REPLENISHMENT: A MUSICAL NARRATIVE INSPIRED BY SLEEP

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The *Replenishment* cycle contains five works that allude to the experience of sleep, beginning with awake drowsiness and ending with the piece inspired by rapid eye movement (REM) sleep, titled *Conceiving Realities*. This last piece is an intermedia work composed for chamber ensemble, live painting with biofeedback, computer, and audiovisual processing. This critical essay describes the composition of *Conceiving Realities* within the context of the *Replenishment* cycle, followed by a thorough analysis of the research involved in the technological aspects of the piece, and finally, a description of the instrumentation, notation, intermedia elements, and technology comprising the work. *Conceiving Realities* uses a system of interactions between painting, biofeedback, music, and video, in which a painter wears brainwave and heartbeat sensors that send data to a computer patch processing the sound of an ensemble as the painter listens and creates the painting while responding to the music. This requires a passive biofeedback system in which the painter is focused on listening and painting. The computer uses the data to process existing sounds, instead of synthesizing new lines. The score blends elements of traditional notation, graphics, and guided improvisation; giving the performers some creative agency. This alludes to the way in which scenarios in dreams occur without voluntary control of the dreamer. Finally, a camera captures the painting and projects three video screens applying individual types of processing to the original video stream, controlled in real time by the amplitude of the ensemble. All these elements create an immersive experience for the audience that is mediated by the interaction of sight and sound.

ACKNOWLEDGEMENTS

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I dedicate this work to my parents and siblings for their unconditional support. I am grateful to Bailey Chapman, Kathleen Crabtree, Yao Cui, West Fox, Sarah Jay, Trevor Mahaney, Alex McKamie, Michele Newman, Kourtney Newton, Seth Shafer, and Alexander Strader, for participating in the premiere of this work; as well as Cassie Lear, Joel Auringer, Shelby Blezinger, Mike Capone, and Rebekah Ko, for their collaboration and insight during the composition of the first two pieces. This entire project is dedicated to the memory of Jessica Sara Ramirez.

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PART I

AN INTERMEDIA WORK ABOUT SLEEP

Chapter 1

Introduction: The Experience of Human Sleep

Conceiving Realities is the culminating work in a set of five pieces about the human sleep cycle entitled *Replenishment*. The first piece of *Replenishment* is inspired by sleep deprivation, while the last four pieces reference individual stages of sleep. *Conceiving Realities* is based on the last stage, called rapid-eye movement (REM) sleep. During REM sleep, brain activity accelerates close to wakefulness levels, and it is when most vivid dreams occur.[1] The piece alludes to the experience of dreaming through the blending of the senses and the merging of familiarity with unpredictability.

Conceiving Realities uses acoustic/electric instruments, computer music, live painting, and live video. The computer part features live processing and an algorithmic sampler with sounds recorded on an autoharp, a bass guitar, a tuba, and a zither instrument of my design. The painter wears brainwave and heartbeat sensors, which generate the data used to modify the parameters of the audio processing. Similarly, the overall sound alters the visual element, consisting of three videos of the live painting processed individually. The amplitude of the sound in the room controls the amounts of processing for each video.

The use of live painting in *Conceiving Realities* is inspired by the dormant mind's tendency to create scenarios while dreaming. This is also reflected musically by including improvisatory sections.

The instrumentation is the result of combining the forces of the previous four pieces with three new performers. This was prompted by the way in which dreams often feature

[1] William Moorcroft, *Understanding Sleep and Dreaming* (Boston: Springer, 2013), 144.

occurrences from daily activities amidst unfamiliar scenes.

This document describes the process behind the composition of the *Replenishment* cycle, with an emphasis on the final piece *Conceiving Realities*. This piece brings the set to conclusion with a climactic ending, and was the focus of my thesis for the Master of Arts program in Music at the University of North Texas. While this paper focuses on the last piece of the cycle, it is important to provide a description of the full set. This will help place the conceptual framework of *Conceiving Realities* in context with the work that precedes it.

Humans experience sleep in cycles alternating between two types of sleep, namely, rapid eye movement (REM) sleep and non-REM sleep. The latter of these is split into three stages, and precedes REM sleep. Each part of this cycle reflects individual patterns of brain activity. The body begins the cycle on the first stage of non-REM sleep, which is a transitory stage consisting of light sleep with occasional muscle twitches; brain activity begins to slow down in this stage. The second stage features even slower brain activity, with brief high-energy electrical bursts. The last stage of non-REM sleep is much longer and has the slowest level of activity and breathing. Finally, REM sleep features movement of the eyes, fast breathing, dreaming, and brain activity which resembles that of a state of wakefulness.[2]

[2] "Brain Basics: Understanding Sleep," National Institute of Neurological Disorders and Stroke, accessed April 2, 2017, http://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/Understanding-Sleep.

Chapter 2

A Cycle of Compositions about Sleep

The concept for *Replenishment* emerged after writing the first piece, *Lassitude*, which was inspired by the experience of sleep deprivation. I wrote the piece both in and about this state. *Lassitude* uses a prepared bass drum created specifically for the piece, with a string running across a bridge placed perpendicularly on the membrane of the drum. This string can be bowed, struck, or plucked; producing a distinctive palette of sounds.

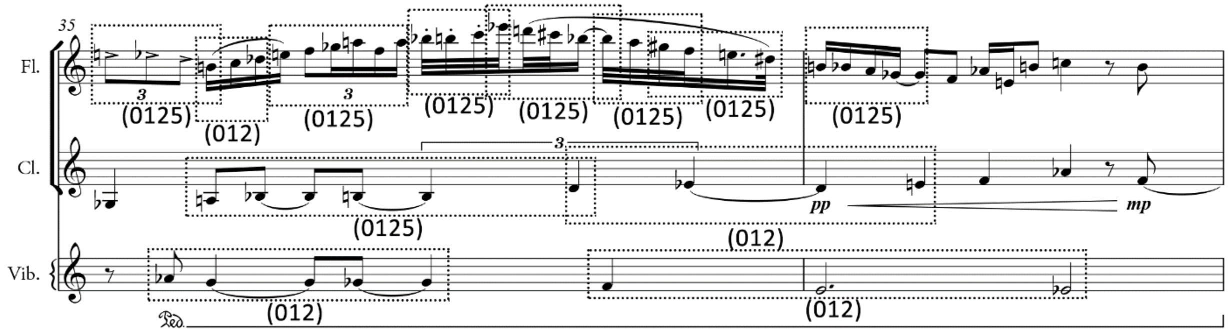
Shortly after writing *Lassitude*, I had a lesson with Elainie Lillios, who was visiting the University of North Texas as a guest composer. After looking at the score and listening to the recording, she encouraged me to use the prepared drum along with stringed instruments to explore the capabilities of the combination of bowed strings. This inspired me to write more pieces for the drum, while my fascination with the human brain and the physiology of sleep enticed me to keep writing on the subject; especially if the drum was going to be included. These factors contributed to my desire to write a set of pieces that would be derived from the concept begun in *Lassitude*.

2.1 *Lassitude*: On Sleep Deprivation

In my first composition seminar at the University of North Texas, I worked with a flutist, clarinetist, and percussionist from the Nova Ensemble. The performers' experiences and strengths became important compositional elements for the piece as I sought to explore the timbral capabilities of each instrument. This was ideal for working with these specific musicians, since all three of them were interested in timbral exploration and had plenty of experience in the subject.

Early 20th century atonality and a loose application of set-class theory to this harmonic world were the starting point for much of the material of *Lassitude*. However, as the project unfolded, harmony and timbre became closely linked in a freer harmonic design, focusing particularly on harmonic combinations that connected with harsher timbres. I began playing with a (0125) set as a sort of grounding. I transformed this set and others freely throughout the piece, while also adding intervals and timbral features at will. Example 2.1 shows some transformations of (0125) and its subset (012), with free pitches at the end of the passage picked for their intervallic contour.

Example 2.1. *Lassitude*, mm. 35-36



Sleeplessness inspired the piece from the start, at first simply because most of the writing happened late at night after long and busy days. As I became aware of this psychological state while writing, I began to allude to it intentionally in the music. I kept a slow pace and open spaces throughout the piece. Dissonant intervals and chords extend into the timbral effects of microtones and multiphonics in the winds and cluster chords in the vibraphone. Example 2.2 shows a microtonal cluster created by the interaction of the three instruments.

Example 2.2. *Lassitude*, mm. 38-39

The stringed drum evolved from my dissatisfaction with the role of the bass drum as a purely rhythmic instrument. After some experimentation, I attached an electric guitar string to the rim of the drum, drawing it across the membrane. I used a wooden bridge to support the string and transfer the sound to the drum head. The string could then be bowed, plucked, struck, or scratched. This design allowed a continuum between the exploration of sustained timbral transformations and a more traditional rhythmic use of the bass drum. Figure 2.1 shows a diagram of the finished prepared drum.

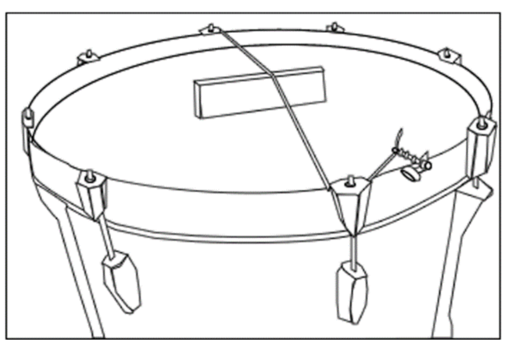


Figure 2.1. Preparation of the drum

Some methods used in *Lassitude* influenced the rest of the cycle, providing a sense of musical narrative. The drum is also featured in the second piece, *Somnolence*. In addition to the instrumentation, elements of the harmonic material of this piece appear in *Conceiving Realities*.

2.2 *Somnolence*: First Stage, Falling Asleep

Somnolence is the second piece of *Replenishment*, and is composed for viola, cello, the prepared drum, and computer. It introduces the use of computer music to the cycle, which is a feature of all the succeeding pieces in the set. The electronic part was built in the Max/MSP environment, and comprises an algorithmic sampler with varying degrees of delay processing on some or all the voices.

To maintain consistency with the stringed instruments, I recorded sounds from an autoharp, using different playing methods and sorting the samples into categories. These include single plucked strings, multiple plucked strings, bass bow bowing, nylon-string bowing,[3] struck strings, and some ambient sounds produced unintentionally in the recording session. The sounds were analyzed with a sample analysis tool provided by Andrew May, who also helped me extensively in the creation of a tool to transpose the samples in the patch. For the pitch framework, I chose to use the three asymmetric division scales created by Wendy Carlos.[4] These scales, called alpha, beta, and gamma, remain the harmonic basis for the sampler parts throughout the rest of the pieces in the *Replenishment* cycle. The pitches are chosen by random numbers sent to Markov chains of probability based on the examples from the Algorithmic

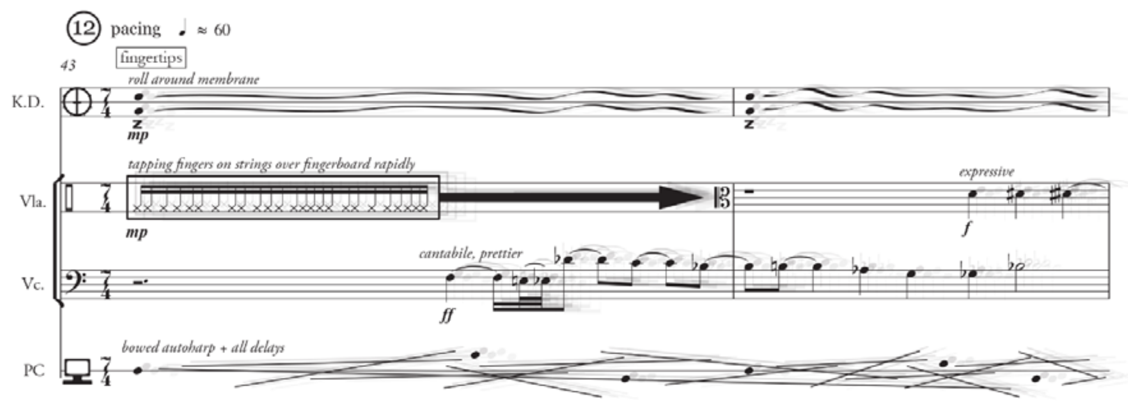
[3] The design for this bow was inspired by those used in a performance of Kirsten Broberg's *Resonant Strands* cycle, in which I had the opportunity to perform one of the bow parts in a performance of the work by the University of North Texas' Nova Ensemble.

[4] "Three Asymmetric Divisions of the Octave," Wendy Carlos, accessed April 5, 2017, http://www.wendycarlos.com/resources/pitch.html

Composer website.[5] This process is also used to determine the rhythmic quality of the sampler by using Markov chains to set the time delay before playing the following sample.

Somnolence was inspired by the first stage of non-REM sleep, which marks the beginning of a gradual process into falling asleep.[6] An individual experiencing this stage alternates between wakefulness and light sleep, with the possibility of having quick dreams with visual image fragments.[7] To allude to these undulations between two mental states, I decided to create polarities in the type of notation, flow of time, use of computer, and method of creation (i.e., direct notation, improvisation, or both). Despite these binary states, there are also gradients between them. The different degrees within these polarities symbolize the fluidity of the intermittence between sleep and wakefulness. Example 2.3 shows one of the moments of blurred delineation between some of the extremes. In this excerpt, time is kept by meter and the notation is mostly traditional, while the computer sampler is active and delay lines process all the voices.

Example 2.3. *Somnolence*, mm. 43-44



[5] "Algorithmic Composition: Markov Chains in Max MSP," Algorithmic Composer, accessed April 2, 2017, http://www.algorithmiccomposer.com/2010/05/algorithmic-composition-markov-chains.html.
[6] Moorcroft, *Understanding Sleep and Dreaming*, 22.
[7] "Brain Basics: Understanding Sleep."

Somnolence also alludes to the way in which a person gradually gives up control of mental activity when falling asleep. The use of improvisation does this by shifting some of the creative authority from the score to the performers, while the music from the sampler is generated in real time by the Max patch. The intensity of the processing and sampler activity grows gradually throughout the piece, representing the increasing drive towards deeper sleep. By the end of the piece, delay processing is applied to all the voices and all the categories of samples are fully active.

