Exquisite Score – A System for Collaborative Musical Composition

by

Daniel Manesh

Submitted to the Department of Electrical Engineering and Computer Science
in partial fulfillment of the requirements for the degree of Master of Engineering in Computer Science and Engineering

at the MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 2016

© Massachusetts Institute of Technology 2016. All rights reserved.

Author

Department of Electrical Engineering and Computer Science

May 20, 2016

Certified by

Joseph A. Paradiso

Alexander W Dreyfous (1954) Professor of Media Arts and Sciences

Thesis Supervisor

Certified by

Eran Egozy

Professor of the Practice

Thesis Supervisor

Accepted by

Dr. Christopher Terman

Chairman, Masters of Engineering Thesis Committee
Exquisite Score – A System for Collaborative Musical Composition

by

Daniel Manesh

Submitted to the Department of Electrical Engineering and Computer Science on May 20, 2016, in partial fulfillment of the requirements for the degree of Master of Engineering in Computer Science and Engineering

Abstract

Exquisite Score is a web application which allows users to collaborate on short musical compositions using the paradigm of the parlor game Exquisite Corpse. Through a MIDI-sequencer interface, composers each contribute a section to a piece of music, only seeing a brief fragment immediately preceding their section. Exquisite Score went through many iterations and was tested by several students and musicians. Several short pieces were produced, some of which are included and analyzed here. Exquisite Score succeeds in providing a new way to create collaborative musical compositions that celebrate the novel and creative.

Thesis Supervisor: Joseph A. Paradiso
Title: Alexander W Dreyfoos (1954) Professor of Media Arts and Sciences

Thesis Supervisor: Eran Egozy
Title: Professor of the Practice
Acknowledgments

A huge thanks to my advisor Eran, for providing invaluable feedback throughout this project, for gathering so many testers, and for getting me interested in combining technology and music in the first place. Thanks also to Joe Paradiso, for providing insight and guidance along the way. Also, a special thanks to Evan L. for several compositions, great feedback, and general encouragement.

Thanks to everyone who tested out Exquisite Score: Merry, Sherry, Grant, Val, Luke, Lisa, Nick, Anna H., Drew, Rotem, James, Eric, Donovan, Jonathan, Danielle, Nathan, Tiffany, Liza, Peter, Archana, Sam, Dan B., Madi, So Yeon, Gershon, Emily, Eran, Reo, Dan S., Larry, Chris, Alex, Deena, Dustin, Adam, Evan, and Steve. Without your contributions and feedback, the project could not have gone anywhere. A special thanks to those who tried it out as a parlor game: Archana, Dustin, Madi, Emily, Evan, and Anna H. Thanks also to Nick in particular for providing several very amusing contributions.

And of course, many thanks to Anna W., my friends, and my family.
Contents

1 Introduction 11

2 Background and Related Work 13
   2.1 The Exquisite Corpse: Definitions ................................. 13
   2.2 Exquisite Corpse Inspired Art ................................. 14
      2.2.1 Film .................................................. 14
      2.2.2 Music .................................................. 15
   2.3 Exquisite Corpse on the Internet ................................. 16
      2.3.1 Epic Exquisite Corpse .................................. 16
      2.3.2 Folding Story ......................................... 17
      2.3.3 Exquisite Forest ....................................... 17

3 Exquisite Score - Goals and Motivation 19
   3.1 Goals .................................................. 19
   3.2 Motivation .................................................. 21
      3.2.1 Educational Value .................................. 21
      3.2.2 Artistic Value ....................................... 22
   3.3 System details and tools ....................................... 23
   3.4 Development Process ........................................ 24

4 Iteration 1 - Button Grid 25
   4.1 Design Description ........................................ 25
   4.2 Testing .................................................. 28
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.3 Results</td>
<td>29</td>
</tr>
<tr>
<td>5 Iteration 2 - Piano Roll Sequencer</td>
<td>31</td>
</tr>
<tr>
<td>5.1 Design Description</td>
<td>31</td>
</tr>
<tr>
<td>5.2 Testing</td>
<td>34</td>
</tr>
<tr>
<td>5.3 Results</td>
<td>36</td>
</tr>
<tr>
<td>6 Iteration 3 - Fixed Form Pieces</td>
<td>41</td>
</tr>
<tr>
<td>6.1 Fixed Form Pieces</td>
<td>41</td>
</tr>
<tr>
<td>6.1.1 Rondo Form</td>
<td>42</td>
</tr>
<tr>
<td>6.1.2 Minimalist Variations</td>
<td>43</td>
</tr>
<tr>
<td>6.2 Testing</td>
<td>44</td>
</tr>
<tr>
<td>6.3 Conclusions</td>
<td>45</td>
</tr>
<tr>
<td>7 Analysis</td>
<td>47</td>
</tr>
<tr>
<td>7.1 Qualitative Analysis</td>
<td>47</td>
</tr>
<tr>
<td>7.1.1 Piece 4</td>
<td>49</td>
</tr>
<tr>
<td>7.2 Quantitative Analysis</td>
<td>56</td>
</tr>
<tr>
<td>7.2.1 Measuring Similarity and Extracting Musical Features</td>
<td>56</td>
</tr>
<tr>
<td>7.2.2 Results</td>
<td>58</td>
</tr>
<tr>
<td>8 Conclusion and Future Work</td>
<td>63</td>
</tr>
<tr>
<td>A Survey Results</td>
<td>67</td>
</tr>
<tr>
<td>A.1 Iteration 1</td>
<td>67</td>
</tr>
<tr>
<td>A.2 Iteration 2</td>
<td>78</td>
</tr>
</tbody>
</table>
## List of Figures

1-1 An Exquisite Corpse ink and pencil drawing by Yves Tanguy, Joan Miró, Max Morise, and Man Ray [18]  

3-1 The Exquisite Score system  

4-1 The Novation Launchpad - an eight-by-eight grid of buttons that can be used as a step-sequencer.  
4-2 The main editing region from the compositional interface in the first iteration of Exquisite Score.  

5-1 A piano-roll style MIDI-sequencer interface from Ableton Live.  
5-2 The compositional interface for the second iteration of Exquisite Score.  

6-1 A Rondo after the first three fragments have been composed. Fragments 4, 5, 6, and 7 all receive hints from the left and from the right.  
6-2 The composition order for a Minimalist Variations piece. The current fragment being composed is shown in white and the hints are shown in gray.  

7-1 The third fragment of Piece 1, along with its hint from the second fragment. This is a musical non sequitur: it has very little in common with the previous section.  
7-2 Piece 2, fragment 7. The composer abruptly transitions to the tune of “Jingle Bells” halfway through the fragment.
7-3 Fragments $B$ and $C$ of “Baby Spade”. Fragment $C$ has a very similar bassline to fragment $B$. 

7-4 Fragments $B'$ and $C'$ of “Baby Spade”. Both fragments share the same bassline as fragments $A'$ and $C$. 

7-5 Piece 4: Fragments 1, 2, 3 

7-6 Piece 4: Fragments 4, 5, 6 

7-7 Piece 4: Fragments 7, 8 

7-8 Tonal similarity to the first fragment for five different pieces. The average similarity of the first fragment to fragments in other pieces is shown as a dashed line. 

7-9 Full ensemble similarity to first fragment for each piece 

7-10 Average comparative similarity scores versus fragment distance
Chapter 1

Introduction

Exquisite Corpse is a game popularized by surrealists in the 1920’s wherein artists collectively assemble an image. In one variation of the game, also known as Picture Consequences, three players begin by folding a paper into thirds. Player one draws a head in the top third of the paper, extending the lines just over the edge to the middle third. Player one then folds the paper and passes it on to player two. Player two, seeing only the bottom edge of player one’s drawing, draws a torso and arms on the middle third of the paper, again extending lines slightly over into the bottom third. Player two then folds the paper again, passing it to player three, who, seeing only the bottom lines from the arms and torso, finishes by drawing the legs [22].

In another, word-based variation, players begin by agreeing on a sentence structure, for example “The adjective noun verbs the adjective noun.” Players then pass around a paper, filling out the sentence one word at a time, unaware of the preceding words. The name Exquisite Corpse comes from a particular sentence created in this manner: “Le cadavre exquis boira le vin nouveau” - the exquisite corpse shall drink the new wine[16].

This thesis presents Exquisite Score, a web application which allows the collective composition of short musical pieces inspired by the game of Exquisite Corpse.

Chapter two has a high-level discussion of the Exquisite Corpse paradigm and describes related work, including several examples of art inspired by Exquisite Corpse and examples of web applications inspired by Exquisite Corpse.
Chapter three introduces the Exquisite Score system, providing design goals which serve as a basis for evaluation.

Chapters four, five, and six explore three iterations of the Exquisite Score system, describing the design decisions, the actual interface, and the testing results of each. The first two iterations focus on the compositional interface, and the third focuses on further exploring compositional paradigms.

Chapter seven provides a qualitative and quantitative analysis of some of the resulting musical pieces.

Chapter eight describes conclusions and future work.
Chapter 2

Background and Related Work

2.1 The Exquisite Corpse: Definitions

In the introductory essay to the collection “The Exquisite Corpse: Chance and Collaboration in Surrealism’s Parlor Game,” Kochhar-Lindgren, Schneiderman, and Denlinger have the following to say of the rules of Exquisite Corpse:

The “rules” of Exquisite Corpse never veer toward an ossification of dogma, and yet the contributors to this volume nonetheless hold onto baseline definitions of the Corpse across the decades: edges and new figures are created by a fold, a drawing, or an analogous aesthetic move. This edge allows for the processing of information in endless varieties of undulations. For the Surrealists, to fold was to hide and to reveal at once - to hide the body of work that the next participant might automatically wish for, and to reveal, in the few lines pressing over the fold, the possibilities of a ludic experience that becomes simultaneously both singular and collective [9].

This description describes all the necessary elements of an Exquisite Corpse: a piece of art is constructed collaboratively by several artists, and each artist receives only some context from other artists via some type of fold which links their contributions.

To describe the aspects of Exquisite Corpse, I will use the following terminology throughout this thesis:
**Fragment** The artistic contribution of one individual. The fragments are stitched together to form the complete piece.

**The Fold** The juncture where fragments are stitched together. In the drawing version, this is just the edge of a fragment, the fold of the paper.

**Occlusion** Refers to what is blocked from each contributor. In the drawing game, all but the edge of the paper are occluded.

**Hint** The section of the previous fragment or fragments that a contributor sees when they create their own fragment.

**Shared Region** The area of a contributor’s fragment that will be seen by other contributors. The shared region for one contributor becomes the hint for the next.

**Contextual Backbone** The extra context a contributor has, beyond the hint. For example, a contributor might know they are meant to be drawing legs because they are at the bottom of a paper.

### 2.2 Exquisite Corpse Inspired Art

The Exquisite Corpse has evolved from a ludic pastime of the surrealists into a viable way to make art. This section briefly examines artwork created within the Exquisite Corpse paradigm and explores how the paradigm is adapted to the realms of both film and music.

