1.1 Search Criteria

Base on Kell and Wanderley's study which created a whitelisted words for music sequencer, keywords such asrt *Sequence, Sequencer, Groovebox, Beatbox, Step, MIDI, Pattern, Tempo, BPM, Machine* were used to search on the App Store. Before each application been downloaded, it's description had been briefly overviewed to make sure it was designed for music purpose. Also, in the searching criteria, "iPad only"was chose and results were sorted under the relevance of keywords.

3.1.2 Classification criteria

The different approaches of interacting with the applications were used to classify the user interface of the music sequencer applications into several categories. The mappings of the sequencer were broke down into 4 operations, which were *changing pitch, triggering sound, timing and changing timber*.

Changing Pitch. Becasue the way most traditional instruments' pitch were changed discretely, for example, piano, guitar and violin. The majority of musical application including sequencer follow this trend. Besides, pitch is dominated by grid-like, buttom-to-top mapping in music sequencer hardware. Therefore, grid-based, buttome-to-top and discrete pitches layout is widely adopted.

Figure 3.1 is a good example of this classic interface, in which the interface is divided into 16x16 grids. The time, which is separated into 16 steps, only moves one step at a time from left to right. The blue vertical line works as a reminder of current time, and also indicates what is coming next(in the next step). The white square, on the other hand, represents the sound of a certain instrument. In this case, it represents an electrical sound called *FUTURE*. The column in each step is divided into 16 scales and which are the pitches of the instrument. The white squares located in the top of the grids are high pitch sound of the instrument, on the contrary, the pitch of the sound from the bottom is relatively low.

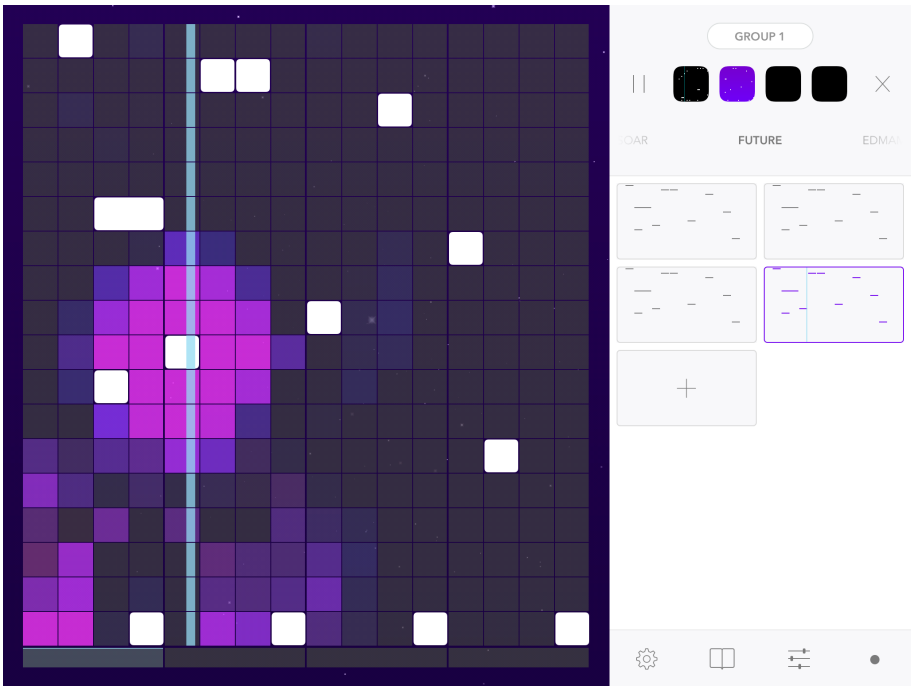

FIGURE 3.1: Beatwave: grid-based, buttome-to-top and discrete pitch layout

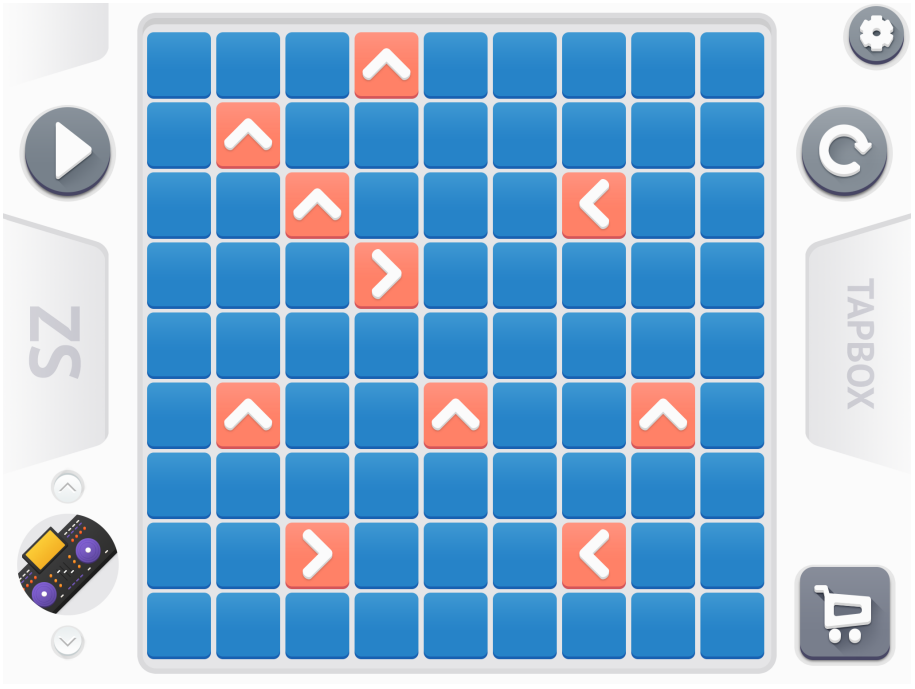

FIGURE 3.2: SoundZen: grid-based, right-to-left and discrete pitch layout

However, not all the grid-based sequencer applications increase pitch from bottom to top. There is a small portion of sequencer increase pitch from left to right. For instance, SoundZenHD used a left-to-right pitch mapping (see figure: 3.2).

In addition to the discrete pitch mapping, there are attempts to implement the continuous pitch. *CSketch Lite* followed the classic grid-based layout, but it implements continuous sequencing (see Figure 3.3). By implementing the continuous sequenceing, *CSketch Lite* is able to prodecue continuous sound in a series steps rather than make discrete sound step by step, which breaks the bound of the traditional music sequencer. Therefore, the pitch is changing continuously in *CSketch Lite*. In figure 3.3, the yellow and blue line denote the trend of pitch changing. Take the top-left yellow line as an example, the pitch of the sound is continuously droping from G# to F. Even though, the pitch of the above music sequencer applications are still linear mapping.