2.3 *Dimming*: Second Stage, Towards the Depths

The third piece in the cycle, *Dimming*, is inspired by the second stage of non-REM sleep, in which, the body becomes more relaxed, eye movement stops, and brain waves slow down.[8] This is the stage where sleep spindles and K-complexes occur.[9] Sleep spindles are fast and intense oscillations in brain activity, while K-complexes are slow fluctuations of brainwaves with high amplitude.[10] These occur as the brain begins to block sensory information to prevent its arrival to the neocortex.[11]

The instrumentation of this piece consists of electric guitar and computer. The computer patch is derived from the one built for *Somnolence*: it uses the sampler and the Wendy Carlos scales as well, though the samples for *Dimming* were recorded on an electric bass guitar. The piece uses a time-controlled cue list to progress through events in the computer part, changing the rhythmic density and harmonic language.

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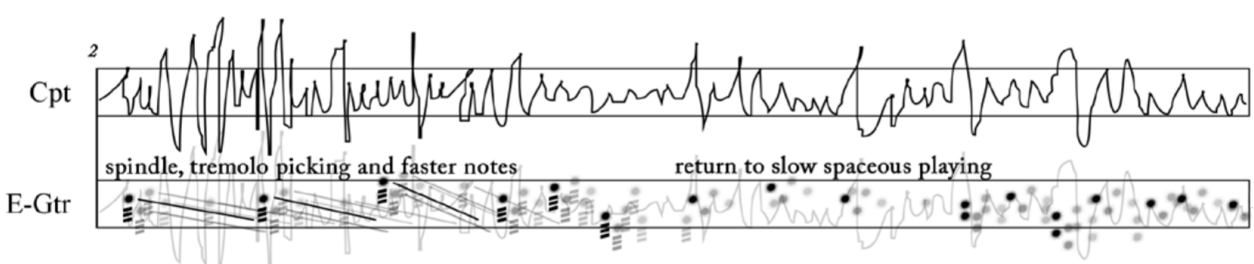
[8] "Brain Basics: Understanding Sleep."
[9] Moorcroft, *Understanding Sleep and Dreaming*, 23.
[10] Ibid., 19.
[11] Ibid, 109.

The form is based on the interaction between the three types of brain states that occur in the second stage of non-REM sleep: moderately slow waves, fast sleep spindles, and slow but wide-ranged K-complexes. The idle, slow state uses sporadic playing on the guitar and sampler, while the state symbolizing spindles consists of fast tremolo passages on the guitar and the sampler. The rhythm of the computer part becomes much faster in these sections, when the cue list activates the set of samples of fast tremolo gestures. The guitar part calls for rapid tapping using both hands. For the K-complex moments, both the guitar and the bass sampler perform long glissando passages representing the slow, high-amplitude brainwaves.

The progression through the cues is automatic, with the guitarist following the bass part as it alternates between the three types of moments. The timeline was determined by looking at various brainwave scans of Stage 2 of non-REM sleep and developing a score from it. The guitar part is improvisational, based on verbal and graphical instructions describing the actions corresponding to each of the three statuses; Example 2.4 illustrates one of these moments.

Example 2.4. *Dimming*, m. 2



2.4 *Submergence*: Third Stage, Deep Sleep

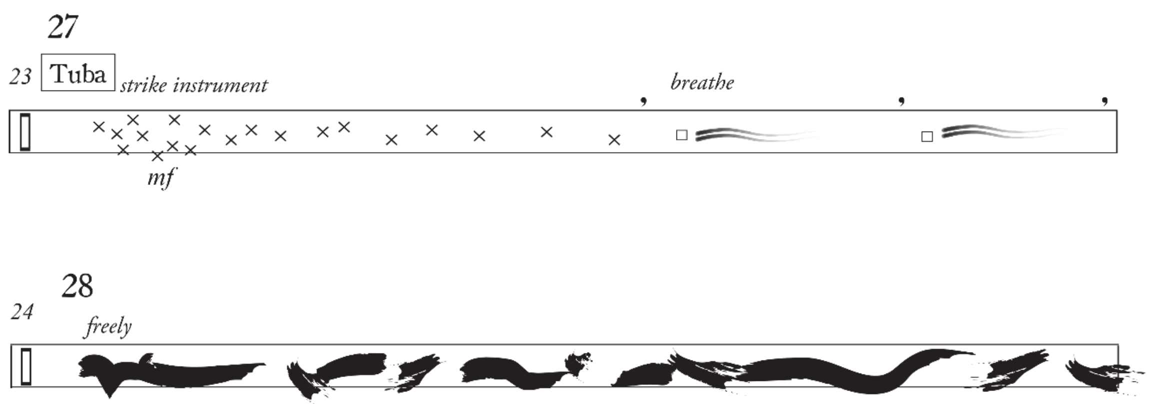
Submergence, for tuba and computer, is the piece inspired by the third stage of non-REM sleep, often called "deep sleep," which is characterized by delta waves in brain activity.[12]

[12] Ibid., 23.

At this point, which is the idlest point of the brain throughout the sleep cycle,[13] brain activity slows down to allow repairs in the brain and body.[14] For this reason, *Submergence* is the slowest piece of the cycle. Much of the sound world of the piece resides in lower pitch registers, alluding to the low frequency waves that characterize the brain activity in this stage.[15]

Submergence features a combination of improvised and traditionally notated material. Example 2.5 shows some of the ways in which the score mediates and structures the improvisational parts.

Example 2.5. *Submergence*, mm. 23-24



In addition to the tuba, the performer requires a tablet, using TouchOSC[16] to communicate with the patch. I built a layout on TouchOSC Editor software to allow the performer to navigate through cues, control the volume of each voice, and monitor the input signal from the tuba with a custom level meter made with a series of virtual LED lights within the layout that light up when the input signal reaches a certain level. Example 2.6 shows the

[13] Ibid., 23.
[14] Ibid., 251.
[15] Ibid., 19.
[16] "TouchOSC," Hexler, accessed April 6, 2017, https://hexler.net/software/touchosc.

instrument changes, as well as how the score uses graphical notation for the tablet part. The numbers on the lines indicate the number of fingers to be used on the panel.

Example 2.6. *Submergence*, mm. 20-21

The computer part contains three elements that act independently of each other. One of these is a fixed audio track, which is split into segments to allow flexibility in the pacing of the performer. The performer triggers each segment when progressing through the cues, sending the signal to a series of delays with very high feedback. The volume of the processed signal is kept at zero while the segment plays; at the end of the sound fragment, the volume of the delay line is ramped up as the fixed segment is simultaneously faded out. This allows the track to keep resonating if the clip ends before the performer has finished playing through the cue.

The patch also features a series of additive synthesis oscillator pairs. An automation algorithm gradually alters the frequency of these oscillators through random number generation that is then fed into several tables combining quadratic, absolute value, and fold-over functions to generate each value. The resulting number is scaled to assure that the difference in frequency between each pair of oscillators is always between 0.5 Hz and 4 Hz, since this is the amplitude range of the delta waves characteristic of deep sleep.[17] The use of additive synthesis helps create an audible representation of frequencies that are below the human audible range. Though the wave pairs evolve gradually through randomized automation, some parts of the piece call for the performer to use a Cartesian coordinate panel on the tablet to override the automation and control the frequencies by hand.

The third voice of the computer part is a sampler based on the ones used in *Somnolence* and *Dimming*. In the case of *Submergence*, the sample plays tuba sounds from a recording session with Seth Shafer, who also premiered the piece and provided insight during its composition. The sampler is treated in the same manner as the ones used for the previous pieces—i.e., by sorting the sounds based on their timbral quality and activating them in groups when desired, and then transposing them algorithmically through probability chains using the Wendy Carlos scales.

2.5 *Conceiving Realities*: Rapid-Eye Movement and Dreams

Conceiving Realities is the last piece of the *Replenishment* cycle. In addition to being my MA thesis piece, it is also the part of the cycle that symbolizes REM sleep, the stage for vivid dreams and faster brain activity. For these reasons, *Conceiving Realities* uses a more complex approach, resulting in a more substantial work and ending the set with a climax. The concept for this piece began with the simple intention of using a brainwave sensor to control the live processing of instruments. As I developed the intricacies of this concept, I began researching the use of brainwave data in music, which helped me find a starting point in the pre-compositional stage of the piece.

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[17] Ibid., 19.

While the use of computer music differentiates the previous sleep-inspired pieces from the sleeplessness-inspired *Lassitude*, the use of biofeedback and intermedia elements distinguishes *Conceiving Realities* from the rest of the sleep pieces. The interaction between various types of media creates a connection between the sight and sound, while the musical use of live data generated by the brain and heart of a performer on stage provides a sound layer resulting from the process of creation as experienced in real time.

Before presenting a more detailed description of the musical and aesthetic material in *Conceiving Realities* in the fourth chapter of this paper, I explain the research that informed the creation of the technical part that helped to achieve the intermedia goals for the piece.

Chapter 3

Preliminary Research in Electroencephalography

The desire to use brainwaves to control aspects of the music inspired the first ideas of *Conceiving Realities*, which would draw on the connection between the creation and perception of music on a physical level. The original idea involved performers using brainwave sensors; this eventually transformed into having one person affecting the music, leading to the incorporation of a visual artist. The concept then evolved into a fully integrated intermedia loop between sound, sight, and biofeedback.

3.1 Measuring Brainwave Activity for Creating Music

The idea of using brainwave information in music has been implemented by composers for over half a century now. Throughout this time, advancements in computer technology and neurological research have made this possibility much more attainable and affordable to composers and artists. Musical use of brainwave data has advanced from creating pure sonic representations of electric activity in the brain to building complex systems in which the computer interprets the data and uses it for composing intricate musical passages. Other systems allow interaction between the user and the computer, functioning as a kind of brain-controlled instrument. The present research consisted of studying the existing body of musical and scholarly work pertaining the use of brainwaves for making music, thus inspiring and informing the composition of *Conceiving Realities*.

I investigated different approaches, from those in historic works using brainwaves to more contemporary examples. It was useful to keep in mind the difference between mapping brainwave data to music synthesis systems, and using the data to alter an existing sound signal coming from an acoustic source. It was also important to consider the interaction between the natural sound and the electronics in the orchestration of the piece. The processing should create a sound layer that will complement the live ensemble, regardless of unpredictable changes in the patterns of brainwave activity of the artist.

3.2 Examples of Electroencephalography in Music

Electroencephalography (EEG) is the practice of measuring brainwave activity through electrodes attached to a subject's scalp, which measure the electrical signal coming from the brain.[18] Since the first experiments in observing human brainwave activity by researcher Hans Berger in 1924, many individuals have used this technique to create several types of Brain-Computer Interface (BCI) systems with applications in multiple fields, ranging from medicine to the arts.[19] Research in using brainwave signals in music for Brain-Computer Musical Interface (BCMI) systems is not as advanced as it is in other fields: for example, EEG is being implemented in the medical field to allow disabled patients to control mechanical devices.

Composers like Alvin Lucier and Richard Teitelbaum began composing musical works for EEG and other biofeedback systems in the mid-1960s.[20] Since then, composers have used various approaches to making music with EEG, from direct sonification of the brainwaves to interactive BCMI systems in which the user and computer react to one another.[21]

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[18] Thomas Hermann and Gerold Baier, "Sonification of the Human EEG," in *Sonic Interaction Design*, ed. Karmen Franinovic and Stefania Serafin (Cambridge, MA: The MIT Press, 2013), 285.
[19] Eduardo Reck Miranda and Andrew Brouse, "Interfacing the Brain Directly with Musical Systems: On Developing Systems for Making Music with Brain Signals," *Leonardo* 38, no. 4 (2005): 331.
[20] Ibid., 332.
[21] Joel Eaton and Eduardo Reck Miranda, "On Mapping EEG Information into Music," in *Guide to Brain-Computer Music Interfacing*, ed. Eduardo Reck Miranda and Julien Castet (London, UK: Springer, 2014), 227-228.

Until recently, the effectiveness and reliability of EEG technology for real-time musical systems had been in its initial stages of development.[22] One problem with decoding EEG data reliably is the noisiness and complexity of the electrical data. Using frequency analysis tools informed by the understanding of current neurological research and the increasing advancement of technology, researchers have been able to create more reliable tools for building more robust BCI systems.[23] Fabian Lotte has studied methods for the analysis of EEG data in determining a subject's current mental state by isolating frequency ranges and extracting salient features or specific channels from the data.[24] In the past twenty years, researchers in multiple fields of study have been able to use EEG technology to control computer cursors and even allowing individuals to move prosthetic limbs with their brains.[25] One recent research involved the use of EEG to dial a telephone with brain signals.[26] Such types of advancements in neuroscience and computer science can also be applied to complex musical systems.

More sophistication in the application of analysis and processing tools can lead to the creation of mutually responsive interactive systems in which both the computer and the human subject adapt to the behaviors and responses of each other.[27]

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[22] Ibid., 222.
[23] Fabien Lotte, "A Tutorial on EEG Signal-Processing Techniques for Mental-State Recognition in Brain-Computer Interfaces," in Guide to Brain-Computer Music Interfacing, ed. Eduardo Reck Miranda and Julien Castet (London, UK: Springer, 2014), 134.
[24] Ibid., 140.
[25] Miranda and Brouse, "Interfacing the Brain Directly with Musical Systems," 331.
[26] Mohammad-Mahdi Moazzami, "EEG Signal Processing in Brain-Computer Interface" (Master's thesis, Michigan State University, 2012).
[27] Eaton and Miranda, "On Mapping EEG Information into Music." 226.

Alvin Lucier first used electroencephalography in music by amplifying his alpha waves, attaching loudspeakers to percussion instruments that reacted to the pulse in his *piece Music for Solo Performer* (1965).[28] Shortly after the premier of Lucier's piece, Richard Teitelbaum was using the alpha waves of two performers to control synthesizer modules built by Robert Moog in his piece *In Tune* (1968), along with other types of biofeedback such as breath and heart beat sensors.[29] David Rosenboom's piece *On Being Invisible* (1976-77)[30] used EEG data mapped to parameters of voices captured on microphones while looking to create a sophisticated system that requires practice and understanding of the instrument by the person wearing the sensor.[31]In a more recent example, Eduardo Reck Miranda's piece *Activating Memory* (2014)[32] paired up a string quartet with a BCMI quartet wearing electrode caps that convert EEG data into musical scores for the string players in real time.[33] Another recent piece using EEG for musical purposes that combines EEG musification with an intermedia approach is Lisa Park's *Eunoia* (2013)[34]. She translated brainwave data into sound waves that vibrate five plates with water on top of speakers, creating ripples that visually represent the sound obtained by the EEG

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[28] Ibid., 233; Alvin Lucier, "Music for Solo Performer," *OHM+: The Early Gurus of Electronic Music*, track 18, (Long Island, NY: Ellipsis Arts, 2005), DVD; "Alvin Lucier – 'Music for Solo Performer' (1965)," YouTube video, 11:56, posted by "Carlos Conceição, November 27, 2010, http://youtu.be/bIPU2ynqy2Y.