#### 2.2.1 Film

An example of Exquisite Corpse in film is the 2000 documentary *Mysterious Object at Noon*, directed by Apichatpong Weerasethakul [13]. The film itself is not composed as an Exquisite Corpse - instead it is a documentary in which the film crew travels throughout the Thai countryside, asking people they encounter along the way to continue a story. It is essentially a massive, word-of-mouth exquisite corpse, captured
on film. The narrative is three-fold: there is the actual constructed story, the story and background of each contributor, and the story of the journey to create the Exquisite Corpse.

Another documentary called *The Exquisite Corpse Project* uses a similar approach [15]. In this documentary, five comedy writers come together to assemble a screenplay. The adaptation of the Exquisite Corpse paradigm is straight-forward: each writer contributes a fragment of 15 pages, with only the last five pages from the previous fragment as the hint. The film presents a realization of the completed screenplay interspersed with documentary footage of the writing process. As with *The Mysterious Object at Noon*, we have multiple levels of narrative: both the result of the Exquisite Corpse and the story of its assembly.

### 2.2.2 Music

People have also experimented with applying the Exquisite Corpse paradigm to musical composition. One such collaboration was done for the website Think Jar Collective by composers Doug Organ, Trevor Rockwell, Peter Belec, Kris Schindel, Lyle Bell, and Ben Weinlick [6]. To compose, the group first agreed on a contextual backbone: a tempo, a length for the piece, a key, and a random theme, such as “Dystopia/post-apocalypse, stolen identity and a relationship story”. Then, each contributor composed one track for the resulting piece: one bass, one lead, two vox effects tracks, and one percussion. The resulting tracks were layered on top of each other. Of particular interest here is that no composer received any hint from the other composers and the only cohesive element was the contextual backbone.

Another musical example is the hour-long Exquisite Corpse piece commissioned and performed by the Zephyr Quartet for the Adelaide Festival of the Arts in 2016 [8]. The piece is a collaboration between the Zephyr String Quartet, twelve composers and two animators. Each composer was given the end of the previously composed fragment as the hint, and the results were stitched together temporally. This straight-forward application of the Exquisite Corpse paradigm to music resulted in a well-received, sold-out performance.
One more musical example of interest is the “$100 Guitar Project”, spearheaded by Nick Didkovsky and Chuck O’Meara [7]. In the project, an old electric guitar is passed around between several musicians across the United States, and each uses it to compose and record a short fragment. It is not exactly an Exquisite Corpse because the fragments are not assembled into one piece, but the pieces are collected and released on a CD, so they can be experienced as a unified collection. Here, the contextual backbone is a physical artifact: a charming old electric guitar.

2.3 Exquisite Corpse on the Internet

The Internet is a great medium for Exquisite Corpse style collaboration because it allows for easy collaboration with strangers and for collaboration at a massive scale. Furthermore, with a computer, the programmer who creates the game can tightly control the occlusion by controlling the hint size and explicitly providing the contextual backbone. A computer-based system allows for certain scenarios which might not be possible or easy with physical objects, for example, dividing a very large piece of paper into thousands of small squares.

2.3.1 Epic Exquisite Corpse

Xavier Barrade’s *Epic Exquisite Corpse* is an online implementation of the drawing version of Exquisite Corpse [20]. The website is a single, massive 2D collage composed square by square. Anyone who visits the website can draw a fragment to be included in the collage. The composer of a new fragment is given a small square with just one or two edges of the surrounding fragments visible. The interface is very simple: in draw mode, clicking and dragging creates black lines, and in erase mode, it erases them. The input is somewhat limited in that there are no colors and there is only one stroke width, but this simplicity also lowers the barrier for contributing. The website is a massive collaboration: the resulting collage has over 70,000 fragments composed by users from over 172 different countries[21].
2.3.2 Folding Story

*Folding Story* is a website that lets users play a word-based variation of Exquisite Corpse [1]. Instead of constructing a sentence, the final result here is a short, paragraph-long story. Each fragment is under 180 characters, and each story is composed of 10 fragments. The hint is the entire previous fragment: everything before that is occluded. *Folding Story* has been active since 2010 and there are over 6,500 stories completed.

2.3.3 Exquisite Forest

*Exquisite Forest* is an Exquisite-Corpse-inspired system for collaborative animation conceived of by artists Chris Milk and Aaron Koblin and produced as a collaboration between the Tate Modern and the Google Data Arts team [4]. The website was active from 2012 to 2014 – no new animations can be added now, but the old animations are still available to view. Each fragment is a short animation, and larger animations are created by stitching together fragments temporally. The system allowed for branching: each complete work is a tree, so each leaf provides a new path through the animations and a new way to experience the complete work. Branching not only allows for a fragment to be experienced in multiple contexts, but also provides a mechanism to save larger works from uninspired or intentionally bad fragments. If someone really likes the beginning of a piece but does not like the direction it goes half-way through, they can create a new branch and see how else the piece might progress.

*Exquisite Forest* is not a true Exquisite Corpse because nothing is hidden: the author of a fragment can see all the previous fragments in a work, and even gets to choose where there fragment should go (i.e. they can start new branches).
Chapter 3

Exquisite Score - Goals and Motivation

3.1 Goals

The overall goal of this project was to make an online system which allows users to compose a piece of music using the Exquisite Corpse paradigm. The name given to the project is Exquisite Score, because the system is an Exquisite Corpse game for musical scores. Before actually designing such a system, I set aside three main goals which informed design decisions along the way. The goals also serve as a framework for evaluating the success of the Exquisite Score system. The three goals are as follows:

1. **Compelling Collaborative Pieces** The system should be able to produce a lasting musical artifact. That is, each individual’s contribution should be stitched together to create a complete piece, and the system needs to be powerful and general enough that the piece can be musically interesting and compelling. It should be clear who composed which sections of the resulting piece so listeners can understand the overall compositional narrative (i.e. who composed what and in what order). The piece should be easily shared with anyone who has access to the Internet.
Whether or not a piece is compelling or interesting is of course subjective. Though there is no ground truth, results from user surveys can give a good approximation.

2. Meaningful Occlusion At the heart of Exquisite Corpse is occlusion. In the realm of drawing, all but the edges of the previous fragment are occluded. The idea of occlusion can be applied in several ways to a musical piece. Perhaps the most direct translation from the spatial occlusion in the drawing version of Exquisite Corpse is temporal occlusion, where fragments are joined linearly through time and when someone composes a new fragment, they only get to see the last few seconds of the previous fragment, for example. This type of occlusion can be seen as ‘horizontal,’ because traditional musical scores map the horizontal axis to time. Another viable type of occlusion is ‘vertical occlusion,’ where, for example, multiple people compose for the same segment of time, but they compose for different instruments. Fragments are stitched together on top of each other, all occurring at the same time. The occlusion is that participants would not be able to see what other instruments are doing in the same time slot, or perhaps they can only see one other instrument. A good example of vertical occlusion is the collection of pieces composed for the Think Jar Collective which are discussed in section 2.2.2. Again, the term ‘vertical’ is related to traditional musical scores, where multiple instruments are stacked vertically.

Though occlusion will inform the compositional process, one could imagine the same process without occlusion. That is, when a user composes a fragment, they could be given full information about what everyone else has already composed. There should be a reasonable difference in the final piece depending on if previous information was occluded. In other words, if nothing is hidden from the composers, we would expect they could produce a reasonably cohesive and satisfying piece, but if most of the previous material is hidden, we expect the results to be surprising. Occlusion should create pieces that are locally cohesive but globally fragmented.
Whether or not the occlusion was effective can be evaluated through surveys, and the results of occlusion can be analyzed empirically, as is done in chapter 7.

3. Accessible to Non-composers A good comparison for accessibility is the paper-and-pencil version of Exquisite Corpse. Most people can fold over a paper, pick up a pencil, and draw. Naturally better artists may produce better individual sections, but that does not preclude amateur artists from enjoying the game and producing something they find satisfying. Similarly, someone with minimal compositional experience should be able to contribute to a piece with this system. There is a tradeoff, of course: simplicity aids accessibility, but compositional power necessitates complexity. For example, if the system allowed a user only two pitch classes to compose with (e.g. only the notes D and A), it would be fairly simple for an amateur musician to create something, but it would be difficult for almost anyone to produce a piece they found satisfying.\footnote{The exception, perhaps, is the composer György Ligeti who has successfully composed with only two pitch classes in the first piece of his set Musica Ricercata\cite{10}.}

The goal for this system is to be usable by people who have some musical training or experience but who do not necessarily compose. This can be measured through survey results and by examining the fragments by non-composers.

3.2 Motivation

If Exquisite Score provides a new, fun game, that may be enough to justify its existence. Beyond its ludic value, Exquisite Score has both educational and artistic value.

3.2.1 Educational Value

One important part of learning to compose is to actually practice composing. Anyone who uses Exquisite Score will gain experience composing. Even if a user does not
aspire to be a composer, compositional experience can still help to develop a deeper appreciation for music.

The system encourages composition by lowering the barriers to composition. Each composer only has to compose a short section. If eight people come together to compose a piece, each person only has to compose one eighth of the piece, but then each person gets to enjoy all eight sections. Occlusion and collaboration lower the stakes for composers. With collaboration, a composer might feel less self-conscious about their contribution because they know it is only a small portion of the entire piece. With occlusion, a composer might feel less self-conscious because their contribution is not expected to be tightly related to the rest of the composition – most of the composition is hidden! The idea of lowering barriers to making music is discussed by music teacher Micah Volz, who in an article for the *Music Educators Journal* suggests an Exquisite-Corpse-inspired improvisation game to lower barriers to musical improvisation for high school students [19].

Aside from lowering the barriers of composition, the system rewards composition by making it a collaborative and social process. Users are not composing to the void – one user’s composition has a real impact, at least on the next composer who must work off of their contribution.

Exquisite Score gamifies composition by incorporating elements of chance. Because of the occlusion, it is possible that a user’s composition sounds very strange after the entire previous fragment, even if it appeared to transition nicely. This can create suspense and surprise, and can turn composition into a fun game. This idea is supported by Malone, who offers both ‘hidden information’ and ‘randomness’ as heuristics for creating fun and educational computer games, as they engage curiosity and provide a challenge [11].

### 3.2.2 Artistic Value

André Breton described the Exquisite Corpse as “an infallible means of sending the mind’s critical mechanism away on vacation and fully releasing its metaphorical potentialities” [3]. In a way, the Exquisite Corpse enforces artificial creativity. Pieces
composed using the Exquisite Corpse paradigm probably would not have come about without the occlusive elements. The resulting pieces may be meandering or disjoint, but they might also be creative and adventurous. There is a tradeoff here: unity and intention versus creativity and surprise. Even if an artist does not find the sacrifice in unity and intention a worthy tradeoff for creating new artistic works, they could surely still use the results of an Exquisite Corpse as an inspiration.

As shown in section 2.2, artists have managed to apply and adapt the Exquisite Corpse paradigm to produce musical works and films. This shows that Exquisite Corpse is a general and powerful enough tool to generate long-form works of art which are meant to have relevance beyond the parlor.

As discussed in section 3.2.1, Exquisite Corpse can gamify musical composition, providing extra motivation to create music. The Exquisite Corpse is also a way to encourage collaborations that might not have otherwise happened.