Except for the linear mapping though the grids, some few Apps adopted the non-linear pitch mapping. For instance, *Orbita* simulates the movemment of a small planet orbits around a central planet along an elliptical path. And in this case, different color of "planet"represent different instruments, which produces sound while elliptical orbit. The pitch is changing continuously based on the distance between the small planet and the central planet(see figure 3.4).

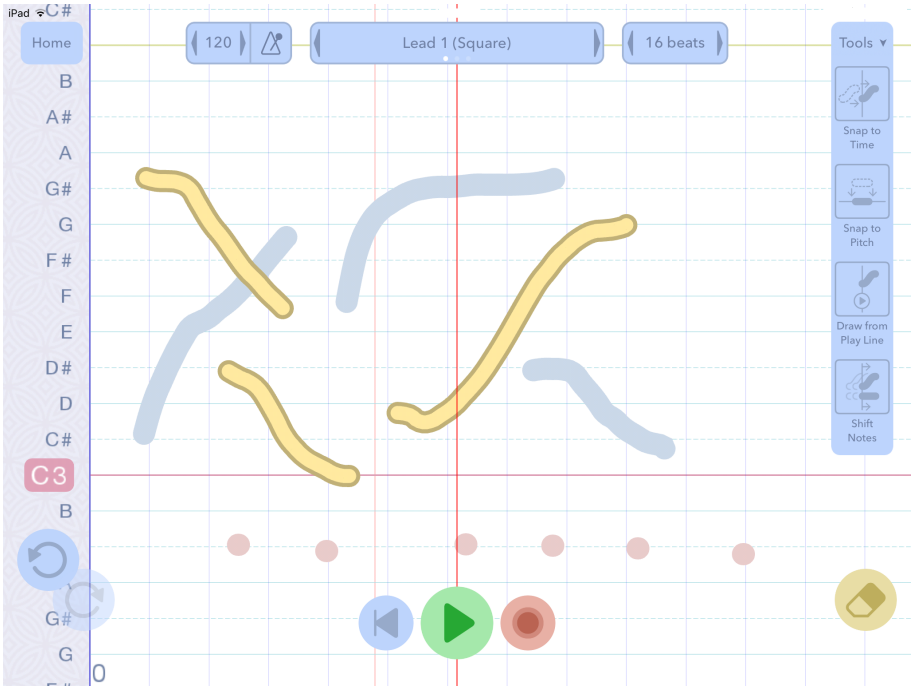

FIGURE 3.3: CSketch Lite: grid-based, top-to-bottom and continuous pitch layout

It is not unusal of mapping pitch to colour in music applications [Kell and Wanderley, 2014]. However, there was only one music sequencer found to represent pitch with

different colors (see Figure 3.5). In *Volotic*, there is an emiter which continuously emits red little dot sequently. The red color, in this case, means note C or **Do** which is the first note of the fixed-Do solfge scale. Once the red little dot passed though a tone assigner, it's tone changed relatively and so as it's color. In Figure 3.5, the green symbol is a tone assigner called TUNNING, and the number in the middle denotes what note it is going to assign. There are seven different TUNNINGs which together consist the key of C(or C major).

However, this color-based mapping is not intuitive. It takes significant effort to link different keys to colors. Besides, in this case, the two colors between pitch E (**Mi**, the third note of the C major scale) and pitch F (**Fa**, the fourth note of the C major scale) is very difficult to distinguish. This unintuitive mapping could be the reason why the color-based pitch is not widely implemented, and we will look into the details in the next chapter.

Triggering and Timing. In Kell and Wanderley's study, the mechanics of how users inteacted with applications and the methods of how time was represented were studied seperately. However, in most music sequencer applications, time is used to triiger sounds. Therefore, triggering and timing were analyzed together in our study.

Unsuperisingly, given the fact that toggles are primary used on sequencer hardware, virtual toggles are the most commonl method for users to control sequencer applications to start producing sounds. In Figure 3.1, 3.2 and 3.3 there are virtual toggles acting as main switch to control the play/stop operation. After the main switch turned on, time is uesd to determaine the triggering sequence of a series of notes or several pieces of sounds. Likewise, timing in the majority of sequencer applications follow the convention of sequencer hardware, which time move from left to right. Some very few applications don't have an explicity display of time, such as *Orbita* and *Volotic* (see Figure 3.4, 3.5).

Timber and Volumn The majority of music sequencer applications use toggles to change timbers and volumn. Normally, there are several preset timbers and users can shifted between different timbers by selecting one of the preset timbers. Only a very small number of applications use additional control over timber. *Volotic* uses the the symbol of different instruments to represent the unique timbers (see Figure 3.5. Essentially, it is still a toggle but in a twisted form.

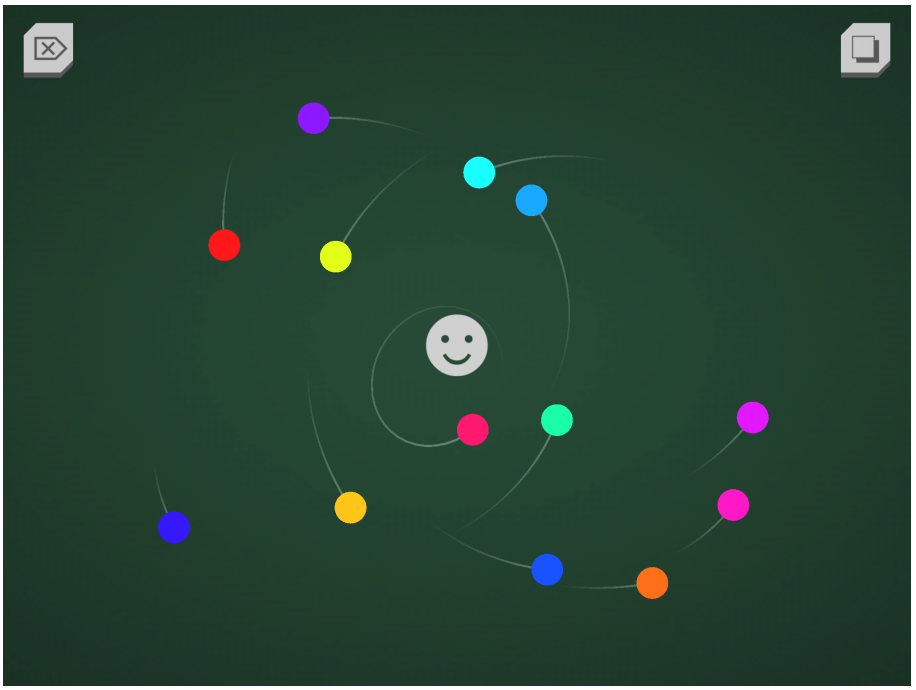

FIGURE 3.4: Orbita: elliptical orbita, non-linear and continuous pitch layout

The reason why mapping of volumn is combined with timber is the majority of music sequencer use the same mapping which is a slider or toggle. Other volumn controls are very rare. *Orbita* is the only example of using the distance between the satellite and the planet to control the volumn. The volumn is turn up when satellite get close to the central planet. Conversely, the volumn goes down when two planets move apart.