[29] Richard Teitelbaum, "Improvisation, Computers and the Unconscious Mind," *Contemporary Music Review* 25, no. 5/6 (2007), 498-500.

[30] David Rosenboom, *Invisible Gold*, recorded at the Music Gallery in Toronto, February 12, 1977, Pogus POGUS 21022-2, 2000, compact disc; "On Being Invisible, Part I," YouTube video, 23:49, posted by "The Orchard Enterprises," September 24, 2014, http://youtu.be/JTTHbuTXvEw.

[31] Garrett Laroy Johnson, "Performing Embodiment. Negotiating the Body in the Electroencephalographic Music of David Rosenboom" (Master's thesis, Arizona State University, 2015), 84-87.

[32] "Activating Memory - Experiment," SoundCloud Excerpt, 7:16, from a performance at the Peninsula Arts Contemporary Music Festival, Plymouth, UK, on February 9, 2014, posted by "Eduardo R Miranda," February 9, 2014, http://soundcloud.com/ed_miranda/activating-memory.

[33] "Prof Eduardo Miranda," Plymouth University, accessed October 22, 2016, http://neuromusic.soc.plymouth.ac.uk.

[34] "Eunoia," Vimeo video, 2:08, excerpts from a live performance, posted by "Lisa Park," April 30, 2013, http://vimeo.com/65175792.

system.[35] Dan Wu and a team of researchers have created a system to generate music from the EEG data of sleeping minds. They created a system that maps brainwave data into MIDI[36] information, creating music in diatonic scales and conventional meters from the data previously obtained from a sleeping subject during a night of sleep.[37]

3.3 Categorizing Approaches to Brainwave Musical Creation

In their article "Interfacing the Brain Directly with Musical Systems: On Developing Systems for Making Music with Brain Signals," Eduardo Reck Miranda and Andrew Brouse list three types of musical systems using EEG regarding the interaction between the user and the computer. A system is *user-oriented* when the computer adapts to the EEG data of the user, giving musical meaning to the information obtained from the signal. In such a system, the subject wears a brainwave sensor and the computer creates the music based on its programmed responses to several types of data; thus, the computer adapts to the user. A system is *computer-oriented* when the subject intentionally focuses on obtaining a desired response from the computer program. In such a model, a user may try meditating or shift mental focus to perform the BCI instrument. *Mutually oriented systems* involve both the user and the computer reacting and adapting to each other in a mutually interactive system.[38]

Another way of categorizing EEG musical systems is by focusing on how the musical material is generated. Joel Eaton and Eduardo Reck Miranda describe this type of categorization

[35] "Eunoia," Lisa Park, accessed October 23, 2016, http://www.thelisapark.com/eunoia.
[36] Musical Instrument Digital Interface (MIDI) is a standard protocol that allows communication between digital instruments and computers.
[37] Dan Wu, Chaoyi Li, Yu Yin, Changzheng Zou, and Dezhong Yao, "Music Composition from the Brain Signal: Representing the Mental State by Music," *Computational Intelligence and Neuroscience* (2011): 2.
[38] Miranda and Brouse, "Interfacing the Brain Directly with Musical Systems: On Developing Systems for Making Music with Brain Signals," 334.

in the paper “On Mapping EEG Information into Music.” Looking at various EEG musical systems that have been used before, they sort various approaches to the treatment of the data into three categories: EEG sonification, EEG musification, and BCI control. *EEG sonification*, is a form of biofeedback whereby the brainwave signal is directly mapped into a form of sound. By sonifying the signal, the sound becomes an unaltered representation of the electrical data received by the sensor. *EEG musification* involves matching features of the EEG data into predetermined organized musical systems. Finally, *BCI control* involves creating systems in which the user can obtain direct control of the sonic result through the intentional focus of cognitive activity.[39]

Although much of the recent musical work and research of both authors focuses on expanding the possibilities for BCI control, they do not discard the validity of using other systems for creating music. The processes of sonification and musification may not offer direct control of the sound to the user, yet both approaches can still provide useful tools for music composition and performance. This is especially true of musification, where brainwave features can be used to control predetermined musical systems.[40] These two categories do not need to be mutually exclusive from BCI control; in fact, BCI control will likely require using one of the previous two methods to synthesize the musical material.

Lisa Park’s *Eunoia* combines BCI control and musification within a mutually oriented system. Park uses five speakers with flat dishes containing a small amount of water placed on top of the speakers that resonate with her brainwaves while creating visual patterns. The

[39] Eaton and Miranda, “On Mapping EEG Information into Music,” 227.
[40] Ibid., 228.

headset sends EEG information to the computer, which translates this data into sound based on the different frequencies of brain activity. This creates the music sent to the speakers which form ripples in the water that vibrate in patterns relative to the sound frequencies. To perform this piece, Park stands in the center of the circle of speakers wearing a wireless brainwave sensor while evoking different emotions.[41] The system uses musification to translate her mental state into sounds, while an aspect of control remains on her intention to focus on specific thoughts. The brainwaves are sorted into their respective frequency ranges, detecting those that are also responsible for attentive and meditative states.[42] This system allows the computer and the user to interact with each other as the performer must listen to the sonic result while affecting it.

While the idea of manipulating sound through intentional cognitive activity as a mental instrument that one learns how to play and control can be interesting, creating music from unconscious brain activity can provide a different yet equally useful artistic aesthetic. Much as indeterminate music relies on elements of chance as a conceptual framework, the free representation of direct unconscious cognition can be used as a driving factor of a piece.

Eaton and Miranda mention ways in which EEG musification has been useful for creating music, in spite of not quite being a form of BCI due to its lack of active control. Showing previous work of Miranda and other researchers, they describe useful ways for mapping brain activity from different regions of the brain to predetermined systems of pitch and rhythm. This can create interesting unconscious cognitive music from the brainwaves.[43] One study they

[41] "Eunoia," Lisa Park, accessed November 26, 2016, http://www.thelisapark.com/eunoia.
[42] Ibid.
[43] Eaton and Miranda, "On Mapping EEG Information into Music," 229-232.

mention is that of Dan Wu and a group of researchers who created a system to musicalize the EEG data of a sleeping subject.

In their study, Wu and his team captured the brainwave data of a 25-year-old subject sleeping with a 32-channel brain cap on multiple nights, using the data to musicalize the brain activity. The researchers then mapped features of the EEG data to musical material using knowledge from neurological research and conventional notions of musical relationships,[44] achieving this through various methods of analyzing data and assigning musical parameters accordingly. The stages of sleep represented musical segments for which the tonality, tonic and rhythmic quality remained constant. The level of arousal in brain activity determined aspects of the emotional expression of the music, such as the tempo and tonality of a musical segment.[45] The musical material was plotted into 4/4 bars, in which the EEG frequency fluctuations determined the placement of each chord and the melodic rhythm. The melody was based on the tonality established earlier for each segment, using chord tones at prominent moments, such as the beginning of bars.[46]

This approach presents a system where the data from the EEG is transcribed into specific musical ideas predetermined by the programmers. Therefore, this type of BCI falls into the category of EEG musicalization. As such, the computer adheres to specific rules on how to translate the signal into music using arbitrary-but-meaningful relationships corresponding to emotional expression. It is also a user-oriented system: the brainwave information did not need

[44] Wu, et al., "Music Composition from the Brain Signal," 2.
[45] Ibid., 2-3.
[46] Ibid., 4.

to be captured in real time, as the researchers used the subject's sleep data from a previous night.

The following figures illustrate how Wu and his team used brainwaves to write music. Figure 3.1 shows a sample of the EEG during rapid-eye movement (REM) sleep and slow-wave sleep (SWS). To show the musical systemization of the data, Figure 3.2 displays a pair of musical passages created by the system after analyzing the EEG information.

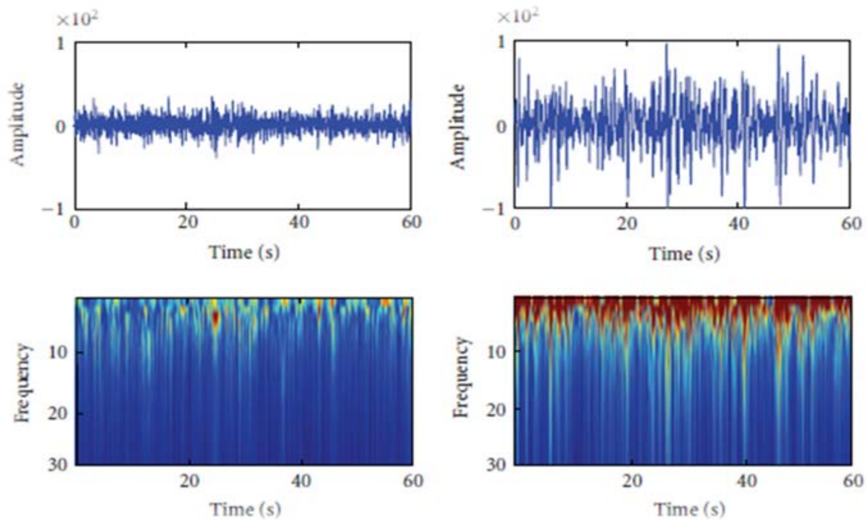

Figure 3.1. Brainwave activity of the sleeping subject, shown in amplitude and frequency over time during the stages of REM sleep (left) and SWS (right).

Figure 3.2. Samples of the music derived from REM sleep (a), and SWS (b).

3.4 Passive Brain-Computer Interface Systems for Creating Music

Laurent George and Anatole Lécuyer's paper "Passive Brain-Computer Interfaces" describes a type of Brain-Computer Interface (BCI) in which the users are not meant to focus on controlling the system with their brain activity. While their research applied to general uses of EEG not limited to music, this type of BCI can be very effective in the musical composition of pieces using EEG without conscious control.

In the introduction to the article, the authors define the difference between active and passive types of BCI systems. While an active BCI is centered on the user intentionally focusing cognitive activity to control the system, a passive BCI reacts to the EEG data without seeking active control from the user, who is then able to focus on a primary task.[47] The information provided by the EEG can then be used to add complementary interactions between the individual and the system.

The benefits of a passive BCI do not diminish the artistic potential of an active BCI, as the usefulness of each system depends on the purpose of a piece. For example, an active BCI may be much more effective for pieces that focus on meditation and introspection. Therefore, the decision to make a musical system passive or active depends on its purpose and context.

For *Conceiving Realities*, the passive approach was necessary for generating processing data from the unconscious brain activity of the artist, whose primary task is the painting, while also listening to the ensemble. The role of the EEG is to then monitor the artist listening, while providing the data to affect the overall sound.

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[47] Laurent George and Anatole Lécuyer, "Passive Brain-Computer Interfaces," in *Guide to Brain-Computer Music Interfacing*, ed. Eduardo Reck Miranda and Julien Castet (London, UK: Springer, 2014), 297.

3.5 Application of the Research in *Conceiving Realities*

In *Conceiving Realities*, the painter wears an EEG sensor while creating art in real time, with a chamber ensemble playing simultaneously. The sound of the ensemble is captured with microphones and sent to the computer interface. The brainwave data then affects parameters of the sound of the ensemble in real time through signal processing.

Listening to the ensemble can alter the artist's unconscious cognitive activity, therefore also influencing the same brain activity that keeps affecting the sound of the instruments. This creates a feedback system based on the interaction between the listening brain of the artist and the sound of the musicians, in which both sides alter and react to one another. This relationship adds an element of synergy between the musicians and the artist. The processing of the sound of the musicians will become dependent on the emotional response of the artist, which will be influenced by the same sound being altered by her mental state.

The interaction between musicians and artist also creates a connection between the two types of media, building a relationship between the senses of sight and sound. The live art piece should be abstract in nature and its aesthetic should be inspired by the artist's reaction to the music. With these guidelines, the artist creates the painting as the piece progresses in an improvisatory fashion. To further blur the sensual experience of the audience, the live art is captured by a camera and its video input is processed using data from the sound of the musicians and projected onto a screen. This furthers the connection between the sonic and aural elements of the piece.

This approach helped to connect the various elements of the piece, as the processing of the instruments (for example: delay parameters, such as the length between echoes and the overall density of the delay) was affected by the brainwaves of the artist; meanwhile, the music of the ensemble affected the way in which the audience perceived the art, by mapping the sound amplitude to parameters of the three videos (contrast, saturation). This creates a relationship between sight and sound, while maintaining the EEG sensor as an important but not central aspect to the piece. Instead, the focus of the piece is the interconnectivity between the senses, as the various media create an aural and visual experience for the audience.

Chapter 4

Writing the Intermedia Piece *Conceiving Realities*

In the spring of 2015, I enrolled in a course called Performing Electroacoustic Music, co-taught by Andrew May and Elizabeth McNutt. Its focus was the performance and composition of music with instruments and electronics. One of the first assignments for this class prompted the students to brainstorm and describe a fantasy scenario for an electroacoustic piece, regardless of current technological limitations. I imagined an ensemble of live performers using brainwave sensors to expand the capabilities of their instruments at will. While this would require multiple sensors for each musician, along with advanced BCMI technology to control these accurately, this idea became a starting point for the conceptualization of *Conceiving Realities*. The next step was to bring together the concept of the *Replenishment* cycle cohesively to a close in a piece that would feature this technology in an essential—yet not a leading—role.

4.1 Concept and Brainstorming

When I began thinking about the piece, I was considering two factors. One was the interest in using biofeedback in a supporting role by affecting live signals; the other was the conceptual development of a piece inspired by REM-sleep. Unlike the fantasy scenario where musicians control their effects at will, using a passive system better fits the narrative of the creative, dreaming mind, since unconscious brain activity would be controlling the sound.

This approach would also differ from the brainstorming exercise in that the piece would use only one sensor. Having sensors for all the musician could be costly, both financially and with regard to computing power. It would also complicate the logistics of the piece exponentially, with very little noticeable (if any) difference in the resulting sound. I wanted the person wearing the headset to be involved in another activity, thus reflecting the brain effort required of such an activity rather than seeking to control the sound.