If one views the Exquisite Corpse as a method for generating spontaneity and surprise in music, it is worth comparing it with the ultimate form of spontaneous collaboration in music: improvisation. In improvisation, players typically get to hear all other contributions, but they must produce music on the spot, and players do not necessarily have the time or memory to fully process everyone else’s contributions. While the spontaneity and creativity in improvisation are the result of the immediacy of sound creation, in the Exquisite Corpse they are the result of purposeful concealment. Exquisite Corpse can help provide the spontaneity of improvisation with less immediate pressure and more time to think.

### 3.3 System details and tools

As discussed in section 2.3, the Internet is a great medium for Exquisite-Corpse style collaboration. With a web application, anyone with an Internet connection can participate, and it is easy to collaborate with complete strangers. A web application is particularly advantageous to a native desktop application because it requires no additional downloads and can be accessed from any machine with an Internet connection.
and a browser.

The Exquisite Score system is a web application which uses the Python Flask framework connected to a PostgreSQL database. Exquisite Score is served from a Digital Ocean virtual machine using gunicorn and nginx and, as of writing this, is hosted at https://exquisitescore.xyz.

![Figure 3-1: The Exquisite Score system](image)

On the client-side, there is a musical editor created in HTML and Javascript using SVG and HTML5 canvas elements. For actually playing audio, Exquisite Score uses MIDI.js, a library which provides an easy way to synthesize sounds through the WebAudio API.

### 3.4 Development Process

I developed the Exquisite Score system in three iterations. Each iteration consisted of a design phase, an implementation phase, and an evaluation phase. The evaluation phase involved gathering test subjects to try out the web site and fill out surveys about their experiences.

The first iteration focused mainly on evaluating the compositional interface. The second iteration focused on both the compositional interface and the complete web site experience. The third iteration focused on exploring extensions of the Exquisite Corpse compositional paradigm. The next three chapters outline all three iterations in detail.
Chapter 4

Iteration 1 - Button Grid

4.1 Design Description

The design for the compositional interface was inspired by physical step sequencers, for example the Novation Launchpad [14]. The device has an eight-by-eight grid of square buttons, where buttons are lit up when they are activated. Pitch is mapped to the vertical axis, and time is mapped to the horizontal axis, and the system loops once it gets to the last column. I chose this interface as inspiration because it is simple and intuitive, and it does not require any knowledge of musical notation, so it is friendly towards beginners.

![Fig 4.1: The Novation Launchpad](image1)

For this iteration, the compositional interface looks like several of these step sequencers.

---

1 The device is not exclusively a sequencer, but it can be used as one
quencers arranged in a grid. There are several distinct rectangular containers which contain button arrays - I will refer to each of these containers as a *sequencer-pad*. Each sequencer-pad corresponds to one section (about two measures) for one instrument. Each composer might be expected to compose four of these sections, which are arranged horizontally, side-by-side. One complete fragment, then, is four sections wide. If there is more than one instrument, there is another row of sequencer-pads placed directly beneath the previous row. In other words, the sequencer-pads are arranged horizontally by time and vertically by instrumentation, and the buttons inside each individual sequencer-pad are arranged horizontally by time and vertically by pitch.

The screen is divided into two regions, a ‘summary score’ on top and a main editing region below that. The main editing region displays a single column of sequencer-pads at a time, where that column is the active section. Within the active section, the user can click on a button to activate or deactivate it - activated buttons are colored and inactive buttons are gray. There are four circular buttons above the active column of sequencer-pads: a play button, a stop button, a loop button, and continue button. Pressing the play button will play the current section, stopping at the end. The playhead, a vertical line spanning the entire column, advances to indicate the current time, and when a note is played, the square lights up. If the loop button is pressed, when the playhead reaches the end, it starts again at the beginning of the section. If the continue button is pressed, the playhead will advance to the next section once it reaches the end, and the next column of sequencer-pads gains focus in the main editing region. In order to move a different section into the main editing region, a user can either click the edge of the next or previous sections in the main editing region, or click a section in the summary score on the top of the page.

The pitches mapped to the vertical axis are the complete chromatic scale. This choice was made in an attempt to give composers enough choices to make varied compositions. One could imagine a simpler system where the pitches were mapped to a pentatonic scale, for instance. This certainly would make composition easier, but would also limit compositional choice. Insufficient choice may lead to a piece created with occlusion sounding no different than a piece created without occlusion.
Figure 4-2: The main editing region from the compositional interface in the first iteration of Exquisite Score.

The sequencer-pad metaphor does not allow for an easy way to extend note lengths, so all notes have the same duration, which unfortunately limits the power of the compositional interface for this iteration.

This system uses simple horizontal occlusion: if the previous user’s fragment consists of four sections, and the hint size is two sections, then the next composer is presented with a total of six sections, where the first two sections are the last two sections of the previous composer’s fragment. The first two sections are grayed out and uneditable, but the composer can view them and listen to them.

The creator of a piece is referred to as the architect, and each person who contributes a fragment is referred to as a composer. The system is general, in that the architect can choose any width and height for the sequencer-pads. That is, the architect chooses the length of each section, the number of instruments, and the pitch range of each instrument. The architect also controls the hint size, in terms of the
number of sections, how many sections are in a single fragment, and how many frag-
ments make up the entire piece. During this iteration, the only way to architect a
piece was to send a POST request directly to the server - there was no interface to
do this on the website.

The system must distinguish one composer from another: it needs to attribute a
fragment to a particular user in order to prevent a user from composing two fragments
in a row. In this iteration, the system just lets each user enter their name and stores
the result in a cookie.

After a user submits a fragment, they are allowed to view the entire piece up
until, and including, the fragment they composed. This is meant to provide gratifying
feedback - unlike a parlor game, it is not clear how long it will take for the entire
piece to be finished or if the piece will ever be finished. It would not make sense to
wait an indeterminate amount of time before letting a user see how their fragment
fits together with the rest of the composition.

4.2 Testing

For this iteration, the system was tested on six subjects. I composed the very first
section of a piece so that each subject would have the experience of having a hint as
a starting point. At the start of each test, I explained the idea of playing Exquisite
Corpse with music. Then subjects visited the website (at this point, an IP address
hosted from my own computer), and were asked to compose a piece of music. Sub-
jects could ask for guidance if they needed, but there was generally little intervention,
as this was meant to test both subject satisfaction and the usability of the composi-
tional interface. After a subject submitted their fragment, they got to see the entire
composition up to their fragment and were given a short survey.
4.3 Results

While more subjects would have been ideal, six was enough to draw many important conclusions about the design. The full survey results are presented in Appendix A.1, but some conclusions are discussed here.

In general, no one seemed to have trouble figuring out the analogy of buttons as notes, and people had no trouble with the playback features. One subject did not realize they could compose past the first section and some subjects did not realize they could listen to the previous two sections until after they had finished composing their first section. People found it confusing to only have one active section at a time in the editing region. It would have been better to get rid of the idea of an ‘active section’ altogether and just have continuous horizontal scrolling in the editing region.

The surveys presented opportunity for open-ended feedback and targeted feedback about specific features, existing or not. From the open-ended feedback, it was clear that most people thought the interface was simple, but some found that the big grid of notes was overwhelming. Unprompted, all but one of the subjects mentioned that they would have liked audio feedback when activating a note. When asked to rate from one to five the importance of having variable note lengths, every subject responded with either a four or a five. No other feature-request had ratings consistently over three.

It was telling that only half of the six subjects actually composed all four sections that they were meant to compose. For one subject it was a misunderstanding, but two subjects specifically asked if it would be alright to leave some sections blank. If a subject left a shared region blank, I went in and copied one of their previous sections into the shared region so the next subject would not have an empty hint.

Eliminating the discretization of each fragment into four sections is one step to alleviate confusion, but it still does not solve the efficiency problem: composing with this system was just too slow. Going forward, the most important areas for improvement were increasing compositional efficiency and increasing compositional power, for example by allowing variable note lengths.
Chapter 5

Iteration 2 - Piano Roll Sequencer

The second design iteration set out to improve upon the first design by increasing efficiency and compositional power. In this iteration, the compositional interface is redesigned and the basic website architecture is implemented and deployed online at the url https://exquisitescore.xyz.

5.1 Design Description

The compositional interface in this iteration was inspired by the MIDI sequencer interface from Ableton Live, a commercial digital audio workstation [2]. The interface from Live is shown in figure 5-1.

The compositional interface for this iteration of Exquisite Score looks more like a piano roll. Like before, the horizontal axis is time and the vertical axis is pitch. The vertical height of each note is much smaller than in the previous iteration, and unlike the previous iteration’s button-based interface, notes can vary in horizontal width. This new note representation is sparse: instead of activating notes by clicking on them, notes are created by clicking on negative space. A faint grid in the background indicates valid note positions. With the new metaphor of notes as created objects rather than activated ones, it is more intuitive to have draggable, copyable, and extendable notes. Furthermore, this new representation is more economical in terms of screen space. This in itself improves efficiency, because it decreases the distance
the cursor must travel to create new notes.

To create a new note, the user double-clicks on the background grid in an empty location. This creates a rectangular note of unit length and selects it. Selected notes are indicated with a brighter color. If a note is selected, its duration can be extended by clicking and dragging either of its ends. If dragged from the center, a note will follow the cursor to a new location in the score. Multiple notes can be selected at once by holding shift and clicking, or by dragging the cursor starting from an empty location, which creates a selection box. Dragging and extending operations apply to all selected notes.

For increased efficiency, there are copy and paste operations, and for increased safety, there are undo and redo operations. These operations are accessed via typical keyboard shortcuts (ctrl+c/ctrl+v for copy/paste and ctrl+z/ctrl+y for undo/redo).

Each composer’s fragment is continuous in the horizontal direction: unlike the previous iteration, there is no notion of separate sections within the fragment. The analog of a row of sequencer-pads is the background note-grid, which can be clicked to create notes. The note-grid extends for the entire horizontal length of music. Each instrument gets its own note-grid and note-grids are stacked vertically. The hint from the previous composer appears at the beginning of the score, but that region is grayed.
out and uneditable. The previous composer’s name or initials appear above the start of the hint.

To make the vertical mapping of the note grid more intuitive, the rows whose pitches are black notes of a piano are darker than the other rows, and piano keys are shown on the left side of the screen. To make the horizontal grid easier to parse, groups of four columns alternate between lighter and darker shades of gray.

Figure 5-2: The compositional interface for the second iteration of Exquisite Score.

Apart from the composition page, there are four other pages: a sign-in page, a page with a list of compositions, a page to create new pieces, and a page to view a piece.

The sign-in page consists of a sign-in button which allows users to sign in with a Google account. A user needs to be signed in to contribute to any pieces, but a user is allowed to view complete pieces without signing in.

The composition-list page lists each piece, gives its instrumentation, lists the composers, and then possibly gives the options to view or compose. A user can compose for a piece if they were not the most recent contributor, and a user can view a piece if the piece is completed or if they have contributed to the piece. If a user contributes
to a piece, they can view up to and including the fragment they composed, or if the 
piece is complete, they can view the entire thing.