3.2 Results

According to the three main classification crterias, we seperated the

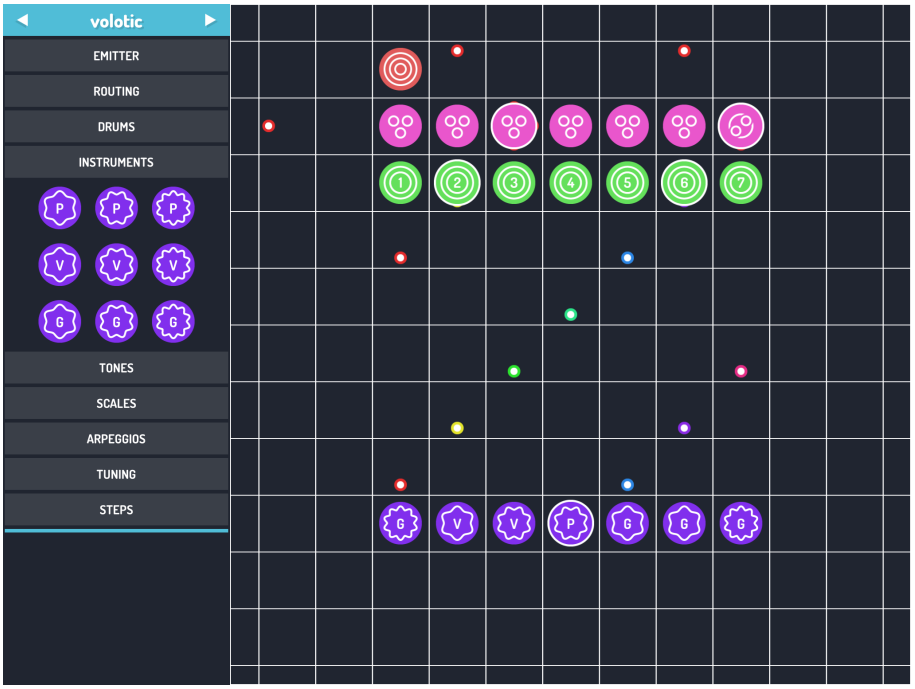

FIGURE 3.5: Volotic: game-like, linear and color-based pitch layout

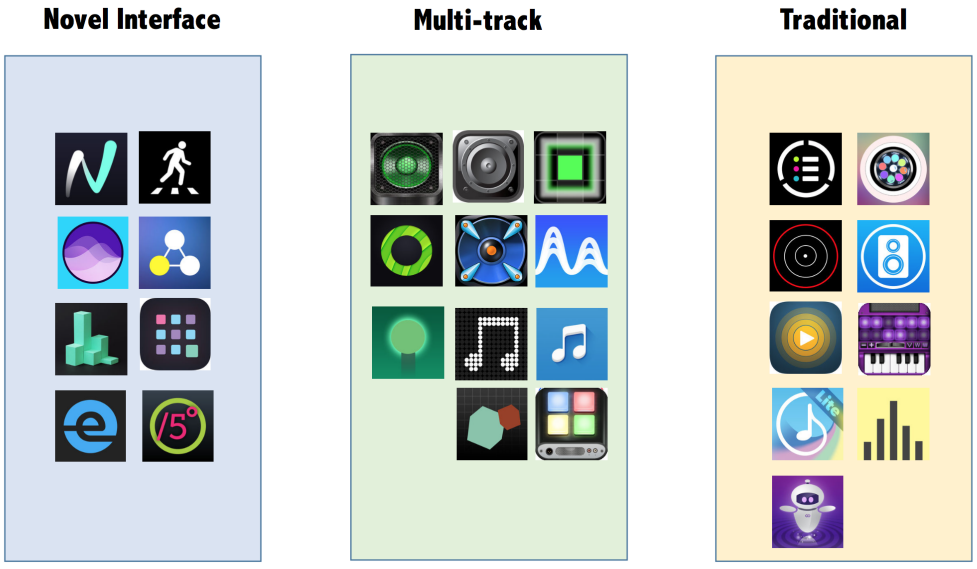

FIGURE 3.6: This is how result of study one going to look like

FIGURE 3.7: Apps under the Novel category

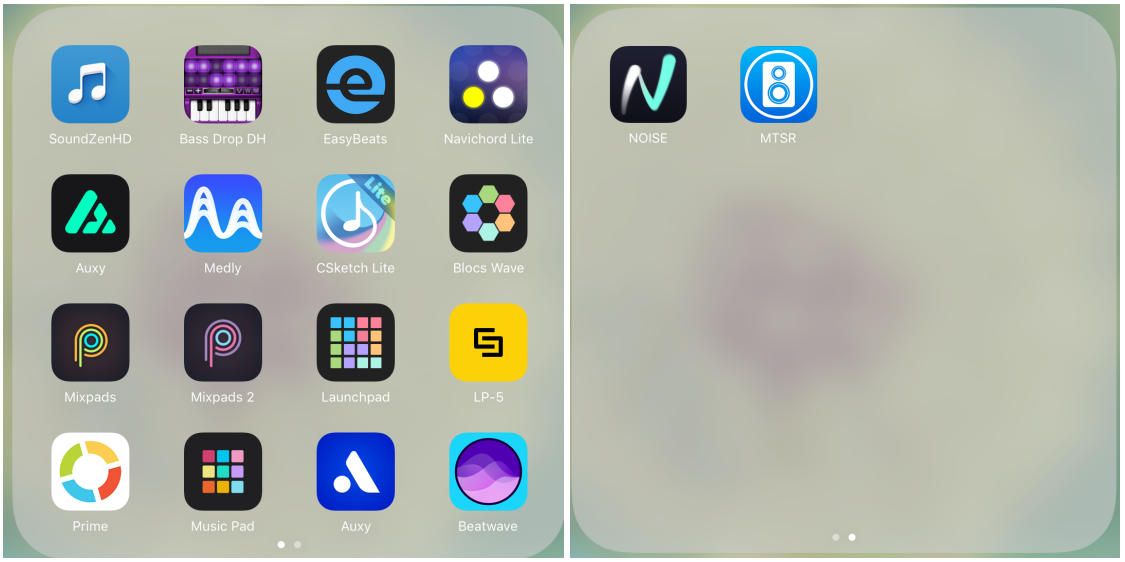

FIGURE 3.8: Apps under the Multi-track category

FIGURE 3.9: Apps under the Traditional category

Chapter 4

Study 2: User Study

Following the first study (See Chapter 3), A laboratory study was conducted to evaluate user experience on different design patterns of music sequencers. Base on the previous work of evaluating music instruments, a questionnaire was designed to measure muscians experience (See Section 4.1.1).

