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An evaluation of touch-based music sequencer apps on iPad

by

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in the
Research School of Computer Science

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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.

Signed: _____

Date: _____

"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

The acknowledgements and the people to thank go here, don't forget to include your project advisor...

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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

Physical Constants

Speed of Light $c = 2.997\ 924\ 58 \times 10^8\ \mathrm{ms}^{-\mathrm{S}}$ (exact)

Symbols

a	distance	m
P	power	W (Js^{-1})
ω	angular frequency	rads^{-1}

For/Dedicated to/To my...

Chapter 1

Introduction

As shown in [Müller et al., 2012].

1.1 Background

1.1.1 The development of NIME

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].

1.2 Related Work

1.3 Research goals and motivation

1.4 Structure

The research project was divided into two consecutive studies()

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 15 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

2.3 Evaluation of musical instruments

2.3.1 From performer's pespective

2.3.2 rom audience's pespective

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 A). 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 as *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.

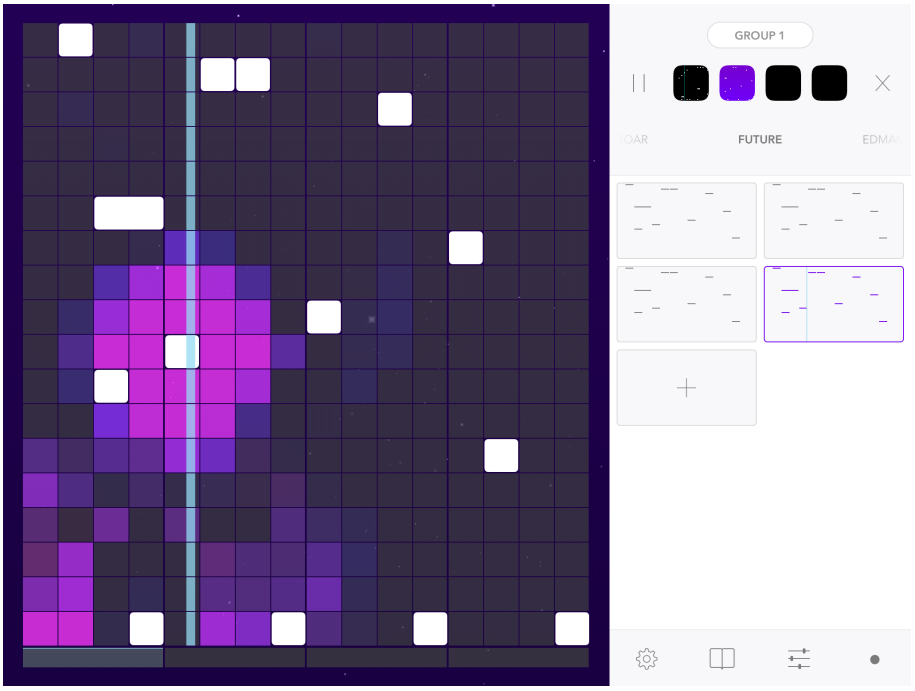

FIGURE 3.1: Beatwave: grid-based, buttome-to-top and discrete pitch layout

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.

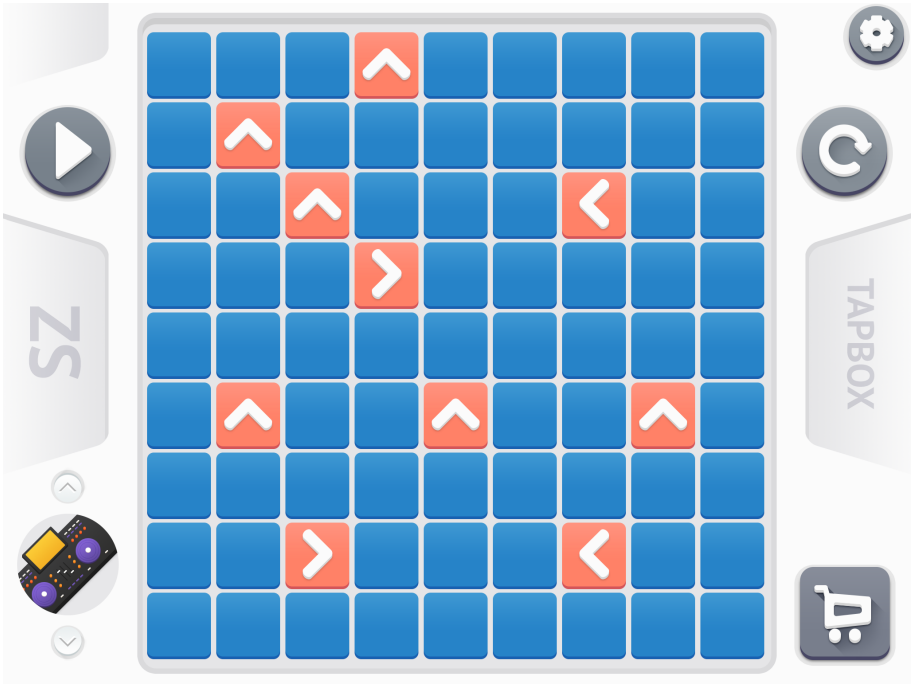

FIGURE 3.2: SoundZen: grid-based, right-to-left and discrete pitch layout

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).