I considered having a musical performer or a conductor wear the sensor, which could provide an activity to generate brainwaves involved in the performance; this idea was quickly invalidated by the desire to use intermedia for the REM-sleep piece. I wanted to write an immersive piece that would relate more to dreaming in order to differentiate the new work from the non-dream pieces in the cycle; however, I finally decided to collaborate with a visual artist who would wear the sensor while creating a live painting. This would build a relationship between sound and sight, mediated by the brain of the artist, and dictated by the creation of the artwork in response to the music. The result would be the addition of a sonic layer to the music that is being performed and heard by the artist while generating the data to process it. To generate EEG data, I used an I-CubeX system with EEG and EKG sensors, and a digitizer to send signals via Bluetooth to a computer. This wireless system allowed the painter freedom of movement and made the technical setup minimally noticeable in performance.

4.2 Instrumentation

There are a few factors that influenced the instrumentation for *Conceiving Realities*. One was the desire for consistency between the pieces: using instruments from the previous parts of the cycle would not only help retain cohesiveness, but it would also be practical for performing the complete cycle. Furthermore, having all the instruments perform on the last piece can also help in bringing the cycle to a satisfying close. Kirsten Broberg's *Resonant Strands* is a good example of this, which may have influenced my decision after having recently performed one of the bowed piano parts on this work. Finally, as a thesis project, writing for a larger ensemble would also provide more substance to the piece, along with the intermedia elements and the concept of dreaming as the primary theme of the cycle.

At the time of deciding upon the instrumentation, I had been performing with both the Balinese Gamelan and the Traditional Chinese Music ensembles at the University of North Texas. This experience inspired me to add a Chinese *pipa* to the piece and to write a section informed by interlocking-voice counterpoint often found in Balinese Gamelan. I also asked two friends and bandmates if they would be interested in adding processed vocals and analog electronics. All these additions would add personal value to the piece, while also incorporating some of my recent experiences in ethnomusicology.[48]

Some of the performers had worked with me in the previous pieces or other projects while others joined while I was writing *Conceiving Realities*. I sought to meet with those who had not worked with me before to discuss ideas and show them score fragments for feedback and suggestions; as well as to find out about their preferences and strengths. In some cases, as with the percussionist, the analog electronics performer, the singer, and the pipa player, I was able to hear them play and come up with a language that would communicate ideas effectively. This had also been the case with performers who collaborated with me in the preceding pieces of the set while writing those, which was useful in expediting the process for *Conceiving Realities*. Nonetheless, some performers were inevitably recruited during the final stages of composition. I had kept the musical language consistent with that of previous pieces, and made

[48] In addition to playing in the non-Western ensembles mentioned above, I also studied the work of my two bandmates' electronic noise duo Wormsign (among other groups) for an ethnography on Denton noise music.

any necessary adjustments after meeting with these newly-found performers. The premiere finally featured Michele Newman on flute, Alex Strader on clarinet, Seth Shafer on tuba, Sarah Jay on voice, West Fox on percussion, Yao Cui on pipa, Alex McKamie on viola (Kathleen Crabtree played viola on *Somnolence*), Kourtney Newton on cello, Trevor Mahaney on analog electronics, and myself on electric guitar. The live art was performed by Bailey Chapman.

Once this instrumentation was set, it was important to determine how the notation and structure of the piece would adapt to the diverse backgrounds of the various musicians involved. Knowing the performers that would be playing the piece was very useful for this purpose.

4.3 Notation

The scoring of *Conceiving Realities* began with the premise of balancing open, graphic notation with more traditional scoring when necessary. While this is mostly true of all the pieces in the cycle relating to a specific stage of sleep, the larger ensemble size and multiplicity of musical backgrounds of the performers demanded more careful planning than the previous pieces. This was especially true regarding the cueing of events and the timing of the few metered sections. I made sure to keep in mind the preferences and strengths of the musicians throughout the writing process.

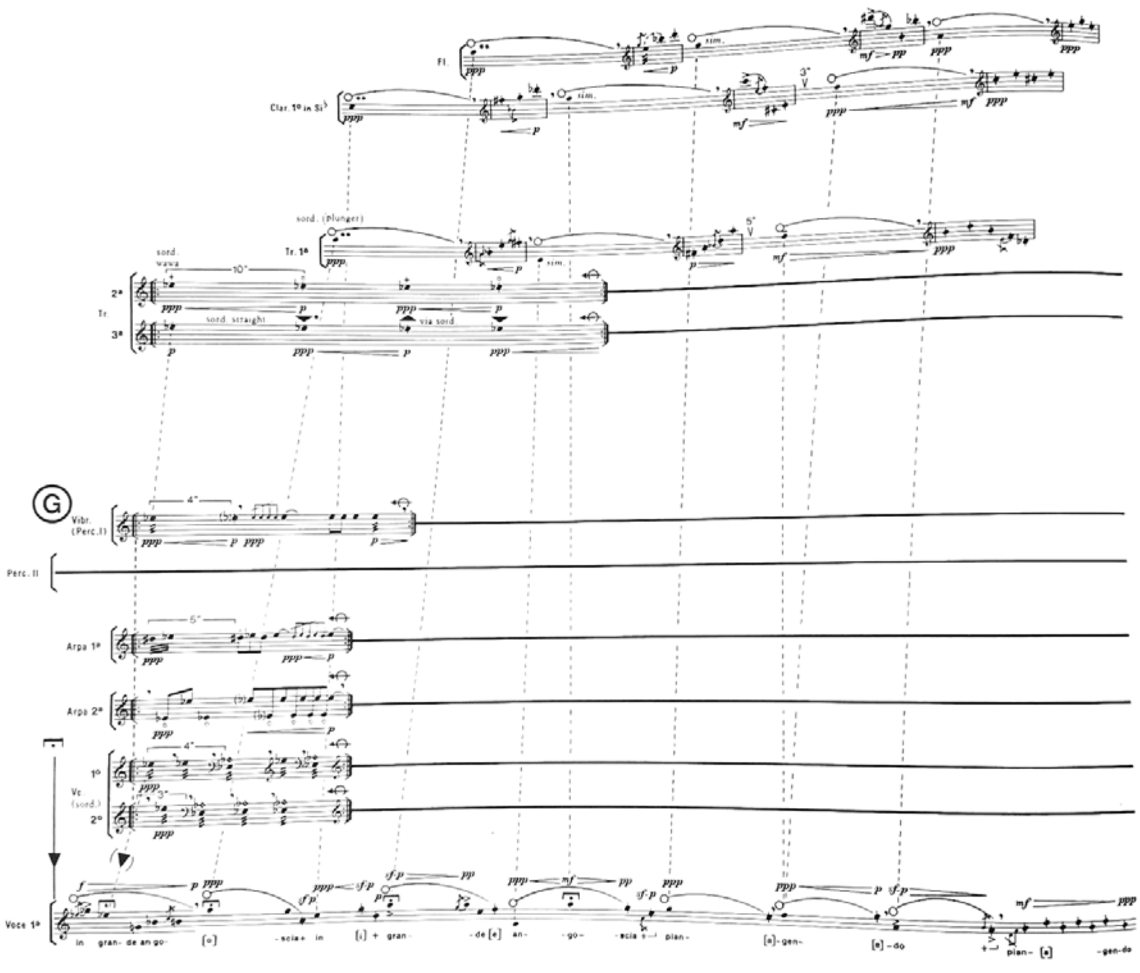
While many of the performers in the ensemble were informed by very traditional Western musical upbringings since childhood, this was not the case with every performer. Trevor Mahaney, the analog electronics performer, is fully self-taught and has never been required to read sheet music to develop his craft. Having had a non-traditional musical background myself, I used my experiences to write a score that could be followed by the performer without having had training in Western notation. I met with the analog electronics performer a few times while writing the part to plan some of the events in the piece and to determine the types of sounds that the graphic elements and verbal instructions required.

I also met with the pipa player Yao Cui during the writing process, who—despite fully understanding Western notation on her instrument—had been originally trained in the Chinese musical tradition, and had little experience with improvisation and graphical notation. We determined an effective way of communicating the musical results of graphics and improvisation instructions. I also learned more about traditional pipa notation of special techniques and timbral effects, which I included in the piece. As for the instrumentalists who had performed on the previous pieces, I maintained a similar musical and notational language to that used with the other works.

While these factors were useful for writing parts, the interaction of the parts and the transitions between events required more careful planning. On the macroscopic level, the piece was divided into events, shown explicitly through cue numbers. Each event may have a different form of measuring time, including traditional metered notation, approximate measurement in seconds, completely open time, or some combination of these. The traditionally metered sections emphasized the instruments played by musicians with the most traditional backgrounds, while the more open parts could have any combination of instruments. To score these free parts, it was important to think about the flow of time in a way that would feel comfortable and natural to the musicians.

One way of dealing with this issue was by using dashed lines in parts that employed successive responses between voices. The pacing of entrances was purposefully left open, allowing for a less strictly-timed progression of voices that would sound more ethereal and dreamlike. Looking at existing pieces that employ this method was useful in thinking about the voicing and orchestration of these cues; these works included Andrew May's *After Diebenkorn*[49] and Luciano Berio's *Laborintus II*.[50] The dashed lines in *Conceiving Realities* indicate progressions of voices and gestures: the timing of these actions is not meant as a precise indication of timing, but rather as a guide to the sequence of events. The following examples illustrate the ways of using dashed lines in these three pieces.

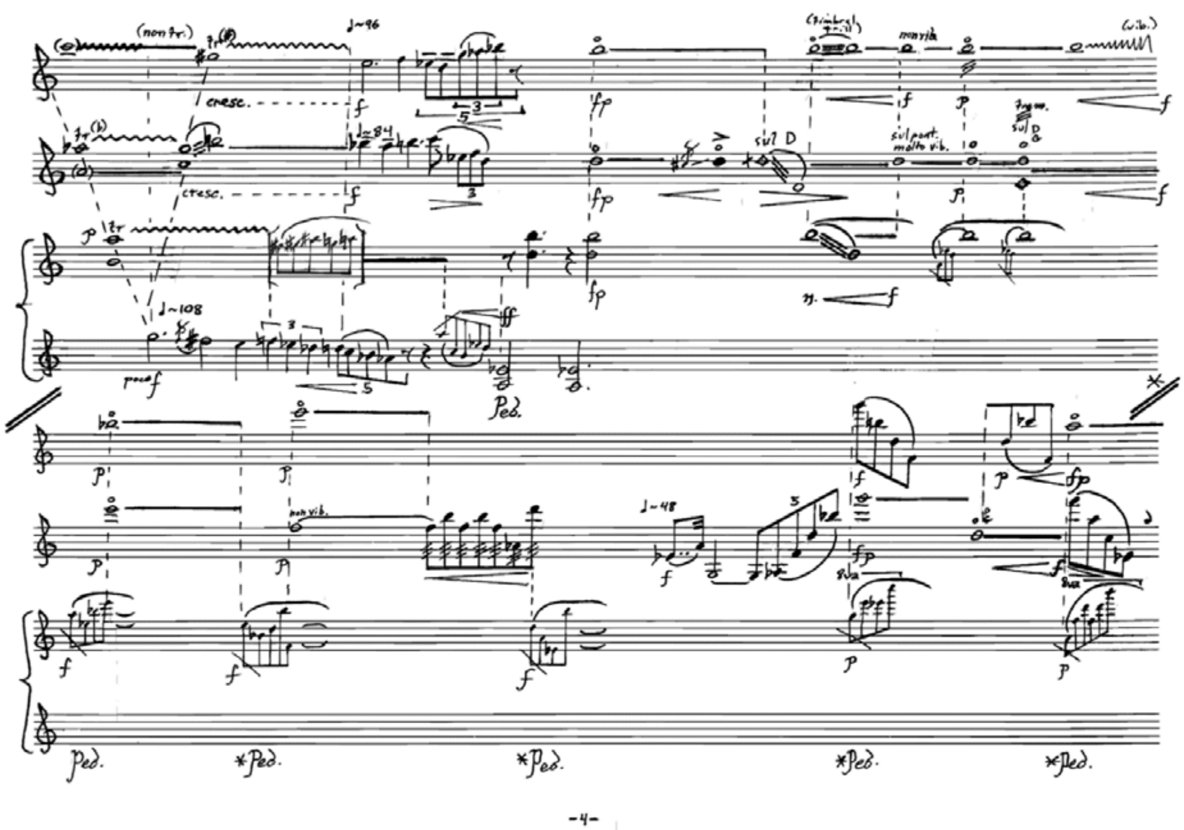
Example 4.1. *Laborintus II*, p. 12



[49] Andrew May, *After Diebenkorn: for flute, violin, and piano*, 2011.
[50] Luciano Berio, *Laborintus II: per voci, strumenti e registrazioni*, Milano: Universal Edition, 1965.

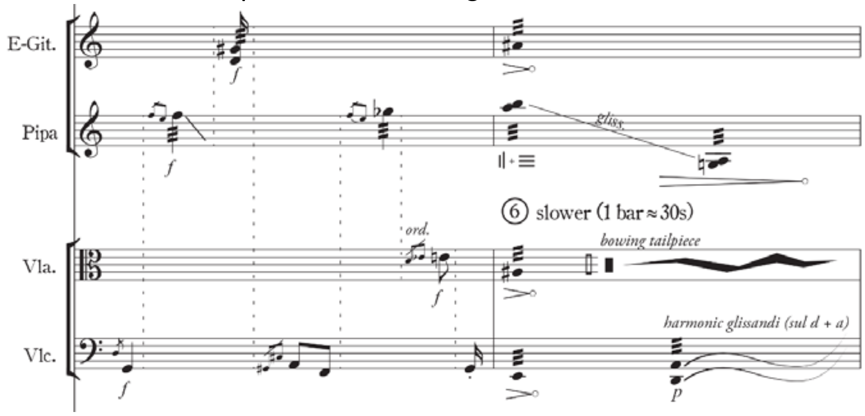
In contrast to this simpler approach, Berio's *Laborintus II* (example 4.1), uses dashed lines with multiple degrees of slant, connecting sequences of events across voices. This is meant to assist the conductor as well as the performers. On May's piece (example 4.2), slanted lines represent successive events and vertical lines simultaneous ones. The flow of time is proportional, though for the sake of clarity, traditionally notated segments use more space than the other events.