4.1 Method

4.1.1 Questionnaire

Base on Schmid's work, which developed a 80-item pool ordered by descending mean importance for questionnaire, 10 questions that scored the highest mark from 9 different categories were used in the user study (see Appendix B).

Schmid indicated the following three criteria for musicians to perceive musical instruments:

Experienced freedom and possibilities (EFP)

Perceived control and comfort (PCC)

Perceived stability, sound quality and aesthetics (PSSQA)

EFP as the predominent facet, mainly targets at evaluating the musicianship and expressivity of music instruments. For example, questions like "*The instrument allows me to*

express myself." are used to decide whether the instruments can let muscians to express themselves; *PCC* is used to assess the controbility of the music instruments. Questions such as *"I can control the sound appropriately."* are setted to identify how well the musicians believed they can control the instruments; *PSSQA* is the most unique facet which analyses the quality of the instruments from the material, the sound and the apperience perspectives. For instance, questions like *"The instrument pleases me sound-wise"* test the sound quality of the instrument. The above three interrelated facets construct the framework of MPX-Q questionnaire.

Factor	Category	Item	μ
EFP	Creativity	The instrument allows me to be creative	6.25
	Enjoyment	I have fun playing the instrument	6.08
	Expressiveness	The instrument allows me to express myself	6.06
PCC	Conformance	The instrument responds well to my actions	6.23
	Control	I can control the sound appropriately	6.04
	Engagement	The instrument allows me to be engaged when I'm playing it	5.98
	Engagement	I feel the urge to play the instrument again	5.79
	Play Comfort	I can recognize that the instrument responds well to my playing	5.85
PSSQA	Stability	I can rely on the instrument when playing it	6.21
	Sound Quality	The instrument pleases me sound-wise	6.02

TABLE 4.1: Items in the questionnaire with thier factor and category(ordered by descending mean importance)

Follow the framework of MPQ-Q questionnaire, 10 questions from 3 factors were implemented in our questionnaire(see Table 4.1). For each factor, only the items score the highest mean importance value in the certain category were picked. Under the EFP factor, we focused at the creativity, enjoyment and expressiveness of the music sequencer. The reason for this, it's because we want to figure out whether the design of the interface is encouraging musicians to explore new possibilities and inspiring musicians' creativity. As for the PCC, items associate with conformance, control and engagement are chose. The reason behind this is when musicians performing on instruments there are a lot of physical interaction between musicians and instruments, whether the musiciain feel conformance and engagement have impact on their overall satisfaction. For items under PSSQA, we only look at the stability and sound quality. Because the more stable of the music sequencer the more confident musicians can rely on it. Same with the sound quality, only the instrument that can satisfy the muscian is able to please the audience.

4.1.2 Participants

In total, twenty participants with different music background were invited and took part in the user study. Fifteen of them are male and five are female. All the participants have at least one year training on music and master at least one instrument. Two participants are semi-professional musicians who have spend more than 10 years on performing and music making. One are currently teaching music in the middle school. The remaining musicians play musical instruments mainly because their parents forced them to do when they were children, however, they were all greatful that they have learned music and still practise the instrument in their spare time.

FIGURE 4.1: Participants test on the music sequencer on iPad

Four of them have learned more than one instrument. One have learned more than five different instruments. The popular pick of instruments are piano and guitar. Ten participants have learned to play piano and three of them have over five years experience. Seven participants have learned guitar and still play guitar occasionnally. Other instruments are drums, violin and flute. Three participants have experience playing drums. Two have learned to play violin. Two have learned some flute many years ago. But only 15% had experience on electronic music before and had played on music sequencer on the laptop.

4.1.3 Interview

Participants were intervied at the end of the user study. The main purpose of the interview is to find out the reason behind their decision on the questionnaire. Besides, the music background of participants such as *"how many years of music training"* were recorded for further analysis.

In order to acquire the deeper reason, all the interview followed the same procedure: 1) Since the majority of the participants did not know music sequencer before, they were asked to describe the similarities among the three different music sequencer applications, and then defined what is music sequencer. which was designed to help them to form a general idea of music sequencer. 2) After that, interviewees were asked to choose their favourite application based on different scenario. Also, the interviewee needed to give reasons why certain music sequencer application was better than another. 3) In the final step, all the questions shifted to an abstract level, where they were asked whether music sequencer application on iPad were an instrument ,and what features that made them thought it is or it is not an instrument.The interviews were recorded on video and audio based on the participants agreement. The recording lasted between 10 to 20 minutes.

4.2 Results

4.2.1 Quantitative Results

From the questionnnaire, in total 600 satisfaction items were extracted. A satisfaction item is a number between one to five, which represents interviewee's degree of agreement over one certain statement. The higher number a statement scored means the more the interviewee agreed with it. The raw data was first recorded on an Excel workbook. Thanks to my supervisor Ben, who offer his help on data visualisation, the tedious numbers come to live. An overview of the participants response on the 10 questions with the selected music sequencer application is given in Figure 4.2.