The create-piece page is not a public-facing page – no other pages link to it. Its purpose is to provide an interface to easily architect new pieces. The Exquisite 
Score server has an API for creating a new piece which can accept a huge variety of 
parameters, so the create-piece page distills these parameters into a smaller number 
of choices. From the create-piece page, the architect can choose various parameters of 
the piece, including how many fragments will be composed, how long each fragment 
is, and how large the hint size is. These are chosen via radio buttons which indicate 
certain presets. For example, one option is “8 fragments, 4-bar hints, long fragments”, 
which corresponds to a fragment size of 64 and a hint size of 16. The architect 
can also choose how many instruments (one, two, or three), the vertical ordering 
of those instruments, the low and high notes of those instruments’ range (locked to 
any choice of a C or a G), the actual instruments (from one of 128 General MIDI 
instruments), and the base velocity (loudness) of each instrument, with choices like 
“loudest”, “medium loud”, and “soft”. For this iteration, I was the only architect, but 
in future iterations architect functionality could be open to the public.

The view-piece page is similar to the edit-piece page, except nothing is grayed 
out, nothing is editable, and it includes the entire piece, or at least as much of the 
piece that the user is allowed to see.

Some aspects of the compositional interface remain inflexible. For example, the 
note grid is fixed, making triplets impossible. The tempo is also fixed for each piece. 
There is no real volume control, apart from the per-instrument velocities given by the 
architect. A composer can put several copies of a note in the same location, though, 
which has the same effect as increasing the volume.

5.2 Testing

The website was hosted online at the url https://exquisitescore.xyz, so user tests 
were done remotely. There were a total of 34 subjects who composed at least one
fragment of music, 19 of whom also completed surveys. Test subjects ranged from MIT student musicians to professional composers.

Subjects were briefed on the system’s purpose, and then asked to contribute a composition to one or more pieces. There were five available pieces to choose from on the piece listing page. The hint from the previous composer was the equivalent of 8 bars for some pieces, and only 4 bars for others.

The tests occurred over several weeks. Earlier tests revealed two major issues that were resolved immediately rather than waiting for another round of development. Those two issues were subjects keeping a lock on a piece and subjects leaving the shared region at the end of their fragment blank.

The issue of keeping a lock on a piece was due to a design flaw. When a user hits compose for a piece, that user puts a lock on the piece until they either submit or abandon their fragment. While this allows a user to leave their composition and come back to it later, it also means a user can click compose, then forget to click submit or abandon, and possibly never use the system again. This is a problem, as it prevents anyone from contributing to that piece in the future. This was resolved by automatically deleting a user’s fragment and freeing the lock on the piece after 30 minutes of inactivity. Inactivity was measured with a heartbeat which pinged the server whenever a user had the compose page open. Users were warned whenever they started a composition that it would be deleted after 30 minutes of inactivity.

The second issue was users not composing into the shared region at the end of their fragment. While this was less prevalent than in the previous iteration, it still happened, and it can ruin a piece because it creates large gaps of rests and provides no hint for the next composer. For immediate damage control, whenever a user failed to compose into the shared region, I manually copied a section of their composition into the shared region. To encourage users to actually compose in the shared region, I put a text label above the shared region indicating that this region was what the next composer would see. This still proved to be confusing – some users thought that ‘shared region’ meant it would be editable by the next composer. Finally, I added an explanatory demo on the main sign-in page and also gave a pop-up warning which
prevented a user from submitting a composition with an empty shared region.

5.3 Results

As before, the survey presented opportunity for both open-ended feedback and targeted feedback about specific features. The full results of the survey are found in A.2.

The very first page of the survey asked two open-ended questions. The first was “What are your initial thoughts and reactions?” Eight users mentioned that they had fun, and seven users mentioned that they thought the project was ‘cool’, ‘awesome’, or ‘neat’. The responses were more positive and enthusiastic than in the previous iteration. The second question was “What three things do you think would make the system better?” This garnered a large variety of responses, from minor UI suggestions to major feature requests to explorations of the compositional paradigm. The responses to this question and the results from the rest of the survey provided a large number of possible improvements and new features to consider. The rest of this section discusses these in detail.

Minor Interface Improvements

- **Visual distinction between instruments:** Instruments are not labelled on the compositional interface. It would be clearer to the composers to include the instrument names to the left of the corresponding note-grids. It was suggested that different instruments could also have different colored notes.

- **Note names:** Even with the keyboard guide, it is not always easy to tell which pitch a note corresponds to. One easy way to correct this is to write the pitch name on the note.

- **Double-click to delete notes:** A few people requested this functionality to be consistent with other digital audio workstations. In terms of efficiency, this
feature makes deleting faster when the user’s hands are already on the mouse or trackpad.

- **Keyboard guide functionality:** The keyboard image on the side of each note-grid serves as a guide for which pitches correspond with which rows. The keyboard guide is not interactive: it would be nice if users heard the corresponding note when they clicked on the keyboard.

- **Better playhead interaction:** Users can click on the horizontal bar above the note-grid to set the playhead to that location so that the next time the user hits play, the piece starts from there. Many users assumed the playhead was draggable, though it was actually moved by clicking. It was suggested that clicking on the note-grid should place the playhead at that location, since currently clicking on the note-grid does nothing (creating a new note is a double-click). This would increase efficiency, as it would give users a larger area to click.

- **More intuitive paste command:** Users found it confusing that the paste command added copies of notes directly on top of the originals. The confusion is understandable: if the original notes are selected, then there is no visual feedback that the paste command has done anything because it pastes the new notes right on top of the old ones and selects them. It would be more intuitive if pasted notes were added at the start of the playhead.

**New Features**

- **Save fragments for later:** As a result of the changes described in section 5.2, unsubmitted fragments are discarded after 30 minutes of inactivity. This could be frustrating if a user works for a while on a fragment but then has to leave the computer for several hours. For this user, it would be nice to have the option of adding another 24 hours to the 30-minute grace period for inactivity.

- **Solo tracks:** There is currently no way to listen to an instrument in isolation. This feature would allow users to mute all but the selected instrument.
• **Note velocities:** Many users requested the ability to make notes louder. This would greatly increase the compositional power of the system.

• **Tempo control:** There is no way to adjust the tempo after a piece is created: the architect has total control over the tempo. Putting the tempo in the hands of the composers would expand the scope of possible compositions and increase the system’s compositional power.

• **Variable rhythmic grid:** Many users requested the ability to have a variable note grid. Currently, the note grid is divided into groups of four and there is no way to create triplets. A variable note grid would greatly expand the rhythmic possibilities for a piece and would go a long way to increase the compositional power of the system. About 50% of users rated the importance of a variable note grid as 4 or 5 out of 5, and two users mentioned it in the initial free-response questions.

• **Adding instruments:** Like tempo, instrumentation is in the hands of the architect and not the composers. Experienced composers might like to have more control over which instruments they can use.

• **Looping tool:** When specifically asked about the ability to loop segments, the majority of users gave an importance rating of either 4 or 5 out of 5. Interestingly, only one user mentioned looping in the open-ended responses.

**Explorations of the compositional paradigm**

• **Composing vertically:** In the open-ended questions at the start of the survey, two users discussed how it would be interesting to layer different instruments on top of previously composed fragments. When specifically asked to rate their interest on this compositional idea later on, 15 out of 19 users gave a rating of 4 or 5 out of 5.

• **Shared theme:** One user suggested that there could be a short musical snippet that is shared with each composer, along with whatever hint the composer gets
from the previous fragments. More generally, one could experiment with adding any type of theme to the contextual backbone, e.g. a picture, a quote, an adjective, etc.

Accessibility and Learnability

- **Clearer instructions:** Over half of the users did not discover the copy/paste and undo/redo functionality. These operations can be extremely helpful in composing, but they are useless if users do not know about them! There are instructions which provide the commands for copy/paste and undo/redo, but users have to click a small button labelled ‘instructions’ to see them. It might be better to display the instructions by default to new users.

- **Shared region explanation:** Several users did not understand the idea of the shared region. It would be useful to provide an explanation of the shared region when a new user begins a composition.

All in all, the test subjects had varying degrees of musical proficiency and compositional experience and people wanted many different things from the system. The experienced composers wanted more compositional power out of the interface, while others found the interface somewhat intimidating. Overall, people seemed to enjoy using the system considerably more than in the previous iteration. The interface seemed powerful enough at this point that people could make compelling pieces, so I decided that in the next iteration, rather than working to perfect the interface, I would further explore compositional paradigms.

This iteration resulted in five completed pieces of eight sections each. These pieces are analyzed in chapter 7.
Chapter 6

Iteration 3 - Fixed Form Pieces

In the *Epic Exquisite Corpse* website, when a user draws a new fragment, they might get to see the edge of the fragment above, below, to the left, or to the right. With the previous iteration of Exquisite Score, composers could only see fragments from immediately before. The goal for this iteration was to introduce a system for composing where the the composer might get a hint from the fragment immediately after theirs, possibly in addition to a hint from the previous fragment. This is the analog of seeing the left edge, right edge, or both edges in *Epic Exquisite Corpse*.

6.1 Fixed Form Pieces

The idea of a fixed form piece is that certain fragments are repeated at specific points in the composition. The main motivation behind repeating fragments is that it easily allows for both left and right hints. As a simple example, if the form is $ABA$ and $A$ is composed first, then the composer of fragment $B$ might get to see the end of $A$ as a left hint and the beginning of $A$ as a right hint. Another consequence of the fixed form idea is that it can provide an opportunity for branching. For instance, if the form is $ABAC$, then both fragments $B$ and $C$ might receive a left hint from $A$, and listeners get the opportunity to see how two different composers responded to the end of fragment $A$. The repetition inherent in fixed form pieces has two additional benefits: it increase the cohesion of a piece and it allows fewer unique fragments to
come together to form a longer piece.

To define a fixed-form piece requires two new pieces of information. The first is the fragment map, which is like the roadmap for the form. If each fragment is numbered by its order of composition, then the fragment map is just a sequence of fragment numbers that indicates where each fragment occurs in the piece. For instance, suppose the form of a piece is ABACA, and sections A, B, and C are each one fragment long. If fragment A is composed first, followed by fragments B then C, the fragment map will be [1, 2, 1, 3, 1]. But, there is no reason fragment A must be composed first! Maybe fragment B is composed first instead, followed by fragments C then A. In this case the fragment map is [3, 1, 3, 2, 3].

The second piece of information needed is the hint map, which describes which hint (or hints) a composer receives when they compose a fragment. A given fragment may receive a hint from the left, from the right, from both, or from neither. There may be multiple choices for which fragment supplies the hint. For example, if the fragment map is [1, 4, 2, 4, 3], then fragment 4 could either receive a left hint from 1 and a right hint from 2, or a left hint from 2 and a right hint from 3. So, the hint map entry for 4 might be either \{left:1, right:2\} or \{left:2, right:3\}. Notice that in this example, the hint map entry for fragments 1, 2, and 3 must be empty, because fragment 4 is the only neighboring fragment and it is composed last.

While the framework implemented in this iteration allows for many possible forms, I experimented with two in particular: rondo form and a form I call Minimalist Variations.

### 6.1.1 Rondo Form

A rondo is a classical form with a principal theme (refrain) which alternates with contrasting themes (episodes). The number of episodes can vary, and episodes can also make more than one appearance. Typical examples of this form are ABA, ABACA, and ABACABA [5].