Example 4.2. *After Diebenkorn*, pg. 4



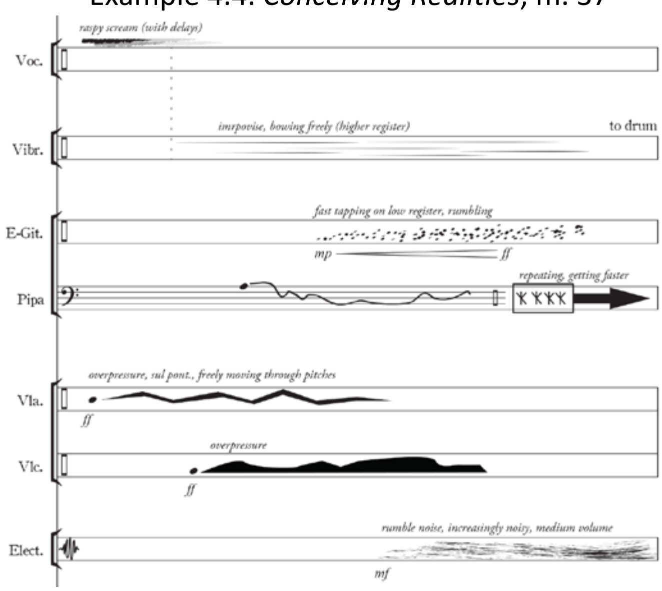
Conceiving Realities takes a simpler approach, using vertical dashed lines as indicators of cues between instruments during free time, non-proportional sections (shown in example 4.3).

Example 4.3. *Conceiving Realities*, mm. 7-8



The graphical notation in *Conceiving Realities* includes visual graphics in combination with verbal instructions, which effectively inspire improvisation by giving the performer an opportunity to interpret graphics freely while still having certain limitations establishing a palette of sonic features to use. The nature of the instructions can vary: some may call for specific techniques (e.g., *sul ponticello* harmonics, "growls," or percussive hits); others seek to invoke certain sonic features (e.g., "bird calls" or "scratching sounds"); still others can be ambiguous descriptions that are more open to interpretation (e.g., "pointillism"). Example 44 shows some of the uses of graphical notation in the piece.

Example 4.4. *Conceiving Realities*, m. 37



4.4 Computer Part

Conceiving Realities uses two computer patches created on the Max/MSP environment. One patch is dedicated to the audio processing while the other controls the video. These two patches were run on separate computers for two reasons: first off, the placement of the computers was important, since one of the computers would be on stage with the performers, while the other would be closer to the video camera; secondly, two computers were used to avoid overloading the processing capabilities of either computer.

The patch with the audio processing is the most complex; it contains a sampler instrument that includes all the samples from the other pieces in the cycle, in addition to sounds recorded on a zither that I built for an independent study with Jeff Morris in my undergraduate coursework at Texas A&M in 2011. The patch also uses delays, but this time there are a series of delay lines that have gradually changing delay times and amounts of feedback. Some of these delay lines use a pitch shifting module before feeding back the signal, causing each of the echoes to be transposed by an amount that is also gradually changing. Additionally, there are four independent pitch shifters that also change in their degree of transposition.

All these parameters (delay times, transposition amounts, and feedback amounts) depend on the data provided by the sensors. A series of *metro* objects reads the current position of the stream of EEG data at different time intervals to provide a number for the delay times and transposition amounts, scaled to be effective to their purpose. For the EKG sensor, the heartbeat rate of the artist determines the amount of feedback for the delays, adding more feedback when the heartbeat accelerates and decreasing the amount when it slows down.

4.4.1 Biofeedback

The sensor kit used for this piece was the I-CubeX Wi-microSystem by Infusion Systems. This consists of a wireless data digitizer with eight inputs for sensors. I used two sensors for *Conceiving Realities*: the I-CubeX BioWave for capturing EEG data and the I-CubeX BioBeat for the electrocardiogram. Although the system used was somewhat old, it happened to be ideal for this piece. Brainwave sensors have become more advanced at capturing different wavelengths, creating more necessity for robust filtering algorithms to sort out the data. Meanwhile, the I-CubeX BioWave's more rudimentary functionality is well suited for obtaining a constant stream of beta waves at the basic level.[51]

The I-CubeX BioBeat did present a small issue, which seem to have been resolved in newer versions of the hardware. As the sensor is attached to a belt that the user fastens around the wearer's torso, there can be some interference from movement and rubbing against clothing. This was resolved by using algorithms which compare the times between beats and filter out unwanted repetitions of peaks, thus allowing the system to only register attacks that were generated by actual heartbeats. Due to the limited amount of time for this somewhat ambitious project, the fine tuning of the electronics had to occur within the same time frame as rehearsals.

4.5 Trial, Error, Adjustments, Additions

During the early stage of testing the biofeedback system, the artist tried on the wearable sensors and we tested how they would interact with the signal processing by talking

[51] "BioWave User Guide," Infusion Systems, accessed June 12, 2017, https://infusionsystems.com/support/BioWave-guide-10.pdf

into a microphone. We also discussed the logistics of the painting, including how to keep paint off the theater, audience, equipment, and musicians; as well as where to place the painting area in relation to the audience and the ensemble. When told about the camera feed capturing the painting process, she proposed painting on a large piece of plexiglass, which would allow her to paint while facing the audience and camera, slowly covering the transparent surface with the paint. I quickly embraced this idea, celebrating the collaborative nature of this project.

The rehearsal process was a bit complicated, due to the difficulty of having all the performers at the same space and time—especially when most of the performers were also involved in the other pieces in the cycle, as these works also required rehearsal (perhaps even more than the more openly-structured *Conceiving Realities*). In preparation for the performance, we had to rehearse in smaller groups, while having individual meetings with some of the performers.

One of the main problems I noticed in these rehearsals concerned the transitions between cues. Initially, I would call out the cues for the sake of time, while considering other ways to let the performers know that one of the free-time events had ended. To assure that there would be no issues in the actual performance, and keeping in mind the limited amount of rehearsals, I decided to borrow a concept used in John Zorn's *Cobra*, and use cue cards. Due to the linear nature of *Conceiving Realities*—as opposed to the open-form nature of Zorn's work—these cues would be in sequential order and each cue would occur only once. This turned out to be an effective solution: since I was also playing guitar and monitoring the electronics, I could simply drop each cue card after each cue. This also gave performers time to prepare for the cue as I held up each card, and to clearly synchronize the starting point when I dropped the card.

This last-minute solution will be incorporated into future performances of the work.

4.6 Performance

The entire cycle was presented on April 28, 2017 in the Merrill Ellis Intermedia Theater at the University of North Texas, making use of the three-screen projection setup to display the three different versions of the video for *Conceiving Realities*. The positions for all the instruments were already set prior to the performance, so the performers for each ensemble could return to their original positions for the final piece.

4.6.1 Technical Issues

In order to have more successful performances of this piece, it is important to note the issues encountered during its planning, rehearsal, and execution. Despite the year-long research and preparation dedicated to the recital, I still encountered a handful of minor setbacks. Although these were not detrimental for a successful complete run-through of the performance, I have taken detailed notes of them and have come up with strategies to make the work much more robust for the future. These adjustments are centered on perfecting the timings of events in the cue lists, further calibrating the volume levels within the patches, minimizing the amount of actions and controls during the transitions between the pieces, and allowing for easier manual intervention of the overall levels of all the voices in a patch, in order to adjust to different spaces if necessary.

4.6.2 Effective Outcomes

A work of this scope and complexity benefits from multiple performances in different venues to fully test and debug its various outcomes. Considering the scope of this project, the premiere was satisfactory. The audience provided positive feedback and showed engagement in the performance, and the performers enjoyed taking part in the collaboration. The presence and acknowledgement of minor difficulties provided a valuable learning experience that will allow me to not only make the technical aspects of the work more robust.

Chapter 5

Conclusions

Replenishment is the most ambitious musical composition project I have undertaken, taking three years to complete, and consuming my energies outside of classes during my MA studies. Each of the pieces presented excellent opportunities for collaboration, allowing me to work directly with dedicated performers and write the music with their personal strengths and preferences in mind. The planning of *Conceiving Realities* was by far the most challenging and rewarding of the set, as it allowed me to compose, rehearse, and perform a piece for a large ensemble, with multiple computer parts, video elements, and intermedia. Coordinating with the performers and their differing backgrounds provided a challenging scenario for the notation, logistics, and performance of the piece. Finding solutions to these challenges has strengthened my craft and technical ability tremendously. *Conceiving Realities* provided me with opportunities to use elements of a fantasy scenario in a work that was more feasible but also more interesting than my original idea.

With all these factors in mind, the next step for this work will be to fine tune some of the problematic elements, note any necessary adjustments, and begin planning a new performance of the work. Since the score is now complete and the computer parts will have been optimized, it will be possible to schedule ample rehearsal time with the ensemble and technical staff.

The experiences obtained in the last three years of composing all of the parts of *Replenishment* will permanently affect my capabilities as a composer. I have gained invaluable practice in researching and employing unfamiliar technologies, while still maintaining the aesthetic goals at the work in the forefront of the process.

The intermedia aspects of *Conceiving Realities* allow for an immersive work in which all the components interact and become equally important agents in the piece. By creating links between the instruments and the brain and heart activity of the artist, the perception of the sound becomes an active determinant in the overall sound. Not only does the sound affect the painting through the perception of the artist, but the activity of painting while listening affects the sound as well.

The video elements create another connection between media, as the processing of the video becomes entirely dependent on the sound of the ensemble. This provides an opportunity for the sound to affect the perception of the art in addition to inspiring the artist while making the painting.

Conceptually, this ties in to the idea of REM sleep and dreaming by emphasizing the idea of creation in real time. The musicians become creators as they have opportunities to improvise throughout the piece; while the artist's painting is completely created in real time in reaction to the music. Dreams are also vivid experiences of perceived realities that are created by the brain in real time; together with visuals and sounds that incite brain activity resembling wakefulness. The connectivity between the senses, in combination with this idea of spontaneous creation makes *Conceiving Realities* an ideal closing piece to the cycle.

Musically and aesthetically, the pieces increase in complexity throughout the set until the final piece, which adds many new elements while retaining aspects of the last pieces. This completes the metaphor of the stages in the sleep cycle, manifesting the power of REM sleep to provide a new set of experiences within the process of sleep.

The combination of cultural spaces in the instrumentation is not for the mere sake of fusing styles, but has a rather specific, twofold purpose. Firstly, it alludes to dreaming in the way that unrelated events are often juxtaposed despite their possible lack of continuity or relevance to each other; and secondly, it created an opportunity to draw inspiration from my experiences with these specific musical traditions. In hindsight, working together with individuals from these varying traditions and finding common ground to communicate musical and aesthetic ideas was somewhat challenging but extremely rewarding. This is not only true in the musical domain, but also in the way that the musicians and the artist affect each other in aspects such as their gestural and performative expressions.

References

Berio, Luciano. *Laborintus II: per voci, strumenti e registrazioni*. Milano: Universal Edition, 1965.

Eaton, Joel and Eduardo Reck Miranda. “On Mapping EEG Information into Music.” In *Guide to Brain-Computer Music Interfacing*, edited by Eduardo Reck Miranda and Julien Castet, 221-254. London, UK: Springer, 2014.

George, Laurent and Anatole Lécuyer. “Passive Brain-Computer Interfaces.” In *Guide to Brain-Computer Music Interfacing*, edited by Eduardo Reck Miranda and Julien Castet, 297-308. London, UK: Springer, 2014.

Hermann, Thomas and Gerold Baier. “Sonification of the Human EEG.” In *Sonic Interaction Design*, edited by Karmen Franinovic and Stefania Serafin, 285-297. Cambridge, MA: The MIT Press. 2013.

Johnson, Garrett Laroy. “Performing Embodiment. Negotiating the Body in the Electroencephalographic Music of David Rosenboom.” Master's thesis, Arizona State University, 2015.

Lotte. Fabien. “A Tutorial on EEG Signal-Processing Techniques for Mental-State Recognition in Brain-Computer Interfaces.” In *Guide to Brain-Computer Music Interfacing*, edited by Eduardo Reck Miranda and Julien Castet, 133-161. London, UK: Springer, 2014.

May, Andrew. *After Diebenkorn: for flute, violin, and piano*. 2011.

Miranda, Eduardo Reck and Andrew Brouse. “Interfacing the Brain Directly with Musical Systems: On Developing Systems for Making Music with Brain Signals.” *Leonardo* 38, no. 4 (2005): 331-336.

Moazzami, Mohammad-Mahdi. "EEG Signal Processing in Brain-Computer Interface." Master’s thesis. Michigan State University, 2012.

Park, Lisa. “Eunoia.” Accessed November 26, 2016. http://www.thelisapark.com/eunoia.

Plymouth University. “Prof. Eduardo Miranda.” Accessed October 22, 2016. http://neuromusic.soc.plymouth.ac.uk.

Teitelbaum, Richard. “Improvisation, Computers and the Unconscious Mind.” *Contemporary Music Review* 25, no. 5/6 (2007). 498-500.

Wu, Dan, Chaoyi Li, Yu Yin, Changzheng Zhou, and Dezhong Yao. "Music Composition from the Brain Signal: Representing the Mental State by Music." *Computational Intelligence and Neuroscience* 2010 (2010).

Musical Examples

Lucier, Alvin. *Music for Solo Performer*. Track 18. *OHM+: The Early Gurus of Electronic Music*, DVD. Long Island, NY: Ellipsis Arts, 2005. "Alvin Lucier – 'Music for Solo Performer' (1965)." YouTube video, 11:56, posted by "Carlos Conceição," November 27, 2010, http://youtu.be/bIPU2ynqy2Y.

Miranda, Eduardo Reck. "*Activating Memory* – Experiment." SoundCloud Excerpt, 7:16. Peninsula Arts Contemporary Music Festival, Plymouth, UK. Filmed February 9, 2014. Posted February 9, 2014. http://soundcloud.com/ed_miranda/activating-memory.

Park, Lisa. "*Eunoia*," Vimeo video, 2:08. April 30, 2013. http://vimeo.com/65175792.

Rosenboom, David. *Invisible Gold*. Music Gallery in Toronto. Recorded February 12, 1977. Pogus POGUS 21022-2, 2000, compact disc. "On Being Invisible, Part I," YouTube video, 23:49, posted by "The Orchard Enterprises," September 24, 2014, http://youtu.be/JTTHbuTXvEw.