In Figure 4.2, x-axis is divided into 10 columns which relatively represent 10 questions in the questionnaire. At the bottom of each column, there are numbers from one to five, which are used to measure participants agreement over the question. The y-axis

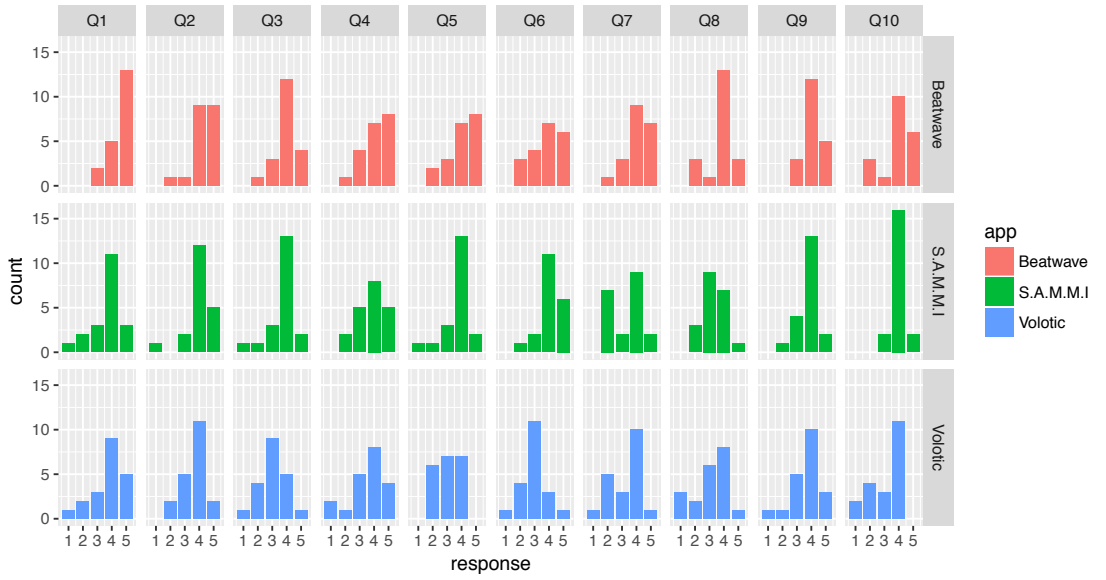

FIGURE 4.2: Overview of participants response over three music sequencer application

consist of three major row. In each row, the height of each bar denote the total amount of participants who shared the same opinion. Take the top-left section for example, for music sequencer *Beatwave*, thirteen participants strongly agreed on question one, five people just agreed on the statement by giving four marks and two people gived neutral comments.

The detailed information of participants opinions over each application is given in Figure 4.3. For each question on the left, there is a relative bar shows the percentage of the five likert scale. For instance, the first row in the top shows 65% participant strongly agreed with the corresponding statement on the left side, meanwhile, 25% people just agree with it. And 10% people remained neutral.

4.2.2 Qualitative Results

The result in this section is based on the information extracted from the interview. According to participants music-training background and the type of instruments they mainly used, we seperated the musicians into three groups: Group One (Playing traditional instruments but with less than three years formal music trainning), Group two (Playing traditional instruments but with more than three years formal music trainning), Group three (Playing electronic instruments and had more than three years formal music trainning). The reason why we don't have a group for musicians who play electronic

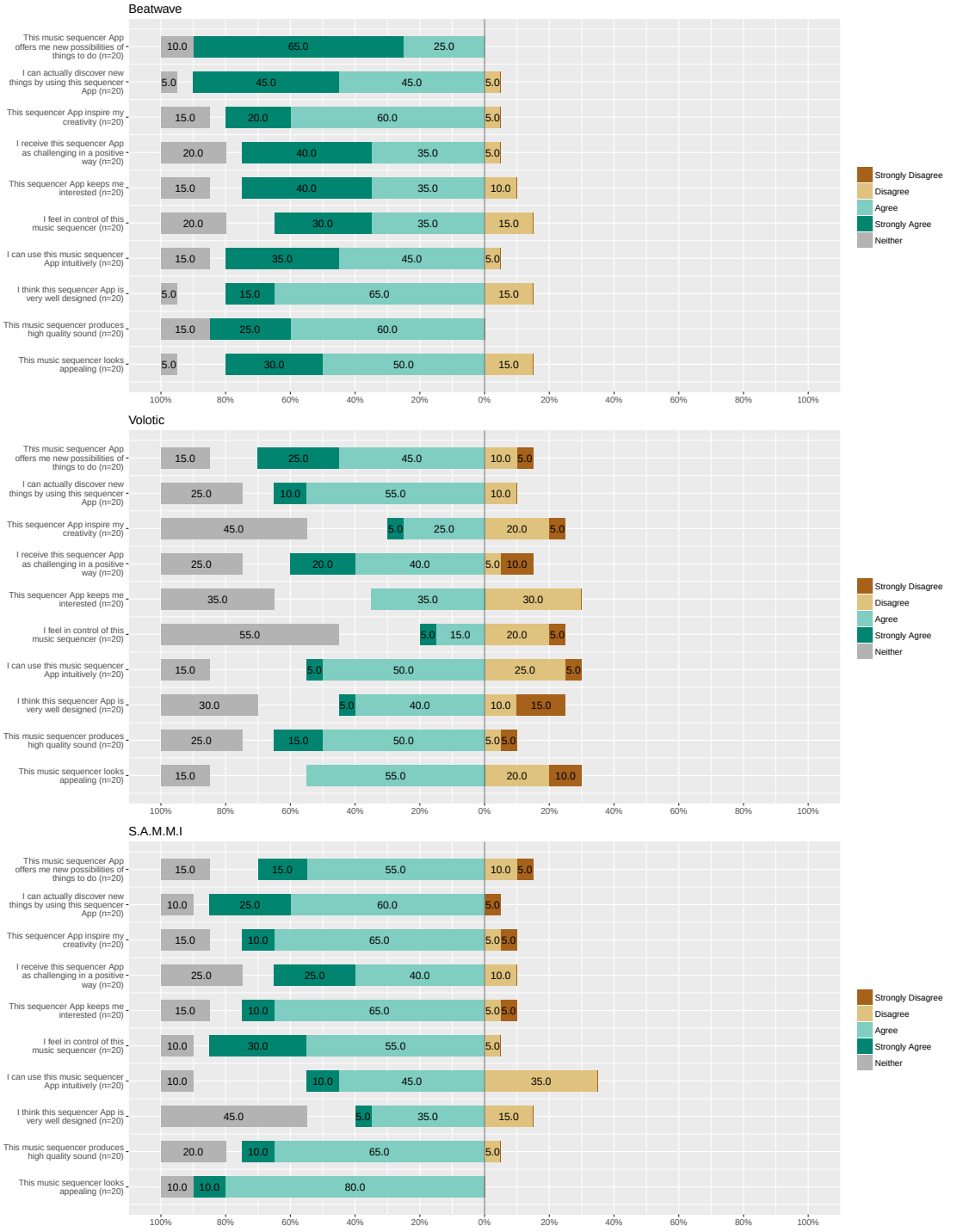

FIGURE 4.3: Participants response on Beatwave, Volotic and S.A.M.M.I

instruments but less than three years formal music training is all the participants who play electronic instruments has many years experience in playing traditional instrument before.