I implemented two different types of rondos. The first is a simple, straight-forward application of the ABACA form, with a coda at the end. The fragment map is
fragments 1 and 2 comprise the A section, fragments 3 and 4 comprise the B section, fragments 5 and 6 comprise the C section, and fragment 7 comprises the coda. The hint-map is straight-forward: all fragments but fragment 1 get a hint from the left, and fragments 4 and 6, the ends of episodes B and C respectively, get additional hints from the right because they link back to the A section.

The second type of rondo also uses the ABACA form with a coda, but the order of composition is different. In this version, the first fragments of sections A, B, and C each receive no hint at all. Thus, the start of each section is created totally independently of the other sections. Then it is up to the rest of the composers to link these independent sections together. The fragment map is [1, 4, 2, 5, 1, 6, 3, 7, 1, 8], where fragments 2 and 5 comprise the B section, fragments 3 and 7 comprise the C section, fragment 8 is the coda, and the A section always starts with fragment 1 but has three variations: fragments 1 and 4, fragments 1 and 6, and fragments 1 and 8. The hint map for this form has fragments 1, 2, and 3 with no hints at all, but fragments 4, 5, 6, and 7 all get hints from both the left and the right. The coda, fragment 8, only gets a hint from the left, since nothing comes after it.

![Figure 6-1: A Rondo after the first three fragments have been composed. Fragments 4, 5, 6, and 7 all receive hints from the left and from the right.](image)

6.1.2 Minimalist Variations

*Minimalist Variations* is a form I invented specifically for Exquisite Score and is meant to be a way to greatly extend the length of a piece while only using a few unique fragments.

The idea is that there are some number of original fragments, e.g. $A, B, C$, and each fragment has an alternate $A', B', C'$. The form is that $ABC$ repeats over and over
again, but each time, one of the sections is swapped out for its alternate, or one of the alternates is swapped back in for its original. If there are \( k \) original fragments, then the piece can be divided into blocks of size \( k \). In the case of \( k = 3 \), each block is made up of either \( A \) or \( A' \), followed by either \( B \) or \( B' \), and ending with either \( C \) or \( C' \). There are a total of eight unique blocks if \( k = 3 \) and in general, if there are \( k \) fragments with \( k \) alternates, there are \( 2^k \) unique blocks.

I implemented the Minimalist Variations form for three sections, \( ABC \). Symbolically, the form is as follows, with a vertical bar dividing each block of three:

\[
\]

Each possible block appears exactly once, with the exception of the original \( ABC \), which comes back a second time as the very last section. The compositional order is: \( ABCA'B'C' \), so the fragment map for this section is then:

\[[1, 2, 3, 1, 2, 6, 1, 5, 6, 1, 5, 3, 4, 5, 3, 4, 5, 6, 4, 2, 6, 4, 2, 3, 1, 2, 3].\]

In terms of the above form, \( A \), \( B \), and \( C \) are fragments 1, 2, and 3, and \( A' \), \( B' \), and \( C' \) are fragments 4, 5, and 6.

The hint map has no hint for section \( A \), a left hint for section \( B \), and then sections \( C \), \( A' \), \( B' \) and \( C' \) all have both left and right hints. The hint-map is especially necessary for this form, because there are multiple possibilities for \( B' \) and \( C' \). For example, \( C' \) can come after either \( B \) or \( B' \), and can come before either \( A \) or \( A' \).

### 6.2 Testing

This iteration was tested with only 7 individuals. Unlike the previous tests, this test was done as a parlor game, where each tester sat around in a circle composing on their laptops, virtually passing each composition on to the next player. As in the previous tests, I was the architect for each piece, so no one had to create new pieces. There were eight pieces to choose from in total, with 3 rondos, 2 minimalist variations, and
Figure 6-2: The composition order for a Minimalist Variations piece. The current fragment being composed is shown in white and the hints are shown in gray.

3 normal pieces (without a fixed form). There was no official survey for this round of testing: only observations and the resulting compositions.

6.3 Conclusions

This round of testing resulted in two completed pieces with the Minimalist Variations form, and several other half-completed pieces. It was difficult to explain the Minimalist Variations form to participants, but most were satisfied just knowing that that each section was repeated several times throughout. The two pieces that were completed are titled “Pillow Cabin” and “Baby Spade”. Each piece is quite compelling and makes for an enjoyable listen, though neither has a very intentional sounding ending. Section 7.1 briefly looks at “Baby Spade” in more detail.

Compared to the pieces of the previous iteration, the Minimalist Variations pieces are much more cohesive. This is to be expected: these pieces have a lot more repetition and four of the six fragments receive hints from two other fragments instead of one. Because the Minimalist Variations form is more complicated than the linear form of the second iteration’s pieces, it is more difficult to follow the narrative of composition. As dictated by the form, when fragment $B'$ is repeated, sometimes it comes after $A$ and sometimes it comes after $A'$. As a result, it is not immediately obvious what the

---

The titles of the pieces in this iteration were curated from words created by a random word generator. Other titles include “Teapot,” “Rainbow Tortoise,” and “Butter Chips.”
composer of fragment $B'$ saw as their hint—it could have been $A$ or $A'$. Arguably, this makes the piece more interesting: it may take repeated listens to piece together the puzzle of who received which fragment as their hint.

No rondos were completed, though most had significant progress. One fell apart because the person composing the first $A$ section fragment left most of the shared region empty: the participant thought someone else would also be able to edit this section later. The problem of explaining the shared region was not solved from the previous iterations. The resulting piece has an $A$ section with a large gap in the middle, which destroys the piece’s cohesion. Unfortunately, the $A$ section repeats three times, so overall the piece did not turn out to be very promising.

It was difficult to treat the system like a normal parlor game while testing fixed-form pieces because different forms required different lengths: the rondos required 7 or 8 fragments, and the Minimalist Variations required only 6. Composing can take a while, so in one sitting participants found it difficult to compose more than 6 fragments.
Chapter 7

Analysis

Iterations two and three resulted in several completed pieces. This section provides a qualitative discussion of some of these pieces, followed by a quantitative analysis which measures similarity between fragments.

7.1 Qualitative Analysis

Overall, the pieces show a great deal of local cohesion. The transition between fragments, the ‘folds’, are usually fairly smooth, even if the actual musical material between fragments is dissimilar. There are, of course, exceptions to this rule: sometimes a fold is particularly evident. One example is the fifth fragment of “Piece 4”, shown in figure 7-6. All four prior fragments are very chromatic and in minor keys, but fragment five transitions to a mostly diatonic major key chorale. Though jarring, the transition still makes some musical sense because the previous fragment ends on a C Major chord. The fragments are still fairly related: they have like textures and a similar harmonic rhythm.

Actual non sequiturs happened only rarely, and they seem to only derail a piece locally. One example is the third fragment from “Piece 1”, shown in 7-1. The previous fragment consists of hocketed sixteenth notes, but this fragment has almost exclusively very long notes and almost no rhythmic activity until the very end, where a short chordal motif enters in the bottom line. The next composer dutifully picks up that
motif and the piece proceeds logically from there, though with no hope of relating to the first two fragments.

Figure 7-1: The third fragment of Piece 1, along with its hint from the second fragment. This is a musical non sequitur: it has very little in common with the previous section.

One particularly amusing moment happens in fragment 7 of “Piece 2”, seen in figure 7-2. The fragment starts out with a smooth transition across the fold, reusing material from the previous fragment. Musical tension rises to a climax at the very middle of this fragment, but right at the beginning of the shared region, the composer completely shifts gears and begins an arrangement of “Jingle Bells”. The shared region was demarcated, so the composer clearly intended for the next composer to only see “Jingle Bells”. The next composer follows suit with a more ornamented variation of “Jingle Bells”, ending the piece in a way totally unrelated to the first several fragments.

The two fixed form pieces that were completed are titled “Baby Spade” and “Pillow Cabin”. They are both Minimalist Variation pieces, as described in section 6.1.2, and they are both very cohesive. These pieces had shorter fragments, just half the size of the fragments of other pieces, and the hint was the entire fragment. The pieces are naturally more cohesive because fragments are repeated several times, but some musical ideas also were shared between multiple fragments. For example, in “Baby Spade”, the bassline composed in fragment $B$ (the second fragment) inspires a similar bassline in fragment $C$, and the bassline from fragment $C$ is copied almost exactly
Figure 7-2: Piece 2, fragment 7. The composer abruptly transitions to the tune of “Jingle Bells” halfway through the fragment.

in the remaining three fragments \( A', B', \) and \( C' \). Fragments of “Baby Spade” are shown in figures 7-3 and 7-4.

### 7.1.1 Piece 4

In this section, we will explore in depth “Piece 4”, which is scored for choir (top line) and cello (bottom line). The hint size was 32 sixteenth notes, which is exactly half of each fragment. The piano-roll score of the piece is shown in its entirety, a single fragment at a time, in figures 7-5 through 7-7. Each fragment after the first shows both the fragment and the hint the composer received from the previous fragment.

The very first fragment begins with a rising chord progression. The harmonies are highly chromatic and suggest a minor key. The rhythm is very regular, and the bassline presents a slightly more active motif which is repeated twice. Only half notes and quarter notes are present, and notes all occur on the beat.

The second fragment begins with a similar texture, with half-notes in the vocal line and quarter notes in the cello, but soon we are introduced to a flurry of sixteenth
Figure 7-3: Fragments B and C of “Baby Spade”. Fragment C has a very similar bassline to fragment B.

notes in the cello line. The sudden bustle leads to a series of chromatic chords in the vocal line, very similar to the chords from the previous fragment, but now on the offbeats. Fragment two ends with another flurry of sixteenth notes in the cello line.

The third fragment picks up on the alternating flurries of notes with slow-moving chordal lines. It begins with sustained harmonies similar to the previous fragments, but now in the cello line. We then see a flurry of activity ending in a sustained diminished triad in the vocal line, followed by a similar pattern in the cello line. As the cello sustains a diminished triad, we have one more stream of activity in the vocal line: a sequence of chromatically descending sixteenth notes which build tension and lead right up to the next fragment.

Fragment four resolves the chromatic line from the previous fragment with more
tension: a sustained diminished seventh chord. This fragment continues with a highly chromatic descending chord progression, which gathers momentum by adding more and more voices until it resolves right before the next fragment in a sprawling C Major triad.

Fragment five takes the C Major triad as an opportunity to stray from the chromaticism and diminished harmonies of the previous fragments: right from the start, this fragment breaks into a major key chorale! Although the harmonies are vastly different from the previous fragment, the chordal texture is similar. As before, we see mostly half notes and quarter notes, though this fragment also includes a few eighth notes.

Fragment six continues the chorale with extended minor harmonies leading to a
half cadence. This figure repeats itself exactly and takes us right to fragment seven, which resolves the cadence, more or less, with an open fifth in C. The texture here is still mostly chordal, but a little more contrapuntal. The harmonies lead to a cadential 6/4 chord in C, followed by the dominant, which takes us to the final fragment.

Fragment eight resolves the G major chord with a C minor triad. The vocal line continues holding a C minor triad pedal, with the bottom voice occasionally visiting its upper and lower half-step neighbors. During this, the cello presents a melodic line in C minor. The fragment ends on a rather suspenseful cadential 6/4 chord. Presumably the final composer did not realize they were composing the final fragment.