PART II

REPLENISHMENT

Miguel Espinel

Lassitude

for flute, clarinet and percussion

2014

Miguel Espinel

Lassitude

Instrumentation:

Flute

Clarinet in B♭

Percussion

Prepared kick drum
Vibraphone

Duration: ca. 6 minutes

November 2014

Denton, TX

Performance Guidelines: Special Notations

Flute

Air tones: produce an airy sound keeping the notes lightly audible (air amount at player's discretion).

Tongue rams: Percussive tongue attack.

Tongue pizzicato: Short tongue attack.

Key hits: finger the note and attack with the G key.

Clarinet:

Hum while playing: Play the top notes while humming the diamond notes. (Humming notes are suggested and used for timbral effect, note accuracy and maintaining the drone is not essential)

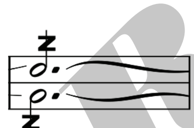
Kick drum:

Clef: Horizontal line in the middle represents the bridge. Staff lines indicate whether to play on one side of the bridge or the other. Indications for *sul pont*. apply to the string while indications to play *on bridge* apply to the bridge itself.

Col legno battuto: play with wooden side of the bow, bridge hits may be replaced.

Sustain: bow note and hold for the length of a stroke at player's discretion.

Membrane pitch bend: push down on membrane while playing note.



Finger buzz roll: buzz roll with fingers, curved lines indicate movement around the membrane of the drum.

Overpressure: play string with bow applying pressure downward towards the membrane, producing a continuous scratchy sound.

Vibraphone:

Pitch bend: hit key and slide mallet on key to produce a glissando effect.

Performance Guidelines: Preparing the Kick Drum

Secure a guitar string across the face of the kick drum, placing a bridge near the middle of the membrane so that it may produce a pitch when plucked, struck or bowed.

Original method of preparation:

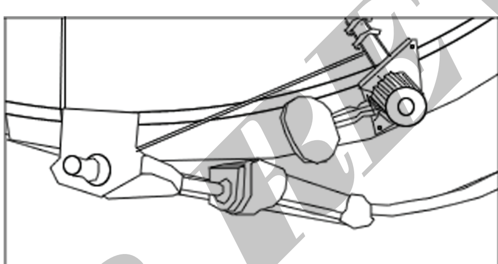
The materials and method used may be modified as necessary. Original method requires attaching a guitar tuning peg to the kick drum by making a small hole. Alternative methods may include using connecting devices or knots on the string.

Draw string under one of the claw hooks across to a hook on the opposite side.

Attach tuning peg to the wooden hoop of the kick drum so that the string can be tightened.

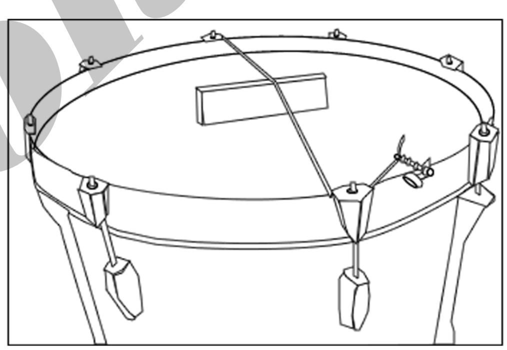
Place a thin wooden bridge near the middle of the drum head
Original preparation uses a wood board 1/4" thick and 4" wide from the membrane.
Perpendicular length from string should be long enough to hold the bridge in place.

Examples and notes on original preparation:



Ex #1: string and peg attachment

Original materials used:
String: 0.046" nickel wound guitar string
Peg: taken from Ibanez RX-20 guitar
(no need to use these specific materials)



Ex #2: completed prepared drum

String should have playable tension.
Original preparation intended for tuning string to G2 on one side and G#2 on the other.
The tuning peg and the bridge can be adjusted accordingly; however, other tuning combinations at performer's discretion are not discouraged.

Lassitude

(Transposing Score)

Miguel Espinel


23
Fl.
Cl.
K.D.
mp
col legno battuto
f
26
To Vib.
Vibraphone
31
n
pp
32
key attacks
toungue pizz
ppp
mf
Vib.
35
mp

37
40
Fl.
Cl.
Vib.
mp
mf
f
mp 3
44
p
bowed
mp
51
53
n
pp
ppp
To K.D.
Kick Drum
overpressure
col legno battuto
56
K.D.


59
61
Fl.
Cl.
K.D.
mf
f
mf
3
mp
bow bridge
col legno battuto
bridge
To Vib.
63
65
lip gliss
ppp
p
3
Vibraphone
To K.D.
Kick Drum
with fingers
To Vib.
Vib.
mp
ppp
71
79
Vibraphone
mp
p
81
3
bowed
mf
f

Miguel Espinel

Somnolence

for viola, violoncello, prepared kick drum and computer

2015

Miguel Espinel

Somnolence

INSTRUMENTATION:

VIOLA

VIOLONCELLO

PREPARED KICK DRUM

COMPUTER

Duration: ca. 11 minutes

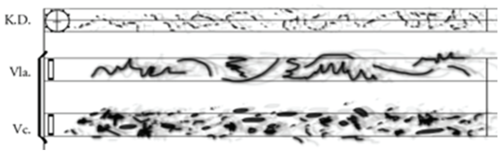
May 2015

Denton, TX

Performance Guidelines: Special Notations

General:

Delays on: Shadows on the music indicate that the sound of the instrument (or samples) will be processed through delays on the computer.

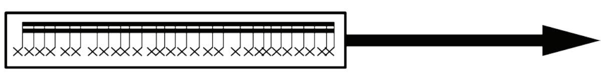


Improvise: Improvise interpreting the verbal indications given. The graphics serve as a visual guideline representing each of the verbal elements (open to interpretation).

Sustain: bow note and hold for the length of the line (at player's discretion).

overpressure ---------| **Overpressure:** bow note with extra pressure (at player's discretion).

Viola:



Tap rumble: Hammer on the strings quickly, creating a rumbling sound. Extend for the duration of the measure, may slow down over time.

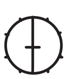
Viola and Violoncello:

Unpitched bowing: Bowing as indicated (bridge, tailpiece, etc.), alternating freely.

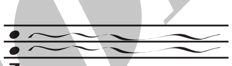
Harmonic glissando: glissandi touching the string with the left fingers at the position of the non-harmonic notes, but without pressing on the fingerboard.

Micotonal notation: 1/4 flat: 1/4 sharp: 3/4 sharp:

Kick drum:



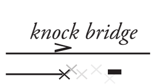
Clef: Horizontal line in the middle represents the bridge. Staff lines indicate whether to play on one side of the bridge or the other. Indications to play *on bridge* apply to the bridge itself. This may be played diagonally where the string meets the bridge.



Rumble: Constant roll, curved lines represent movement around the drum. Direction of movement left at discretion of the performer.

bow
stick
palm

Instrument change: Perform the notes using the indicated instrument. Playing technique may be indicated in plain unboxed text.



Knock bridge on drum: Knock the bridge on the drum producing a loud thump.

Performance Guidelines: Preparing the Kick Drum

Secure a guitar string across the face of the kick drum, placing a bridge near the middle of the membrane so that it may produce a pitch when plucked, struck or bowed.

Original method of preparation:

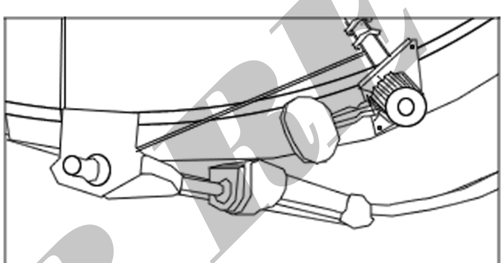
The materials and method used may be modified as necessary. Original method requires attaching a guitar tuning peg to the kick drum by making a small hole. However, the string can be tightened with the tension of the claw hooks alone.

Draw string under one of the claw hooks and pass the tip of the string through the loop at the end of the string to secure it. Pull on the string to tighten the resulting loop.

Draw the string under the claw hook at the other end and tighten until the string is slightly loose, but parallel to the membrane at the height of the rim. Tighten hooks.

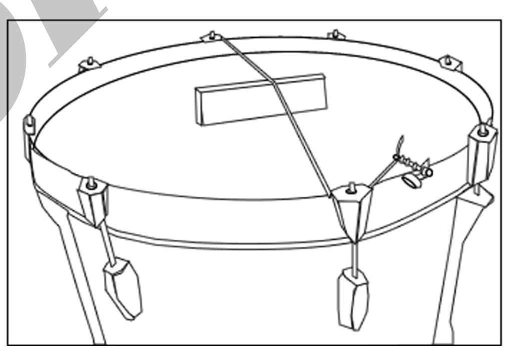
Place a thin wooden bridge near the middle of the drum head.
Original preparation uses a wood board 1/4" thick and 4" wide from the membrane.

Examples and notes on original preparation:



Ex #1: string and peg attachment

Original materials used:
String: 0.046" nickel wound guitar string.
Peg (optional): taken from electric guitar.
(no need to use these specific materials)



Ex #2: completed prepared drum

String should have playable tension.
The string can be easily set slightly loose but straight over the rim, placing the bridge from below to create this tension.

Performance Guidelines: Technical Details

Setting up the electronics:

This piece requires a computer with the Max MSP environment (a free runtime version to run existing patches can be downloaded from www.cycling74.com), a sound interface for input and three microphones to capture all the instruments. Performers and engineers may decide to use the microphones of their choice.

To set up the patch, extract the file "somnolence.zip" to a directory in the computer. Open the file "somnolence.maxpat" and check the audio settings to make sure that they match those of the interface. Set inputs 1-3 to correspond to each instrument.

To set up the sampler, drop the folder called "samples" from the directory (extracted from the zip file) into the folder-drop box inside the patch. Alternatively, it is possible to browse for the folder or write the folder's path directly into the folder path box. Click the "sample list" button in the patch to make sure the samples have loaded correctly (there should be a list showing all of the 171 samples). This list may not be visible in fullscreen mode.

This piece uses a list of cues to progress through the sections numbered on the score. The interface can be used to navigate through cues. Enabling spacebar control allows the spacebar to lead to the following cue at a given time. MIDI cueing can also be activated on the interface. To use MIDI or a pedal to control the cues, select the MIDI device from the drop-down menu.

Now the patch and levels can be tested to perform the piece. Watch the "CURENT STATUS" window to monitor the progress of the piece.

Somnolence

Miguel Espinel

* Time stamps are approximate and do not need to be exact. Performers are encouraged to just follow each other and the computer

** Autoharp Sampler notes and durations are shown as a visual guideline only, note graphics do not account to the actual notes chosen by the patch..


2 drowsier (1 bar ≈ 30")
13
hard mallets
improvise: rumble (rolling mallets around drum membrane, using string for accentuation as desired, whether plucking or striking)
K.D.
improvise: whisper / air (muted strings, light bowing)
improvise: "pointillism"
Vla.
improvise: "pointillism"
Vc.
autoharp plucking + chords
PC
3 faded
4 pacing ♩ ≈ 60
15
a drumstick
string (stick)
mp
membrane (fingertips)
tapping fingers on strings over fingerboard rapidly
mp
cantabile, pretty
ff
autoharp bowing
autoharp bowing + delay
17
palm
bow
overpressure
on bridge
p
fff
mp
harmonic gliss
gliss.
f
ff
overpressure
ff
f
5 blurring
palm
on membrane
20
(1 bar ≈ 20")
mp
pp
harmonic gliss
tr
overpressure
f
pp
mp
mf
dissipating
overpressure
f
p
mf
+ delays on all


6 clumsy ♩≈ 72
24
bow
on bridge
col legno batutto,
on string
palm
on membrane
stick
on string
K.D.
Vla.
Vc.
PC
pizz
arco
ord.
samples off + all dry
28
palm
on membrane
sul ponticello
gliss.
bow
on bridge (alternate as needed)
freely
7 falling
knock bridge
on string threads (bow freely)
+ instrument delays
8 sluggish (1 bar ≈ 30")
33
soft mallets
roll around the drum head, keep loose bridge on membrane
improvise: pointillism, glissandi, air sounds
autoharp chords + all delays
9 lethargic (1 bar ≈ 20")
(1 bar ≈ 30")
35
reposition bridge
hard mallets
improvise: rumble + expressive gestures (mallet rolls, string plucks, string strikes)
improvise: tremolo bowing, glissandi, harmonics
improvise: alternate between bowing sul pont. and on bridge
autoharp ambience + all delays


37
(1 bar ≈ 10-15")
10 pacing, muddled
K.D.
Vla.
Vc.
PC
all samples + all delays
40
(1 bar ≈ 30-40")
11 (1 bar ≈ 10")
hard mallets
improvise: roll mallets with medium pressure around membrane
let sound fade
improvise: tremolo bowing, glissandi, harmonics
let sound fade
improvise: alternate between bowing sul pont. and on bridge
12 pacing ♩ ≈ 60
43
fingertips
roll around membrane
mp
tapping fingers on strings over fingerboard rapidly
mp
expressive
f
cantabile, prettier
ff
bowed autoharp + all delays
45
palm
membrane
mp
bow
string overpressure
f
on bridge
mf
knock bridge
fff
harmonic gliss
gliss.
ff
pizz
mf
f
f

Miguel Espinel

Dimming

for electric guitar and computer

2015

Miguel Espinel

Dimming

Instrumentation:

Electric Guitar

Computer

Duration: ca. 6 minutes

October 2015

Denton, TX

Performance Guidelines and Technical Details

Setting up the electronics:

This piece requires a computer with the Max MSP environment (a free runtime version to run existing patches can be downloaded from www.cycling74.com), and a sound interface for input. The guitar may be plugged directly into the interface.

To set up the patch, extract the file "dimming.zip" to a directory in the computer. Open the file "dimming.maxpat" and check the audio settings to make sure that they match those of the interface. Set input for the instrument.

To set up the sampler, drop the folder called "samples" from the directory (extracted from the zip file) into the folder-drop box inside the patch. Alternatively, it is possible to browse for the folder or write the folder's path directly into the folder path box. Click the "sample list" button in the patch to make sure the samples have loaded correctly (there should be a list showing all of the samples). This list may not be visible in fullscreen mode.