Group I. Participants in this group have less experience in music in general, comparing with other two groups. They found *S.A.M.M.I* was very easy to use becasue of the

intuitive design of interface. Although *S.A.M.M.I* didn't provide much options in terms of different sounds and adjustment on the sound effect, it was complex enough for them to discovery most of the possibilities. Besides, thanks to the annotation of different pitch, *S.A.M.M.I* is the only application that they were able to create a short piece of melody, such as "Super Mario"and "Mary Had a Little Lamb".

The comments on *Beatwave* were mainly focused on the layout of different tracks. They agreed combining severl layers of music together was definitely an improvement, but this design pattern made it more difficult to control comparing to the single-track interface design of *S.A.M.M.I*. Furthermore, participants in Group One believed the visual effect of *Beatwave* gave them a positive feedback. The rippling effect of the current note helped them tracked down the progress of the music.

Volotic was recognized as the most difficult application to create music. Most participants in this group thought "It's more like a game rather than an instrument". But they still thought it was a very good practice and could potentially used to help kids generate interest in music.

Group II. Participants in this group were musicians have more than 3 years professional trainning in traditional instruments like piano. In general, they have relatively deeper understanding of music. Although,*S.A.M.M.I* got most credit by providing explict display of pitch, most musicians in this group didn't rely on it. Because they could accurately justify the pitch by hearing the sound. Besides, the intuitive design of *S.A.M.M.I*'s interface was considered to be redundant. They thought the interface could be further simplified. However, one musician bought up an interesting comment on *S.A.M.M.I*. He fully untilised the explicit layout of control panel by chaning the flavour of music continuously, and explored the possibility of live performing with *S.A.M.M.I*

Beatwave was recognized as an upgrade version of *S.A.M.M.I* by adding new features such as multi-track and visual feedback. Even though *Beatwave* took musicians in Group Two longer time to learn, it provided them a larger platform to express themselves. Because musicians in this group mainly focused on traditional instruments, they tend to duplicate the melody they learned before. Thus, an electronic version of "Song of Joy"was created. And during this process, they found the interface of *Beatwave* was designed to focus on a larger picture of music as a whole rather than create a short piece of melody. Another interesting finding was interviewee in this group didn't give

much credit on the visual feedback, but considered it as decoration which made the user interface(UI) looked fancy.

Same with the participants in Group One, musicians in this group thought *Volotic* was "very confusing". In spite of several demos provided in the beginning, almost all the musicians still found it hard to figure out how *Volotic* worked. Furthermore, timing in *Volotic* was controled by the time that signal(little dots) traveled from one unit to another. However, it turned to be diffcult to control when there were several little dots travelling on the screen.

Group III. Unlikes the previous groups, musicians in this group had exposed to electronic music for a long time, and they all had experience in using a music sequencer hardware or something similar before. Thus, people in this group had certain knowledge on music sequencing, and had experience on making electronic music. The experience on electronic music let those musicians provided suggestions from a more professional perspective. For them, *S.A.M.M.I* was like an instrument for beginner and witch cannot let them fully express themselves.

Most of the conversation was around *Bearwave*. The implementation of multi-track assisted musicians to compose music by editing differet layers. What's more, with the management system to handle different sections of music, it helped musicians to extend the length of their works. Also, considering the appearence of the electronic instruments are becoming more colorful and shiny, the visual effect of *Beatwave* made the interface more appealing compaing to the other two applications. However, there were demand on integrating synthesizer into *Beatwave* so as to have more freedom on sound mixing. An alternative way proposed by one of the musicians was developed an input/output system, which potentially made the application more practical.

The opinions on *Volotic* in group three were more open companing with the other groups. Musicians in this group were tend to give credite for the innovative design of *Volotic*'s interface. Despite the fact that the name of symbols were unclear, they still believed they could make some interesting music with *Volotic* if more time been given.

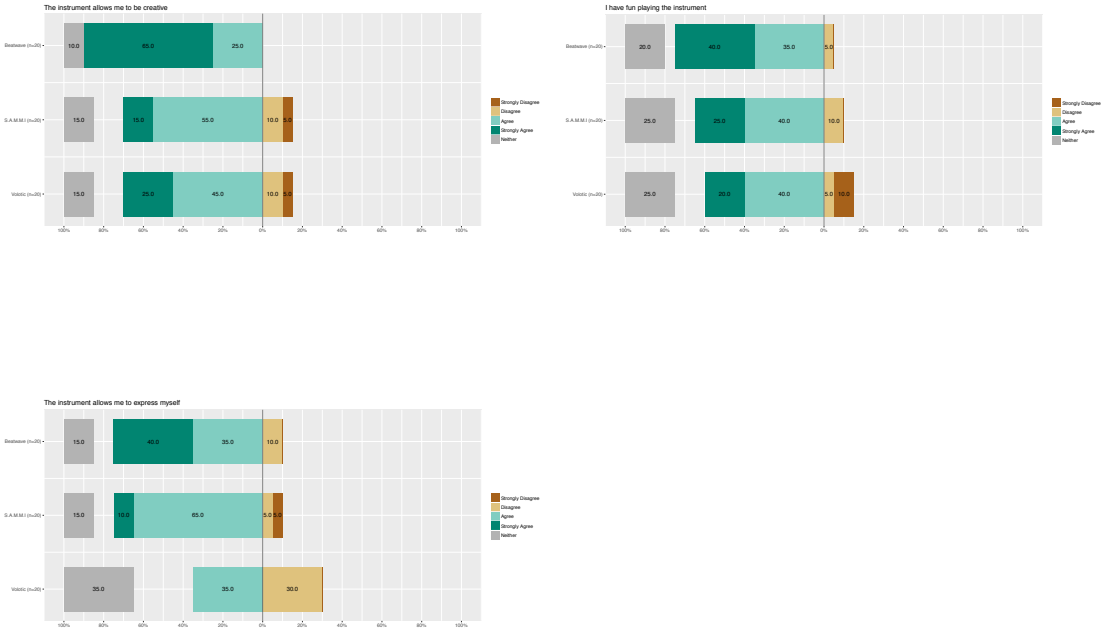

FIGURE 4.4: Statistic results for questions belong to *EFP*

4.2.3 Discussion

From the statistic results extracted from the questionnaire, it is clear to say that the multi-track interface represented by *Beatwave* is the most popular design among musicians. By contrast, the non-traditional interface represented by *Volotic* received most of the nagative comments.