There were no real non sequiturs in the piece. Even though some fragments (e.g. number five) were quite different from the preceding fragment, composers managed to transition smoothly across the ‘fold’. Fragments 1 through 4 managed to stay surprisingly cohesive and fragments 5 and 6 fit together well. Fragment 7 is quite different from fragment 6, but it transitions smoothly and logically. By the time fragment 8 comes around, we have a cello melody over a chordal accompaniment. This contrasts with the first four fragments, which are largely harmonically and motivically driven. In fact, fragment 8 has the first real melodic line of the entire piece. The piece goes from a chromatic minor key, to a diatonic major key, to an ambiguous section with many open fifth harmonies, to a diatonic minor key. It’s all over the place, and yet things still somehow fit together. As we would expect of an Exquisite Corpse, the piece is locally cohesive but globally chaotic.
Figure 7-5: Piece 4: Fragments 1, 2, 3
Figure 7-6: Piece 4: Fragments 4, 5, 6
Figure 7-7: Piece 4: Fragments 7, 8
7.2 Quantitative Analysis

In this section, I analyze cohesiveness of each piece by quantifying the similarity between fragments. I run two basic tests to measure cohesion. The first test is to compare the first fragment of each piece with each of the other fragments in that piece. One would expect the first fragment to be most similar to the second fragment, somewhat similar to the third fragment, less similar to the fourth fragment, and so on. I hypothesize that the first fragment will lose its relevance as time goes on.

The second test is to compare the similarity of every pair of adjacent fragments. If fragment $B$ is composed seeing some of fragment $A$, we would expect that fragments $A$ is more similar to $B$ than it is to most other fragments.

This section only considers the pieces from the second iteration, not the fixed form pieces. The pieces from the second iteration are titled “Piece 1”, “Piece 2”, “Piece 3”, “Piece 4”, and “The Funk.”

7.2.1 Measuring Similarity and Extracting Musical Features

In order to measure similarity, we must first extract features from each fragment. A feature could be the percentage of notes that are Cs, for example. With several feature extractors in hand, we can turn a fragment into a feature vector. One common measure of similarity is to take the dot product of normalized feature vectors [17]. This is referred to as the cosine similarity because the dot product of two unit vectors is the cosine of the angle between them. The overall strategy to measure similarity between two fragments is to first convert the fragments into normalized feature vectors and then to take the dot product.

I implemented several feature extractors in Python. The features were mostly borrowed from the features discussed by McKay and used by the MIDI feature extractor jSymbolic [12]. For rhythmic features, time is discretized into 64 possible times for each fragment.

I implemented the following features:

- **Attack density**: The fraction of all possible times that have at least one note
starting at that time

- **Average note duration**: The average note duration

- **Variability of note durations**: The standard deviation of note durations

- **Fraction of attacks on offbeats**: The fraction of notes which start on an offbeat, where an offbeat is any time that is not a multiple of 4

- **Average simultaneity**: The average number of notes sounding at each unit of time - measured by adding up for each of the 64 possible times the total number of active notes

- **Variability of simultaneity**: The standard deviation of the number of notes sounding at each time

- **Major triad prevalence**: The fraction of times which contain a major triad

- **Minor triad prevalence**: The fraction of times which contain a minor triad

- **Diminished and augmented triad prevalence**: The fraction of times which contain either a diminished or augmented triad

- **Average pitch**: The average pitch as a MIDI number, weighted by duration

- **Note density**: The average number of distinct notes in all time windows of size 4

- **Variability of note density**: The standard deviation of the number of notes in all windows of size 4

- **Average time between attacks**: The average length of time between consecutive note attacks

- **Variability of time between attacks**: The standard deviation of the time between attacks

- **Fraction of silence**: The fraction of times where no notes are playing
- **Pitch class variety**: The fraction of notes that are used at least once

- **Tonality**: Actually 12 separate features, one for each pitch class. For each pitch class, gives the percentage of notes of that pitch class.

When I analyzed a piece, I flattened the individual parts, essentially ignoring which instrument played which notes. I avoided features that would be the same throughout a single piece, for example ‘number of instruments.’ This feature would be dictated solely by the architect, and would not measure the composer’s contribution. Furthermore, because I compared pairs of fragments within the same piece to pairs of fragments between different pieces, a feature that remains constant throughout a piece would artificially make the within-piece fragments appear more similar.

Many of the above features need normalization, or they will tend to dominate the feature vector. For example, the average pitch of a fragment might be something like 60, but the major triad prevalence is at most 1.0. In order to get each feature to range from 0 to 1, for each feature not bounded by 1, I empirically tested for that feature’s max value among all the fragments and then normalized by that number. So if the maximum average pitch was 100, and a fragment’s average pitch was 60, the average pitch feature would have a value of $\frac{60}{100} = 0.6$.

### 7.2.2 Results

The first thing I set out to do was to examine how the first fragment of each piece related to the rest of the fragments. The best results used just the frequency distribution of pitch classes as the feature vector instead of the full ensemble of features. The results are shown in figure 7-8. The graphs plot the similarity to the first fragment for each fragment within a piece, and also plot the average similarity of the first fragment to fragments from other pieces (shown as a dashed line). With the exception of “Piece 2”, pieces showed the predicted diminishing similarity to the first fragment over time.

If we take the full ensemble of features, we get a less dramatic dropoff. We see a general downward trend in “Piece 1” and “Piece 3,” but not in the other pieces. Interestingly enough, “Piece 1” and “Piece 3” were the pieces with the smallest hint
Figure 7-8: Tonal similarity to the first fragment for five different pieces. The average similarity of the first fragment to fragments in other pieces is shown as a dashed line.
The second thing I measured was the comparative similarity between adjacent fragments. Here I used the full ensemble of features to create feature vectors. For each pair of fragments $A, B$, where $B$ received a hint from $A$, I compared the similarity of $A$ and $B$ to the similarity of $A$ with every other fragment not in the same piece. I then got a \textit{comparative similarity score} for $A$ and $B$ which was the fraction of fragments $C$ where $A \cdot B \geq A \cdot C$. A score of 1.0 meant that $A$ was more similar to $B$ than to every other fragment outside the same piece.

The results here were quite promising. Using the complete ensemble of features, I found that 88.6\% of adjacent fragments had a comparative similarity score of greater than 0.5. Of the 35 adjacent pairs, 19 of them had comparative similarity scores of 1.0. Looking at the four adjacent pairs with comparative similarity scores less than 0.5, the second fragment of each pair was always a non sequitur! This set included the non
sequentur fragment 3 from “Piece 1”, discussed in the qualitative analysis and pictured in figure 7-1. The comparative similarity scores for each consecutive fragment pair are given in table 7.1.

I did a similar analysis to measure the similarity of fragments which were two away, three away, four away, etc. As predicted, the similarity decreased as we looked at pairs of fragments which were further away, as seen in figure 7-10. The comparative similarity scores supports the idea that the created pieces are generally fragmented but locally cohesive.

<table>
<thead>
<tr>
<th>Fragments</th>
<th>(1, 2)</th>
<th>(2, 3)</th>
<th>(3, 4)</th>
<th>(4, 5)</th>
<th>(5, 6)</th>
<th>(6, 7)</th>
<th>(7, 8)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piece 1</td>
<td>1.0</td>
<td><strong>0.03</strong></td>
<td>0.94</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>Piece 2</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>0.88</td>
<td><strong>0.34</strong></td>
<td>1.0</td>
<td>0.78</td>
</tr>
<tr>
<td>Piece 3</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td><strong>0.59</strong></td>
<td>1.0</td>
<td><strong>0.25</strong></td>
<td>0.63</td>
</tr>
<tr>
<td>Piece 4</td>
<td>1.0</td>
<td>0.97</td>
<td>0.59</td>
<td>1.0</td>
<td><strong>0.25</strong></td>
<td>0.63</td>
<td>0.5</td>
</tr>
<tr>
<td>Piece 5</td>
<td>1.0</td>
<td>0.97</td>
<td>0.59</td>
<td>1.0</td>
<td><strong>0.25</strong></td>
<td>0.63</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Table 7.1: Comparative similarity scores for adjacent fragments. Non sequiturs (<.5) are in bolded.

Figure 7-10: Average comparative similarity scores versus fragment distance
Chapter 8

Conclusion and Future Work

The Exquisite Score system set out to provide a way to collaboratively compose music online using the Exquisite Corpse paradigm. As of writing this, it is the only system of its kind that provides a compositional interface solely for the purpose of playing Exquisite Corpse with music.

Exquisite Score largely succeeded in fulfilling the design goals outlined in section 3.1. Exquisite Score facilitated the composition of several collaborative pieces and the pieces are highly varied and fairly interesting. The effects of occlusion are certainly present and the analysis in chapter 7 discusses ways in which the pieces are locally cohesive but globally chaotic. The composers had a variety of musical backgrounds, and even those without compositional experience were able to create reasonable sounding fragments which added to the overall narrative of the piece, often in surprising ways.

It would be interesting to further explore compositional paradigms, specifically, different ways in which fragments can be combined to create a complete piece. The implementation of fixed form pieces, discussed in section 6.1, explores one variation, but there are virtually endless possibilities. There is the idea of vertical occlusion, discussed in section 2.2.2, where users compose for the same time segment, but with different instruments or ranges. This can also be combined with the horizontal occlusion to create long pieces out of short, overlapping fragments. For example, when a user composes, maybe they are composing the melody line, and they are provided with both the bassline that happens underneath and also the last two measures of
Another possible exploration is to allow branching, as discussed in section 2.3.3. With branching, a single piece can be experienced in several different ways and pieces can be saved from uninspired or intentionally bad fragments. One could extend the idea to allow for branches to rejoin the original composition – pieces could be a patchwork of musical fragments with several possible paths which split and rejoin, perhaps all arriving at the same final fragment.

Though not necessarily a new mode of composition, it would also be interesting to have pieces without a set length, essentially “infinite pieces”. This would be more similar to the idea of the *Epic Exquisite Corpse* website [20], and would make use of the Internet’s capacity for large-scale collaboration. This begs the question of how one is supposed to experience a large, unbounded work of art. If 50,000 contributors each composed a single 10-second fragment, then the resulting piece would last almost 6 days!

While other compositional paradigms can be quite interesting, they cannot be explored at all without people contributing compositions. The next step for Exquisite Score is to release the website to a larger audience. The system is currently hosted online and accessible to anyone with the url, but there are a few necessary steps to take before releasing it more publicly. First, the page for creating new pieces needs to be revamped and cleaned up. The page has several usability issues: I was the only architect for the user tests, so this page was developed quickly and for my own personal use. The main page which lists all the compositions also needs to be changed: for now, it just dumps all the information from the database into an HTML table. The page needs to be extended to be able to present more than just 10 compositions effectively. It would be better if it listed open compositions separately from completed ones, and if there was a way to filter compositions.

Additional capabilities could also be added to the compositional interface, but they are not absolutely necessary. For instance, maybe users should be able to rate pieces or fragments. More important are minor adjustments to the interface, such as correcting the controls for setting the playhead. Many of these adjustments and
features are described in detail in section 5.3.