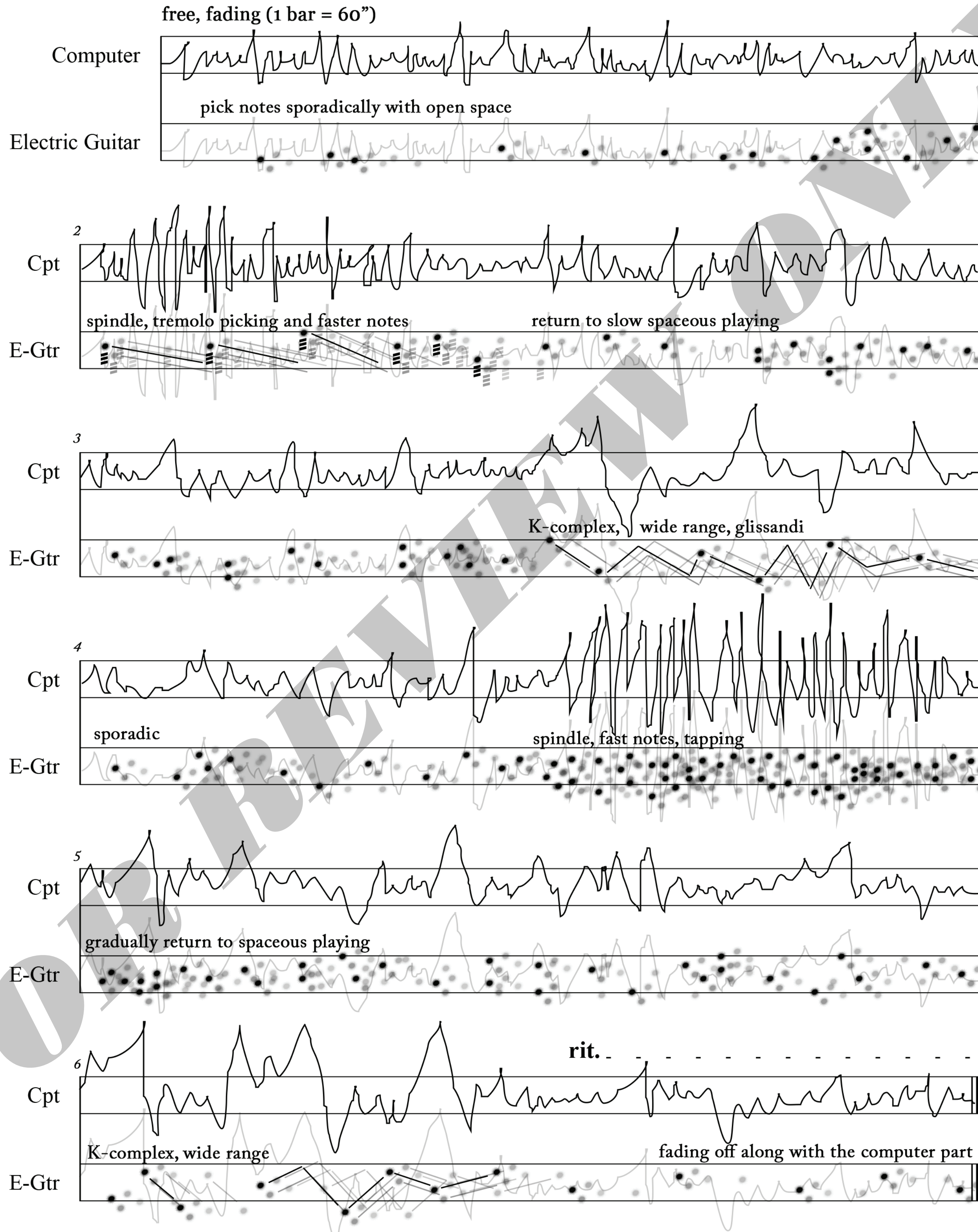
Performing the piece:

Begin the piece by activating either the spacebar or MIDI control. Once the piece begins, the computer part will play continuously until the end. The guitarist follows the computer part in improvisation. The amount of activity is represented graphically in the score. The computer and guitar part follow a freely-artistic representation of multiple graphs of EEG data of brainwave activity of humans during the second stage of non-REM sleep. The guitar part shows general notated contours, techniques and written instructions; the performer should use these only as guides and improvise following the lead of the computer. Scordatura (low to high): C2, G2, D3, G3, C4, F4.

Watch the "CURENT STATUS" window to monitor the progress of the piece.

Dimming

Miguel Espinel



Miguel Espinel

Submergence

for tuba and computer

2017

Miguel Espinel

Submergence

INSTRUMENTATION:

TUBA

COMPUTER

Duration: ca. 18 minutes

April 2017

Denton, TX

Performance Guidelines: Technical Details

Setting up the electronics:

This piece requires a computer with Max/MSP (www.cycling74.com/products/max), a tablet or mobile device with TouchOSC (www.hexler.net/software/touchosc), a sound interface for input, and a microphone to capture the tuba sound. Performers and engineers may decide to use the microphones of their choice.

To set up the patch, extract the file "submergence.zip" to a directory in the computer. Open the file "submergence.maxpat" and check the audio settings to make sure that the audio interface is selected. Set input 1 for the microphone if necessary.

To set up the sampler, drop the folder called "samples" from the directory (extracted from the zip file) into the folder-drop box inside the patch. Alternatively, it is possible to browse for the folder or write the folder's path directly into the folder path box. Click the "sample list" button in the patch to make sure the samples have loaded correctly (there should be a list showing all of the 214 samples). This list may not be visible in fullscreen mode.

For communication between the computer and the tablet, a wireless connection is required. This may be done through a router or through a network created on the computer directly (more reliable). The "Information, READ FIRST" button on the patch details information on how to create an ad-hoc network on Windows 8 (used originally when writing the piece). However, this is usually simpler on other operating systems. You may need to find out how to create an ad-hoc network on your specific operating system; or connect both computer and tablet to the same wireless internet connection (not recommended).

Performance Guidelines: Technical Details

Network settings:

Once the computer and tablet are on the same network they must be able to send messages to each other. The "Find IP address" button on the top right of the patch shows the computer's local IP, which must match the first field on the TouchOSC setings window. The communication ports on the device should be 8000 to send messages to the computerand 9000 to receive messages (these are the default port settings for TouchOSC and the patch is set to match them). If they do not match, they can be set on the TouchOSC settings window as well.

The patch for *Submergence* uses a custom TouchOSC layout, which may be added to your device by copying or downloading the "submersionosc.touchosc" file to your tablet or mobile device. The layout can then be imported to TouchOSC via "Settings>Layout>Add from file." Another way to import the layout is through the "sync" feature on the TouchOSC Layout Editor (also available free on the website).

The custom layout features a power switch to enable and disable the audio for Max; an input volume fader that controls the amount of signal from the tuba microphone that is sent to the patch, along with a peak indicator with six lights (three green, one yellow, one orange, and one red) which indicates the current strength of the signal; a touch-sensitive cartesian plot that alters the frequencies of the additive synthesis wave pairs (labeled Wave Pair Shifting); a six faders that alter the volumes of certain wave pairs (labeled Wave Pair Balance); a cue navigation panel that allows selecting individual cues and monitors the current position within the piece through a green light on top of each cue number; a mixer that allows the user to control the volumes of all the dry tracks, delay tracks, and master volume.

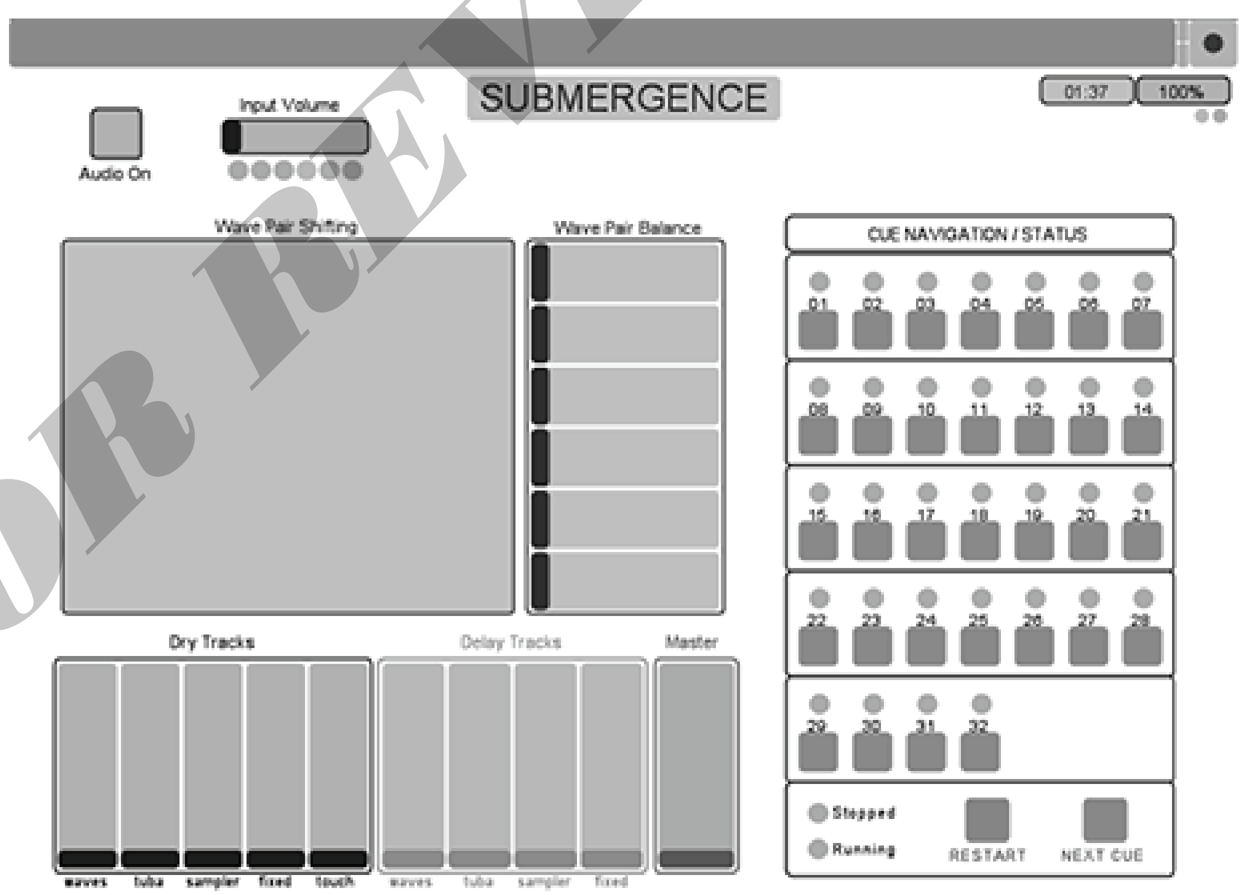
Performance Guidelines: Technical Details

TouchOSC layout description:

The Wave Pair Shifting panel is affected by the amount of fingers touching it at any given moment. The presence of one finger alters the frequencies of the wave pairs in a non-linear fashion, as the coordinates go through several functions to determine the final frequency. A second finger alters the frequency distance between the pairs in the same non-linear fashion. A third and fourth finger add sample sounds from the tuba that change in pitch according to their coordinates.

The Wave Pair Balance influence the volumes of different wave pairs in a similarly non-linear manner.

***Submergence* TouchOSC custom layout:**



Performance Guidelines: Special Notations

Tuba:

 **Sustain:** playing note and holding for the length of the line (at player's discretion).

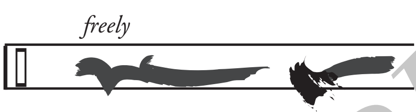
 **Breath:** breathing through instrument to produce a wind sound (pitchless).

 **Tongue pops:** percussive sound created by producing a thud with the tongue while blowing a burst of air through the mouthpiece of the instrument.

▽ **Low pedal tone:** a triangular notehead indicates to play the lowest pedal tone the performer feels comfortable with. Specific pitch not important.

 **Flutter tongue (fz):** tremolo lines indicate flutter tongue.

 **Sing higher note:** play while singing. The higher/smaller notehead indicates singing, while the starting pitch does not need to be exact. the line provides a general contour for pitch variation (glissandi).

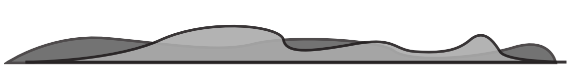


Improvisation: Improvising interpreting the verbal instructions given. The graphics serve as a visual guideline representing each of the verbal elements (open to interpretation).

 **Strike instrument:** hitting the body of the instrument percussively.

Tablet:

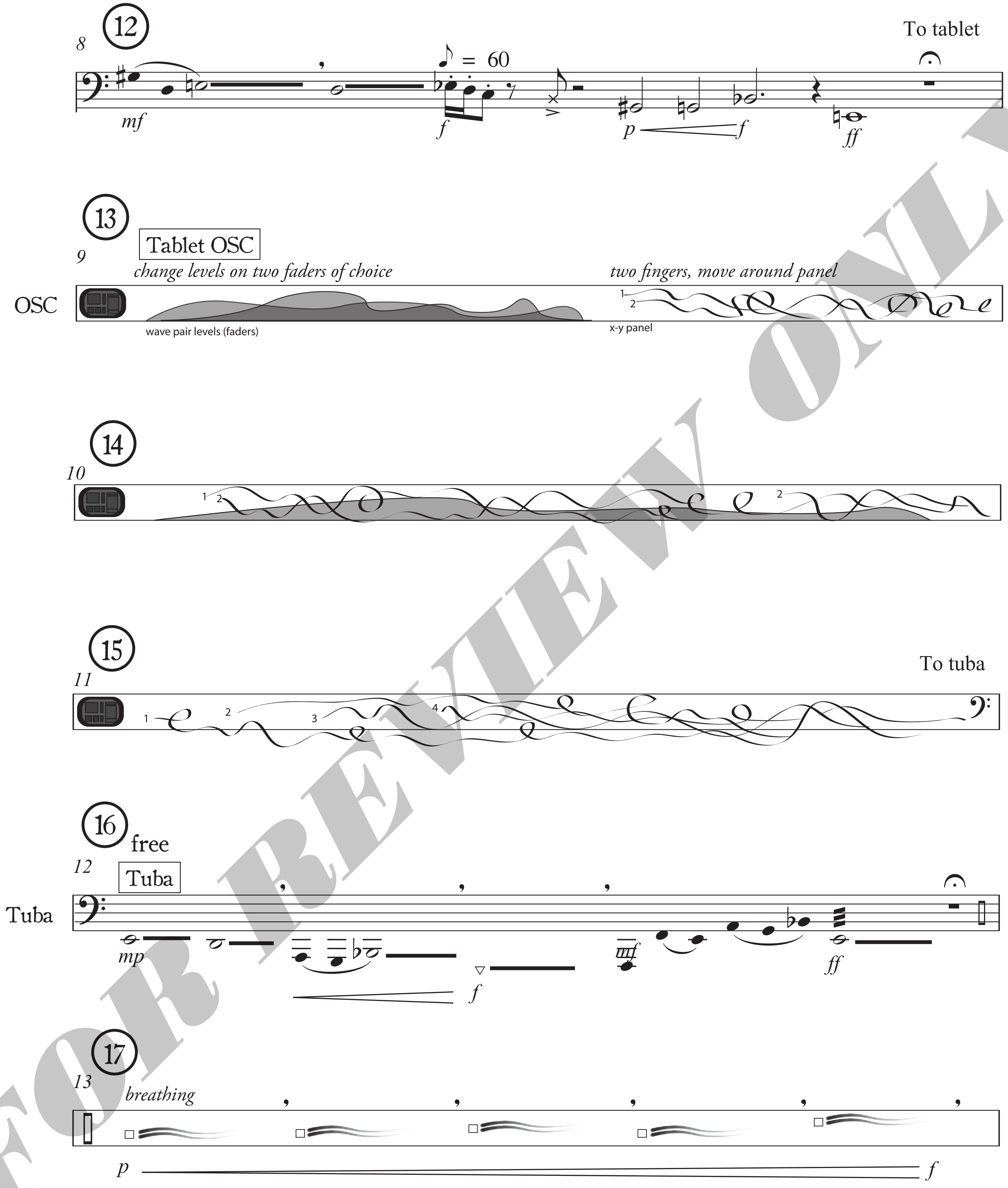
Wave Pair Shifting: move fingers on touch panel, numbers indicates amount of fingers, lines show suggested contour.