Considering the factor each question belong to (see Table 4.1), we can look in details of what specific aspect an interface good at. In Figure 4.4, statistic result for questions belong to *EFP* were grouped together. Apparently, *Beatwave* was the best applcation to encourage musicians creativity. And *Volotic* was slightly better than *S.A.M.M.I* in this category. In enjoyment category, *Beatwave* still gathered most of "Strong Agreement". But *Volotic* was not that fun compaied with *S.A.M.M.I*. For the expressiveness of the applications, *Beatwave* and *S.A.M.M.I* were quite similar, the only difference was musicians had stronger feeling on *Beatwave*. However, opinions on *Volotic* were equally distributed, it looked like musicians had a substential differences on whether the interface of *Volotic* supported them to expressed themselves.

Types	EFP	PCC	PSSQA
Traditioanl	• can not fully express myself • don't have too much options	• very easy to control • intuitive design	• the interface is dull • not appealling
Multi-track	• inspire creativity • a lot of options	• not easy to get start • the layout can be confusing	• the interface is awesome • the visual is very helpful
Novel	• inspire creativity in some degree • it's fun	• very condusing • would be better with with an instruction	• it looks interesting • the interface looks like a game

TABLE 4.2: Items in the questionnaire with thier factor and category(ordered by descending mean importance)

Chapter 5

Conclusion

5.1 Summary

With the repid development of technoldge, mobile devices have become the new playground for musicians to express themselves. With a variety of sensors, as well as the exponentional growth in the processing power, iPad offer an attracitve platform for music performing. Thousands of music applications have been developed for the iPad. Music sequencer applications, as one of the major category of music making applications, have seen a lot of derivation and innovation. But the question is among those novel music sequencer interface which one supports musicians performance and stimulates their creativities. This thesis is trying to answer the above question from the perspective of musicians. In the first study, we analyzed 55 music sequencer applications from App Store and created an interface taxonomy. The music sequencer applications were divided into three groups according to the mapping of pitch, trigger and timber. In the second consecutive study, three most representative applications from each group were selected and tested by musicians to evaluate the pros and cons in the different design approaches. By employing the MPX-Q questionnaire, we quantitatively analyzed the strength and weakness of each sequencer applications. Follow by, a qualitative study was conducted to further investigate the reason behind those design.

5.2 Limitation

Only collect apps from iOS App Store, there are more from android market.

It's hard to say the selected apps are the best representative from their own class.

5.3 Future Work

Design guidline Develop our own sequencer Further investigate other music instrument application on the App Store by employing the user study.

Appendix A

Independent Study Contract

INDEPENDENT STUDY CONTRACT

Note: Enrolment is subject to approval by the projects co-ordinator

SECTION A (Students and Supervisors)

UniID: _u5541558

SURNAME: _Ding FIRST NAMES: _Ke

PROJECT SUPERVISOR (*may be external*): Ben Swift

COURSE SUPERVISOR (*a RSCS academic*): Ben Swift

COURSE CODE, TITLE AND UNIT: COMP4560 Advanced Computing Project

SEMESTER _S1 2017_____

PROJECT TITLE:

An evaluation of touch-based music sequencer apps on iPad

LEARNING OBJECTIVES:

- Conduct a survey & create an interface taxonomy of current music sequencer apps on the iOS app store
- Perform an HCI user study of a selection of these apps (based on the taxonomy) measuring the user experience & preferences of musicians in creating music with these interfaces
- Propose some design guidelines for creating interfaces for music sequencer apps

PROJECT DESCRIPTION:

While musical interfaces have long been studied in HCI, the iPad and app store has produced thousands of novel (and not-so-novel) twists on the "grid-based" sequencer paradigm.

By reviewing a selection (20+) of current iOS sequencer interfaces in depth, this project will create a taxonomy of design approaches, drawing out the common patterns (and areas of divergence/innovation) in these interfaces.

Having performed this classification, the project will further explore the major design axes through a user-study. In this, musicians will be given various apps in an open-ended music-making task, and will answer a user-experience questionnaire and short interview to further probe the impacts of these design choices. As a result, a set of design guidelines/considerations will be produced for the construction of interfaces for music sequencing.

Australian National University

ASSESSMENT (as per course's project rules web page, with the differences noted below):

Assessed project components:	**% of mark**	**Due date**	**Evaluated by:**
Report: name style: research report (e.g. research report, software description..., no less than 45% weight assigned)	90		(examiner)
Artefact: name kind: _____ (e.g. software, user interface, robot..., no more than 45% weight assigned)	0		(supervisor)
Presentation:	10		(course convenor)

MEETING DATES (IF KNOWN):

Every Friday

STUDENT DECLARATION: I agree to fulfil the above defined contract:

KE DING …….. 2017.2.27 ……..

Signature Date

SECTION B (Supervisor):

I am willing to supervise and support this project. I have checked the student's academic record and believe this student can complete the project.

…….. ……..

Signature Date

REQUIRED DEPARTMENT RESOURCES:

SECTION C (Course coordinator approval)

…….. ……..

Signature Date

SECTION D (Projects coordinator approval)

…….. ……..

Research School of Computer Science ***Form updated Jun-12***

Appendix B

App Store Music Sequencer Applications

App Store Music Sequencer Applications			
Application Name	Description	Seller	Link
Music Pad	dj player remix electronic music beat	Xinggui Zhang	<https://appsto.re/au/_Dkmeb.i>
Volotic	N/A	Scott Garner	https://appsto.re/au/-WW64.i
Beatwave	N/A	collect3	https://appsto.re/au/UzERv.i
EGDR808	Drum Machine free	Elliott Garage	https://appsto.re/au/rPfXO.i
LoopStation	N/A	Rene Zuidhof	https://appsto.re/au/UzMw7.i
Noise	N/A	ROLI Ltd	https://appsto.re/au/Zzkr8.i
Music Strobe Starter	N/A	Arun Bab	https://appsto.re/au/y4NFQ.i
Beatbox Looper	N/A	Pierre Guilluy	https://appsto.re/au/Sfk6R.i
Dubstep Invasion	Music And Song Hit Maker	Jochen Heizmann	https://appsto.re/au/Oane3.i