Seeing what other people have created with Exquisite Score has been tremendously fun for me, and it would be great to bring the experience to an even larger audience. For the foreseeable future, the pieces created with Exquisite Score for this thesis will remain accessible at https://exquisitescore.xyz/thesis.
Appendix A

Survey Results

A.1 Iteration 1

These are the survey results from the first iteration of Exquisite Score, discussed in section 4. There were only six testers for this iteration.

Q: What are your initial thoughts and reactions?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nice big grid! It’s a little overwhelming. Big canvas. That’s cool though. Blue on gray is not bad but maybe a little hard to see? Perhaps it could be a lighter gray and a darker blue?</td>
</tr>
<tr>
<td>Cool stuff! The interface wasn’t quite what I expected it to be, but I don’t know how intentional that was.</td>
</tr>
<tr>
<td>i think it should be interesting if i could get to know it more. i would definitely need explanation before i use it.</td>
</tr>
<tr>
<td>reminds me of that looping waffle web app</td>
</tr>
<tr>
<td>I like the simplicity of the design. The interface is intuitive and contributed to a steady workflow. The sound design felt a little cheap, but it did not take away from the experience.</td>
</tr>
<tr>
<td>Nice interface, good colors– could use a bit of instructional text. Not quite sure how the buttons map to notes, but I suppose that’s not the point.</td>
</tr>
</tbody>
</table>
**Q: What three things do you think would make the system better?**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hearing the notes you are clicking as you click them and maybe even resetting the playhead every time you click on note to play from that note. 2. Maybe being able to repeat bars? Like each bar gets a number of repeats 1-4. 3. Working on bars in isolation is difficult (I couldn’t remember what key I was in the key of the bottom square or the third square, etc.). Setting an arbitrary playback loop rather than a per-bar playbook loop would be better.</td>
</tr>
<tr>
<td>1)</td>
<td>I would make it so that you get feedback each time you enter a note (i.e. it plays just that pitch, or even the full set of pitches for a given column) so that you can orient yourself when you’re entering more notes. 2) I would delineate (perhaps optional) metrical and octave divisions (To my mind, it would make the most sense if one were able to choose groupings of twos, threes, or fours). 3) I would introduce the ability to tie notes, so that two adjacent timing slots with the same inputs don’t have to be separate articulations.</td>
</tr>
<tr>
<td>1.</td>
<td>i think when i click the box, i would like to hear the note so i could immediately know it that is the note i want. 2. i think i would like to know what the two instruments are. 3. i think i would like to see the the keyboard of some kind of instrument so the composing is more visual.</td>
</tr>
<tr>
<td>1)</td>
<td>more notation about what notes are being played, which beat we’re on, what sounds are being used; 2) better navigation / selection / etc keyboard shortcuts; 3) immediate audible feedback when a note is pressed</td>
</tr>
<tr>
<td>Adding note sustain and release, note velocity, and note previewing (hear what the note sounds like before using it).</td>
<td></td>
</tr>
<tr>
<td>More text instructions, make clearer that you can write more than one panel, perhaps an overlay bar to show where you are horizontally.</td>
<td></td>
</tr>
</tbody>
</table>
Q: How did you feel about the measure size? (i.e. the length of the current active section)

![Bar chart showing measure size preferences]

Q: How did you feel about the fragment size? (i.e. the length of your entire composition)

![Bar chart showing fragment size preferences]
Q: Did you use the “loop” button?

Q: Did you use the “continue” button?

Q: Did you find the summary score at the top of the page useful?
Q: Did anything about the interface strike you as particularly confusing?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Nothing was confusing.</td>
</tr>
<tr>
<td>I wasn’t immediately sure about saving versus submitting. A separate ‘save’ button might be unnecessary.</td>
</tr>
<tr>
<td>what note the little box represents.</td>
</tr>
<tr>
<td>difficulty of seeing what notes i was actually playing (which may be a limitation of the notation?)</td>
</tr>
<tr>
<td>No, but I realized after a while that I could drag the mouse to paste notes.</td>
</tr>
<tr>
<td>I didn’t know that I could write more than 1 block (more than 16 beats)</td>
</tr>
</tbody>
</table>

Q: Can you think of any other user interface features you would have liked to see?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nope</td>
</tr>
<tr>
<td>It also might be nice to have some preset inputs like ‘major chord,’ ‘minor chord,’ etc.</td>
</tr>
<tr>
<td>i would like to see a keyboard or guitar strings for input so i feel more familiar.</td>
</tr>
<tr>
<td>besides what i wrote on the 1st page of this survey, i would have liked to see UI features that would encourage more collaboration/connection with the previously composed segment</td>
</tr>
<tr>
<td>Mostly note velocity. I guess now that you mention it, something to indicate the white and black keys of a piano.</td>
</tr>
<tr>
<td>maybe optional guidelines for C major? Like, click this button to turn on more complicated musical notation– that way, the default is still accessible to those who dont have any musical training.</td>
</tr>
</tbody>
</table>
Q: Do you have any other feedback on the compositional interface?

Hmmm... triad shaped “stamps?” The bottom voice kinda sucked... The top voice was hard to hear over the middle voice. Being able to listen to the voices in isolation would be nice.

See previous answers.

in terms of buttons, i think it would be helpful if there is some kind of explanation.

besides what i wrote on the 1st page of the survey, more options would be nice - different sounds, different tempo (might be hard to do if i need to continue my composition from an existing segment). ability to make notes of different length values.

It works!

page was too long– I’d like to be able to see everything at once. Maybe use side-by-side layout or have the summary score accessible by button click?
Q: As a feature, how important do you think volume control is?

Optional comments

Would be very sweet but too much gradation would make it cumbersome I think. Maybe like 4 dynamics or something?

at this stage, seems unimportant. being able to tweak the balance of the parts might be more helpful.

The balancing of the instruments seemed a little off to begin with, and putting lots of notes makes it too loud!

I forgot about this, but it was one of the more annoying things about the tool—the middle block sounds were really loud, and I could barely hear the top block’s.
Q: Modality feature - instead of a chromatic scale, the vertical axis could be a diatonic scale, e.g. G Major. The user could have a way to change which scale is mapped to the y-axis. As a feature, how important do you think modality is?

Optional comments

I liked that it was chromatic. Maybe modal guides would be helpful to overlay just as a reference.

This would be really cool—it could also be set up so that the intervalic distances between adjacent notes in the scales was reflected in how large the input buttons are (e.g. a distance of a M2 takes up the size of two smaller m2 buttons)

You can do everything with a chromatic scale, so it doesn’t seem necessary.
Q: As a feature, how important do you think it is to have held notes?

Optional comments

<table>
<thead>
<tr>
<th>Response</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unimportant</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>1</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>2</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>3</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>4</td>
<td>4 (66.7%)</td>
</tr>
<tr>
<td>5</td>
<td>2 (33.3%)</td>
</tr>
</tbody>
</table>

Would be nice for sure.. sounds annoying to implement...

Yes, tying would be a good feature (some sort of click and drag?)

Would help with making it sound less cheap.

maybe use click and drag?
Q: As a feature, how important do you think it would be to have increased rhythmic granularity?

Optional comments

I definitely wanted to do weirder polyrhythms... but on the grid it seems like a challenge (unless you can zoom in...)

This would be interesting—my interface suggestion would be similar to what I said about scalar distances (bigger buttons are longer rhythmic units).

I think it would be cool to be able to change the time signature for each measure.
Q: As a feature, how important do you think it would be to mix up the composition order?

Optional comments

<table>
<thead>
<tr>
<th>Seems like it would be good to do that!</th>
</tr>
</thead>
<tbody>
<tr>
<td>What if you saw information from both the preceding and the succeeding material?</td>
</tr>
<tr>
<td>it is fun but i do think consistency is important in music.</td>
</tr>
<tr>
<td>would be fun. but who would (pre-)determine this overall structure? or there could be a ‘randomize order’ button</td>
</tr>
<tr>
<td>I like the idea!</td>
</tr>
</tbody>
</table>

Q: Are there any other features you would like to see?

<table>
<thead>
<tr>
<th>Mostly tighter auditory feedback in the composition interface.</th>
</tr>
</thead>
<tbody>
<tr>
<td>No, that covers it!</td>
</tr>
<tr>
<td>maybe some kind of sound effect like echo etc.</td>
</tr>
<tr>
<td>More voices/instruments! Lots of percussive sounds.</td>
</tr>
<tr>
<td>more colors? Especially if you implement more features, you could definitely use color to your advantage to visualize things like held notes or volume, etc.</td>
</tr>
</tbody>
</table>
A.2 Iteration 2

These are the survey results from the second iteration of Exquisite Score, discussed in section 5. There were 19 responses out of 33 contributors.

Q: What are your initial thoughts and reactions?

<table>
<thead>
<tr>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool stuff</td>
</tr>
<tr>
<td>A little intimidating to compose music.</td>
</tr>
<tr>
<td>Functional and looks good!</td>
</tr>
<tr>
<td>This is awesome! I love the idea and the simple, focused design.</td>
</tr>
<tr>
<td>This is a really neat idea! I had a lot of fun composing a thing and</td>
</tr>
<tr>
<td>listening to it afterwards - it wasn’t quite what I expected from the</td>
</tr>
<tr>
<td>snippet I’d heard. It was interesting to see how other people took bits</td>
</tr>
<tr>
<td>from the parts they’d been able to see to try to make it flow nicely,</td>
</tr>
<tr>
<td>but it still sounded really interesting.</td>
</tr>
<tr>
<td>It’s pretty cool intuitive and easy to use</td>
</tr>
<tr>
<td>Cool! I felt like my submission was subpar, but it was really interesting</td>
</tr>
<tr>
<td>how the song shaped itself. Really cool!</td>
</tr>
<tr>
<td>Looks like a fun and collaborative approach to composing—a great idea</td>
</tr>
<tr>
<td>The model is easy to work with, and listening to the whole piece at the</td>
</tr>
<tr>
<td>end was quite fun!</td>
</tr>
<tr>
<td>this is cool! this is very cool!</td>
</tr>
<tr>
<td>It was fun! I thought a lot about where I wanted to take the previous</td>
</tr>
<tr>
<td>composer’s piece and tried to stay true to where he was going with it.</td>
</tr>
<tr>
<td>Mine ended up being a bit more diatonic, but I tried to take it slightly</td>
</tr>
<tr>
<td>out like the previous section sounded.</td>
</tr>
<tr>
<td>Cool idea! It feels like some sort of musical game of telephone. The</td>
</tr>
<tr>
<td>idea starts one place and ends up somewhere totally different! The</td>
</tr>
<tr>
<td>editor is a bit cumbersome coming from more ‘polished’ daws but I</td>
</tr>
<tr>
<td>dealt with it just fine. :)</td>
</tr>
</tbody>
</table>
Q: (continued) What are your initial thoughts and reactions?