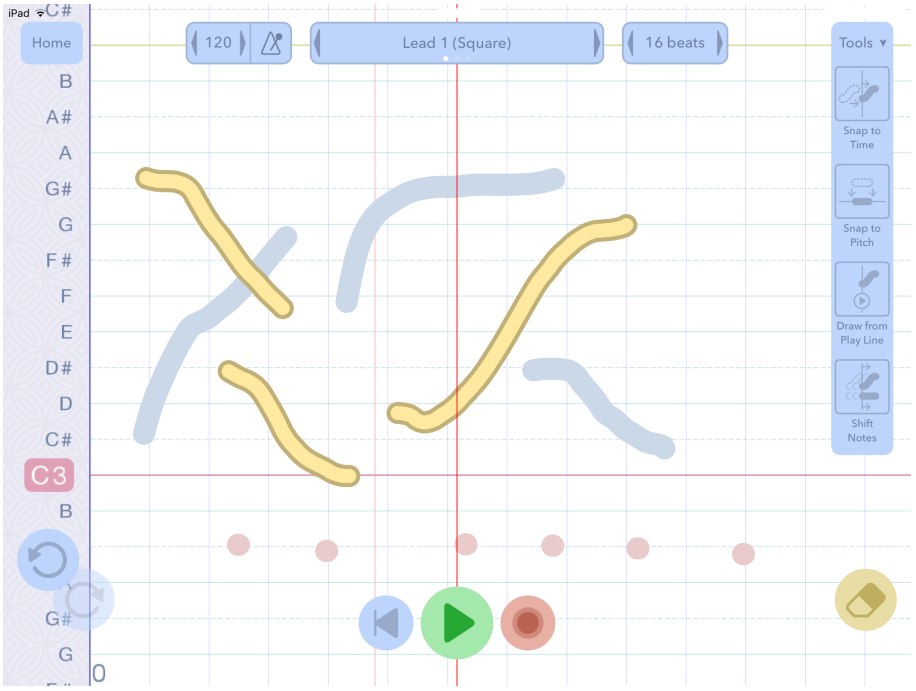

FIGURE 3.3: CSketch Lite: grid-based, top-to-bottom and continuous pitch layout

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, the defect of this color-based mapping is not intuitive. It takes some time 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. See 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).