App Store Music Sequencer Applications(Continued)			
Application Name	Description	Seller	Link
Remix Pads	make groove beats record music app	Alexey Natarov	https://appsto.re/au/R7_pdb.i
Music Touch	Make Mix Music DJ Beats	Qiao He	https://appsto.re/au/D_ZTdb.i
Loop maker	Amazing music maker	Miguel Saldana	https://appsto.re/au/MpDthb.i
Drum Pads Machine	Beat maker dj music studio	Alexey	https://appsto.re/au/JZ9adb.i
Drum Pads Machine 2	Beat maker dj music app	Alexey Natarov	https://appsto.re/au/c5DZdb.i
MIxpads	Virtual dj pads sampler free app	Alexey Natarov	https://appsto.re/au/CPj1eb.i
Loopacks	Music Maker Loop Machine DJ Beats	Hernan Arber	https://appsto.re/au/oXKt1.i
Dubstep Dubpad 2	Electronic Music Sampler	FAD Games LLC	https://appsto.re/au/mCRXO.i
NOIZ	Make Epic Music	Studio Amplify	https://appsto.re/au/KK9Uab.i
Blocs Wave	Make Record Music	Novation	https://appsto.re/au/L0MTab.i
MIxpads 2	Dubstep Trap drum pad sampler for DJ	Alexey Natarov	https://appsto.re/au/oH_ffb.i
Polyphonic!	NA	Flip Studios LLC	https://appsto.re/au/u_PhS.i
Steve Reich's Clapping Music	Improve Your Rhythm	Amphio Limited	https://appsto.re/au/R-JA4.i
Music Pad	remix electronic music beat	Xinggui Zhang	https://appsto.re/au/_Dkmeb.i
Loop Community	NA	Loop Community	https://appsto.re/au/VyLNN.i
LP-5	Loop-based Music Sequencer	Markus Waldboth	https://appsto.re/au/Z6EDN.i

App Store Music Sequencer Applications(Continued)			
Application Name	Description	Seller	Link
Dubstep Song Construction Kit	NA	Jochen Heizmann	https://appsto.re/au/Knd0I.i
Dubstep Filth Factory	Sampler and Loop Machine	Ben Frost	https://appsto.re/au/iHnUX.i
Monolith Loop	Relax Meditate Sleep Zen	Monolith Interactive Inc.	https://appsto.re/au/vfGDy.i
Theremin Synth	Loop Record Download	Luke Phillips	https://appsto.re/au/gJI2bb.i
Music Makr JAM	Create remix share your music!	JAM just add music GmbH	https://appsto.re/au/EXEG0.i
Novation Launchpad	Make Remix Music	Novation	https://appsto.re/au/QNk1I.i
Multi Track Song Recorder	NA	Derrick Walker	https://appsto.re/au/Ygbsx.i
Triqtraq	Jam Sequencer music making on the go	Zaplin Music	https://appsto.re/au/G8XhD.i
Trigger Box	NA	Justus Kandzi	https://appsto.re/au/j4Hn1.i
Composer's Sketchpad Lite	NA	Alexei Baboulevitch	https://appsto.re/au/nWJO_.i
Orbita for iOS	NA	Keijiro Takahashi	https://appsto.re/au/kBIaN.i
S.A.M.M.I.	NA	Christopher Ayles	https://appsto.re/au/YDMeY.i
ScratchVOX	NA	ScratchVOX	https://appsto.re/au/e4aX0.i
Oro	Visual Music	Light the Music LLC	https://appsto.re/au/d6px5.i
Poly	NA	James Milton	https://appsto.re/au/LFspN.i
Mutone	NA	william LINDMEIER	https://appsto.re/au/IkoJM.i

App Store Music Sequencer Applications(Continued)			
Application Name	Description	Seller	Link
WR6000	NA	WEJAAM	https://appsto.re/au/pM3E3.i
SoundZen HD	NA	Tapbox LTD	https://appsto.re/au/dHrZB.i
SoundGrid	NA	Vitaly Pronkin	https://appsto.re/au/fSB3s.i
Visual Beat	Interactive Music Video	Max Moertl	https://appsto.re/au/B-8l6.i
MINI-COMPOSER	NA	Masayuki Akamatsu	https://appsto.re/au/Ar8Ez.i
Loopseque Lite	NA	Casual Underground	https://appsto.re/au/BTm8x.i
Bass Drop	Deep House Electronic music sampler and synthesizer	Ben Frost	https://appsto.re/au/k3rp0.i
Beat Boss	Electronic Dance Music Sampler	Ben Frost	https://appsto.re/au/DWLyU.i
TonePad	NA	LoftLab	https://appsto.re/au/nOx1s.i
Navichord Lite	intuitive chord sequencer	Denis Kutuzov	https://appsto.re/au/kTci2.i
EasyBeats Drum Machine Free MPC	Hopefully Useful Software	Christian Inkster	https://appsto.re/au/gJ1Ot.i
Fifth Degree	MIDI Sequencer	Bernie Maier	https://appsto.re/au/qFZM1.i
Keenzy	NA	Tek Min Ewe	https://itunes.apple.com/au/app/keezy/id605855595?mt=8
Medly	Music Maker	Medly Labs Inc	https://appsto.re/au/CP1c4.i

Appendix C

Questionnaire

An evaluation of touch-based music sequencer apps on iPad

Questionnaire *App*: _____ *Type*: _____ *Date*: _____

**Please indicate how strongly you agree or disagree with all the following statements which apply to you by selecting a number from 1 (strongly disagree) to 5 (strongly agree).*

Question #1: **The instrument allows me to be creative.**

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

Question #2: **The instrument responds well to my actions.**

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

Question #3: **I can rely on the instrument when playing it.**

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

Question #4: **I have fun playing the instrument.**

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

Question #5: **The instrument allows me to express myself.**

1	2	3	4	5
Strongly Disagree	Disagree	Neither	Agree	Strongly Agree

An evaluation of touch-based music sequencer apps on iPad

Question #6: **I can control the sound appropriately.**

Question #7: **The instrument pleases me sound-wise.**

Question #8: **I feel the urge to play the instrument again.**

Question #9: **The instrument allows me to be engaged when I'm playing it.**

Question #10: **I can recognize that the instrument responds well to my playing.**

Appendix D

Interview Questions

This document contains a list of questions that will be asked in the interview.

1. Can you tell me about your experience and training in music? How long have you been learning?

2. What kind of instrument you play most in your spare time, and what kind of instrument you instrument you prefer to play?

3. Among the 3 apps you just played, do you find one app attracted you most, or you think they are all very boring?

4. Have you heard about or used music sequencers before?

5. After playing the three apps, can identify any interface patterns in these music sequencer apps?

6. Did one particular interface most inspired your creativity? How?

7. Do you think the complexity of the interface has an effect on how enjoyable the app is to play?

8. Would you play any of these apps later, or will you tell your friends about them?

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