<table>
<thead>
<tr>
<th>I enjoyed it!</th>
</tr>
</thead>
<tbody>
<tr>
<td>very neat to hear how a piece evolves after you’ve submitted</td>
</tr>
<tr>
<td>This is a neat idea! I kind of used the snippet I was provided as an ‘intro’ to my section, which made me feel kind of guilty – I didn’t know enough about what material came before to treat it appropriately, and after hearing the whole thing I ended up in a totally different genre than what the piece was maybe supposed to be. (Although I guess it’s not “supposed” to be anything, right?)</td>
</tr>
<tr>
<td>fun project! hearing it all played back was a treat.. a number of us who worked on it listened together. super cool.</td>
</tr>
<tr>
<td>very fun and successful, compelling</td>
</tr>
<tr>
<td>Was fun to hear finished piece after doing my section.</td>
</tr>
<tr>
<td>Fun! I also enjoyed checking out other pieces.</td>
</tr>
</tbody>
</table>

Q: What three things do you think would make the system better?

| 1) It might be helpful to hear any other pitches already entered at the point where you are putting a new pitch in addition to the new one (as an option). |
| 2) Reduce vertical scrolling if possible. 3) More visual distinction between the different instruments you’re scoring |
| Stop playing if no more notes past cursor. Ability to disable notes (instead of just deleting them). Click piano keyboard to hear notes. |
| Looping a region would be nice feature, clearer graphical distinction between octaves (it’s hard to tell where you on the keyboard even though the black keys are darkened), not sure what else |
| Easier way to horizontal scroll (shift + mousewheel?), return to stop point option (e.g. if you set the playhead to play from beat 4.2 for instance, then the playhead will automatically jump back to beat 4.2 when transport is stopped), double-click to delete a note |
Q: (continued) What three things do you think would make the system better?

When I would press space to pause, a lot of the time it would keep playing a couple of the notes for a few seconds for some reason. Not sure why. It would also be nice if moving the playhead with the mouse was a bit smoother. Another thing is that I found it difficult to tell what note I was clicking on - I was composing by deciding which chord I wanted to use, but it was hard for me to figure out what the notes were without twisting my head sideways to look at the piano keyboard on the side. Not sure how to make that more intuitive, but maybe putting note names on the keys or something? It would also be nice if the instruments were labeled on the side. It was simple for me to figure out the top was the choir ahhs and the bottom was the cello by testing it out, but there wasn’t a label on it.

I think the different colors for different channels would be slightly more convenient.

Easier to use when you first start- moving the measure arrow thing was a little tricky, and I couldn’t figure out how to copy paste. Maybe having an interface where it was easier to tell what note you were playing (ie when you create the blue line for a G, a little G pops up over it or something), so you don’t always have to cross reference the piano on the left.

There seem to be some bugs that could be firefox-related: 1) playback stops after playing back a couple of times. 2) I didn’t realize that the previous person had composed quite a bit more before the fragment that it gave me. It’s important to me to have a sense of what the entire piece is doing. 3) Can’t think of third thing, sorry

1. Is there anyway you can make some sort of a theme for the background? Something exquisite? 2. Instruction icon can be more visible (or even pop up automatically at the beginning). 3. For some reason, I was not able to listen to the whole last segment of Sam’s composition half way through. Any way you can fix that?
Q: (continued) What three things do you think would make the system better?

- Slightly less buggy navigation (I had trouble moving the playhead), I’d love for double clicking a note to delete the note, just getting the system to fit closer to the interaction of a DAW like Logic

1. Allow single click ‘start playing from here’ anywhere on the editor instead of only those small strips above each editor. 2. This one measure of shared content seems like it can be expanded. Maybe allow the initial composer to decide how much shared content there is? Or maybe the first composer can write a single lined ‘theme’ that all the sub-composers get to hear/work with. (perhaps in conjunction with shared content?) 3. Maybe you could have individuals add in specific instruments separately. For example, the user would hear the shared pre-roll of all 3 instruments then the single bass line someone else put in for the new section and they’re to add the melody on top of that.

1. keep the submit button in the top of the screen maybe? was hard to find 2. give instructions on the composing screen–I had to refer to your email to know what to do 3. maybe have a “save and come back later” button? it was frustrating having to recreate my work after too much inactivity

The only issue I had is that using copy and paste was confusing – when I pasted, it dropped another copy of the notes on the clipboard exactly where the originals were, instead of where the playhead was (as I expected from other DAWs).

1.) copy/paste functionality 2.) not allowing double notes layered on top of each other. 3.) ease of moving and jumping around piece with play cursor.

velocity, additional grid divisions (triplets, 32nd, etc), and the ability to add instruments in the middle of a piece

1) grid/quantization options 2) velocity sensitivity 3) external keyboard record?

better sounds and more control over rhythmic variation, tempo, and time signatures
Q: (continued) What three things do you think would make the system better?

1. Works well for musicians, but might want some sort of auto-help for non-musicians, like suggesting a bass/harm to their melody. 2. Way to choose from a few different midi instruments for part or all of your section. 3. More interplay between diff sections, other than stringing them together. Maybe you must start with the previous section’s bass adding your own melody or vise versa,

1) Bigger pitch range!! 2) Help (It wasn’t even obvious how to “hit play”, and I found out by luck how to copy and paste) 3) Go in both directions?? It could be fun to make an excerpt that had to end in a particular way.

Q: How useful did you find the following features?

- Copy/paste
- Undo/redo
- Extending note lengths
- Moving the shuttle head
- Mouse-drag to select multiple notes

<table>
<thead>
<tr>
<th>Feature</th>
<th>Useful</th>
<th>Didn't know about it</th>
<th>Not useful</th>
</tr>
</thead>
<tbody>
<tr>
<td>Copy/paste</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undo/redo</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extending note lengths</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moving the shuttle head</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mouse-drag to select multiple notes</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

82
Q: Did anything in the interface strike you as particularly confusing?

<table>
<thead>
<tr>
<th>Top keyboard doesn’t line up with notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double click to add a note was unexpected. Enter to return playhead was not intuitive but reasonable.</td>
</tr>
<tr>
<td>The shared regions were at first confusing, but then it quickly made sense what was going on. Maybe some friendlier language there could help.</td>
</tr>
<tr>
<td>Just figuring out which note was which as I went, I'm not used to looking at a sideways keyboard.</td>
</tr>
<tr>
<td>Didn’t know if I was allowed to add stuff to the person’s measure that came before me. I didn’t think so, but then I saw the last measure for me to write is called “shared”- didn’t know if that meant just the notes were shared, or it’d be shared as in both people can edit, if that makes sense</td>
</tr>
<tr>
<td>What’s the difference between the red head and the black head?</td>
</tr>
<tr>
<td>Nope!</td>
</tr>
<tr>
<td>How to use the playhead mostly. I tried dragging it which was very buggy if I didn’t let go of the playhead while actually in the little zone associated with it. I eventually realized I could just select a spot on the playhead to move to that location, which I found less buggy.</td>
</tr>
<tr>
<td>As mentioned in my feedback on the previous page, I sort of wanted to click anywhere to move the playhead. Also, copy/paste didn’t seem to work for me? (at least not with the keyboard cheats)</td>
</tr>
<tr>
<td>The difference between red and black cursors.</td>
</tr>
<tr>
<td>Copy and paste didn’t paste where the play head was. It always pasted at the beginning</td>
</tr>
<tr>
<td>Initially confused by copy/paste and thought it didn’t work, since I tried to paste elsewhere and didn’t realize it pasted right over the copied notes.</td>
</tr>
<tr>
<td>Plenty! I had to guess how to do everything (although most of my guesses were right).</td>
</tr>
</tbody>
</table>
Q: How important would it be to have a looping tool?

Q: How important would it be to have a summary score?

Q: How important would it be to have a compact score view (i.e. score could be collapsed to contain fewer rows?)
Q: How important would it be to have a quick-compose button?

![Bar chart]

Q: Can you think of any other interface features that would make the system better to use?

- Controls to play, and jump the playhead to the beginning would be helpful
- play button, undo/redo as interface buttons
- hmmm... diatonic transformations?
- Highlighting the rows a slightly different color when they contain any note might be interesting, so you have a more immediate sense of what key it's in, or what notes are being used. Simple mixing controls would also be useful - gain/pan.
- Not sure how conflicts could be handled though with other users, since it'd be strange to have those params change in each section.
- larger areas to select - it was hard to choose the exact right line, had to adjust sometimes
- For some reason, I didn’t notice that there was the third row of notes until I listened to the previous segment. Is there a way to make all rows visible, or make it more intuitive to scroll down?
- does this support keyboard functionality? (i don’t remember) like if i typed aabcdfl would it be able to create something (maybe with just quarter notes) with those notes played in a linear sequence?
Q: (continue) Can you think of any other interface features that would make the system better to use?

<table>
<thead>
<tr>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>as mentioned, the keyboard on the left to be usable</td>
</tr>
<tr>
<td>Pressing ‘Enter’ should start at the beginning of the shared measure.</td>
</tr>
<tr>
<td>hold a key down to drag a selection of notes to a new position that is auto</td>
</tr>
<tr>
<td>copy/pasted.</td>
</tr>
<tr>
<td>darker grid lines at measure boundaries</td>
</tr>
<tr>
<td>audio hardware io?</td>
</tr>
<tr>
<td>color coded notes! ie. all Cs are blue C-sharps red, etc</td>
</tr>
</tbody>
</table>

1) Hearing a piece from the front page would be nice. 2) Horizontal scale so I can eyeball the whole thing at once (though I guess that is sort of the “summary score” feature).

An option to limit the notes to certain keys or modes might be interesting. It could make it seem less intimidating to people with less musical training.

Q: How did you feel about the length of music you had to compose?

![Chart showing the distribution of how the participant felt about the length of music they had to compose.]

Q: How did you feel about the length of music you received from the previous composer?

![Chart showing the distribution of how the participant felt about the length of music received from the previous composer.]

86
Q: How impactful do you think it would be to have a variable note grid (e.g. to allow triplets)?

Q: How impactful do you think it would be to have private compositions, where contributions are limited to a specific set of people?
Q: How interesting would you find composing for one instrument at a time? e.g. Composing a piano melody based on a bassline and a couple bars of the previous piano part.

Q: How interesting would you find composing pieces with variants? e.g. Once all fragments are composed, you might continue to compose as follows: you compose an alternative for fragment 2, where you get to see the end of fragment 1 and the beginning of fragment 3. Then, when someone goes to listen to the piece, they have two choices for what the second fragment should be.
Q: Are there any additional features you think would make the system more musically satisfying?

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The midi instruments could be better.</td>
<td></td>
</tr>
<tr>
<td>chords help</td>
<td></td>
</tr>
<tr>
<td>not really</td>
<td></td>
</tr>
<tr>
<td>maybe the ability to swap in a different instrument during your assigned section?</td>
<td></td>
</tr>
<tr>
<td>The more available sounds, the better!</td>
<td></td>
</tr>
<tr>
<td>Variable tempo and turning off grid for additional control</td>
<td></td>
</tr>
<tr>
<td>basic midi properties such as pitch bend, sustain pedal, modulation, etc</td>
<td></td>
</tr>
<tr>
<td>I think better sounds would really make this shine. Would it be possible to bundle in vsts?</td>
<td></td>
</tr>
<tr>
<td>Similar to above variant, a way to take the 8 composed sections (of some bars of) and re-arrange into longer song form.</td>
<td></td>
</tr>
<tr>
<td>Working backwards, as I already mentioned.</td>
<td></td>
</tr>
</tbody>
</table>
Bibliography