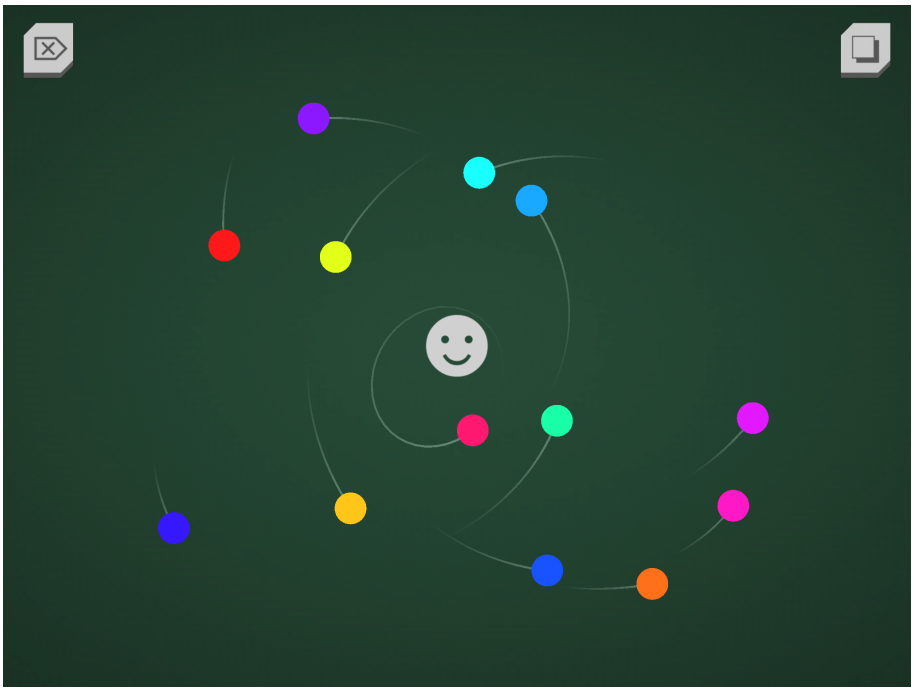

FIGURE 3.4: Orbita: elliptical orbita, non-linear and continuous pitch layout

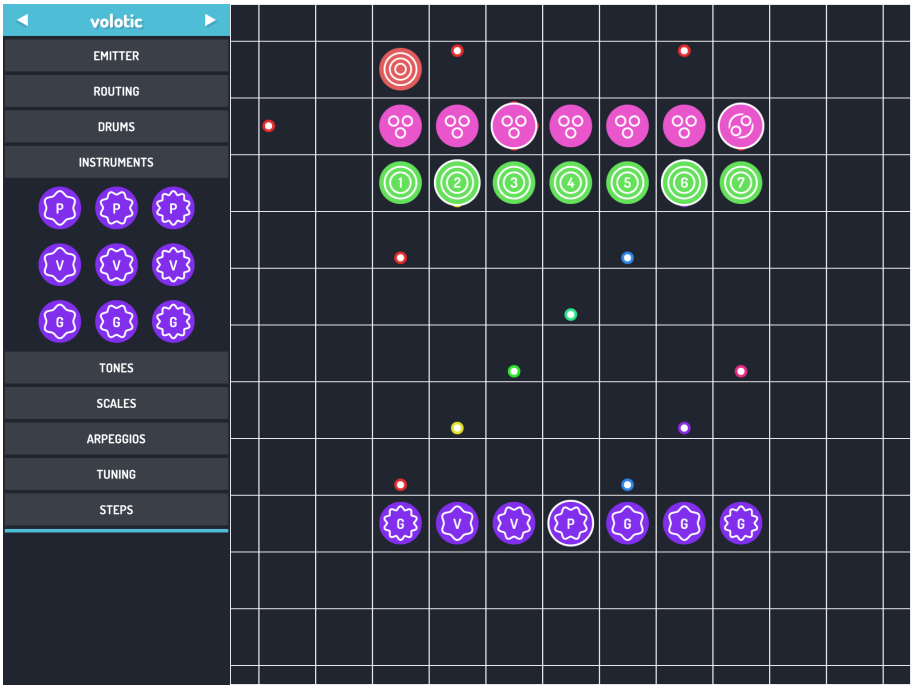

FIGURE 3.5: Volotic: game-like, linear and color-based pitch layout

3.2 Results

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 A).

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

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

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

should be a caption

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.

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.

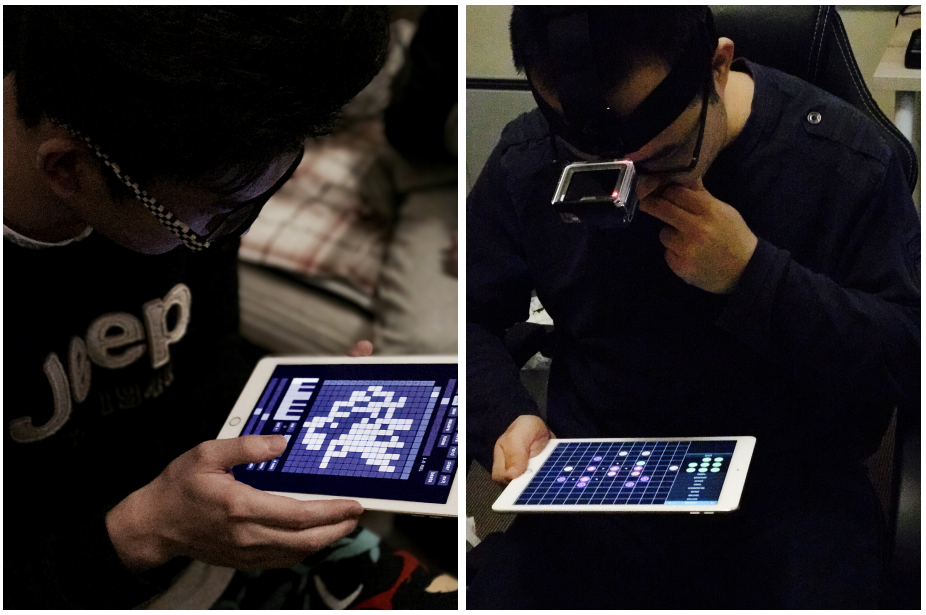

FIGURE 4.1: Participants test on the music sequencer on iPad

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

4.3 Discussion

4.4 Summary

Appendix A

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
Light Medley	NA	Tek Min Ewe	https://appsto.re/au/FU06hb.i
Medly	Music Maker	Medly Labs Inc	https://appsto.re/au/CP1c4.i

Appendix B

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.**

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

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

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

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

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

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

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

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

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

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