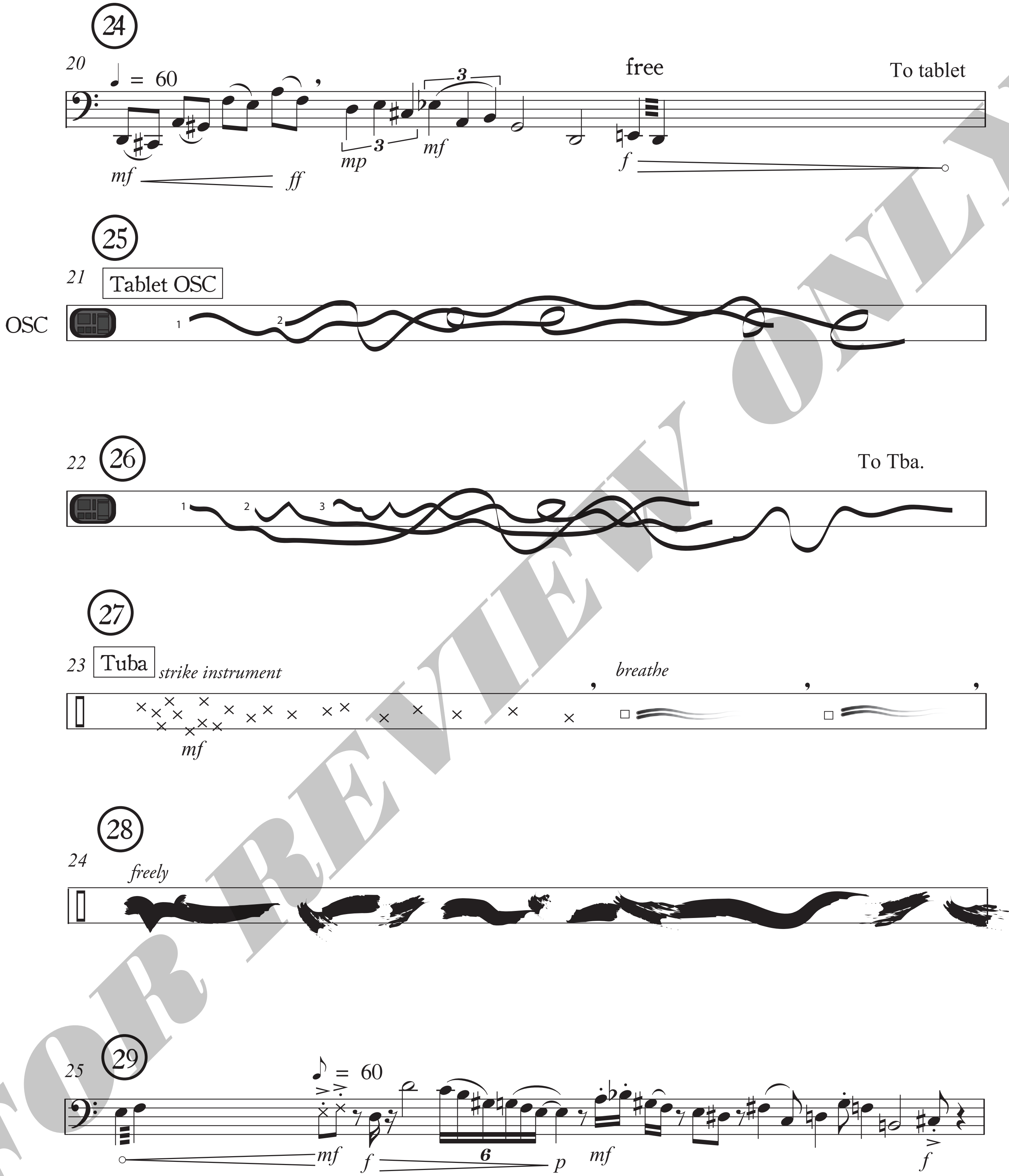
Wave Pair Balance: move the faders for wave pair balance (amount of faders moved and shape at discretion of the performer).

Submergence

Miguel Espinel


12
8
mf
= 60
f
p
f
ff
To tablet
13
9
Tablet OSC
change levels on two faders of choice
two fingers, move around panel
OSC
wave pair levels (faders)
x-y panel
14
10
15
11
To tuba
16
free
12
Tuba
Tuba
mp
f
mf
ff
17
13
breathing
p
f


14
low pt / fz
strike instrument
slap tongue
(general contour)
breathe
f
mf
mp
18
15
♪ = 60
free
19
sing higher voice
(general contour)
7' 17"
p
f
mp
mf
16
20
17
21
f
18
22
mp
mf
f
3
mp
23
free
19
breathe, pitchless


24
20
♩ = 60
free
To tablet
mf
ff
mp
3
mf
f
25
21
Tablet OSC
OSC
22
26
To Tba.
27
23
Tuba
strike instrument
breathe
mf
28
24
freely
25
29
♪ = 60
mf
f
6
p
mf
f


30
26
♪ = 60
mf
f
6
p
mf
f
31
27
p
f
p
f
32
28
accel.
3
mf
ff
mp
f
ff
3
3

Miguel Espinel

Conceiving Realities

for live painter, chamber ensemble, and computer

2017

Miguel Espinel

Conceiving Realities

INSTRUMENTATION:

- **FLUTE**
- **CLARINET IN B♭**
- **TUBA**
- **VOICE**
- **PERCUSSION**
  - **PREPARED KICK DRUM**
  - **VIBRAPHONE**
- **ELECTRIC GUITAR**
- **PIPA**
- **VIOLA**
- **VIOLONCELLO**
- **ANALOG ELECTRONICS**
- **COMPUTER**
- **LIVE PAINTER**

Duration: ca. 25 minutes

April 2017

Denton, TX

Performance Guidelines: Technical Details

Setting up the electronics:

This piece requires two computers with Max/MSP (www.cycling74.com/products/max), an electroencephalogram (EEG) sensor, an electrocardiogram (EKG) sensor, a digitizer for the sensors, a camera that allows live video feed (or one with the proper converters), an audio interface with ten inputs, ten microphones (type of microphones chosen at the discretion and preference of the performers andengineers, considering the performance space), and three projection screens or large monitors for individual video feeds.

The original setup used an I-CubeX Wi-microDig digitizer (www.infusionsystems.com) with the BioBeat EKG sensor and the BioWave EEG sensor. The following instructions may change and the patch may need some adjustments if using another type of sensor.

The I-CubeX sensors communicate to Max through virtual MIDI ports. There are multiple services that may be used for this purpose. The original setup of the piece used LoopMIDI (www.tobias-erichsen.de/software/loopmidi.html) for the creation of the virtual ports.

Once LoopMIDI is installed and active, one must download and open the I-CubeX Connect application, also available on the Infusion Systems website. The digitizer will need to be added as a Bluetooth device on the computer. Once the computer and digitizer are paired, the Connect application will be able to recognize the digitizer. Select the digitizer and open "conceivingrealities_audio.maxpat." The patch has two boxes to select the port, select Wi-microDig on the bottom box first and then the upper one. If all the connections are working correctly, these boxes will turn green and the blue LED light on the digitizer will turn on. For more information on getting started, visit www.infusionsystems.com/catalog/info_pages.php/pages_id/203.

Performance Guidelines: Technical Details

Setting up the camera:

For the camera setup, it is recommended to use a different computer. Open the patch conceivingrealities_video.maxpat on this computer. Set up a camera as the capture device and point it at the painting area. If the camera does not allow live capture, one may use a converter that turns the camera feed into a digital live capture.

Once the camera is set, one may turn on the video feed at the top of the patch. Each of the video windows should be sent to one of the three different displays.

Setting up the performance space:

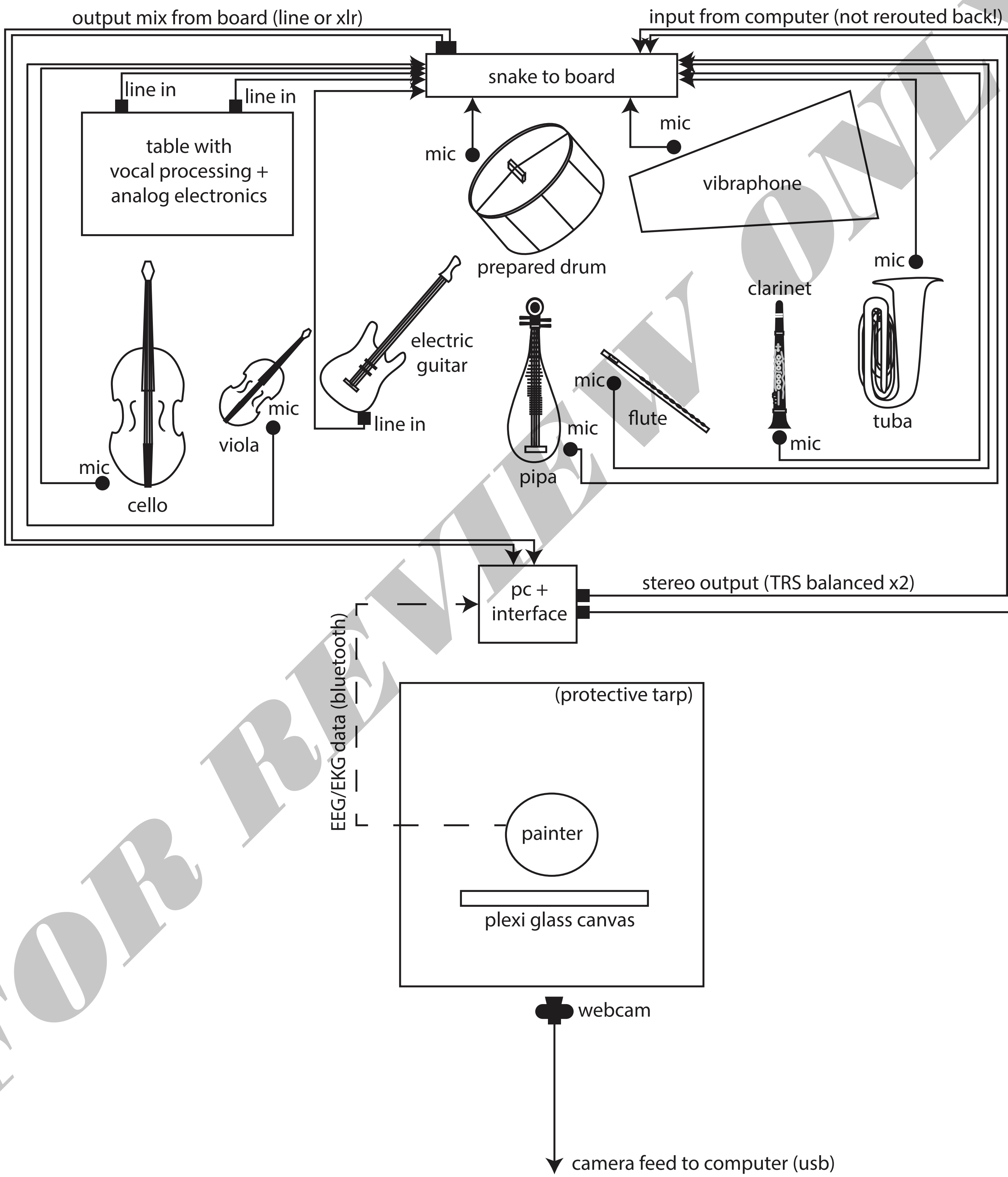
This piece was originally intended to be performed at the Merrill Ellis Intermedia Theater at the University of North Texas in Denton, TX. While the following setup may be used at other spaces, these can be adjusted to any other space as deemed necessary.

The painter should be in the front of the ensemble. For the canvas, a transparent plexiglass surface would be ideal. The painter will stand in front of the canvas facing the audience. The rest of the ensemble sits behind the painter in a flattened semicircle with the painter standing at the middle (opening) of this semicircle. A tarp should be placed under the painter's station to prevent damage to the floor.

The diagram on the following page shows the setup used at the first performance of *Conceiving Realities*. It includes the amount of microphones and signal flow used at the Merrill Ellis Intermedia Theater, which can be used as suggestions, but do not need to be strict instructions at another space, depending on its technical capabilities.

Performance Guidelines: Technical Details

Stage diagram and signal flow:



Performance Guidelines: Performance Details

Time-flow of the piece:

The piece uses cues to indicate the flow of time. While some parts are metered, others are free and dependent on events to progress. For clarity, the person following the cues (originally the guitar player, though the person may be changed if desired) will use signs with numbers, visible to the ensemble, to indicate the transitions between cues. This performer will hold the cue sign to prepare the other performers, then drop the sign on the floor to signal the transition.

Instructions for the painter:

The painter will create an abstract piece inspired by the music. This person should be actively listening to the ensemble while painting. The EEG and EKG sensors will send the data to the computer that will alter the parameters of the signal processing of the acoustic instruments. It is encouraged for the painter to use expressive strokes to accent the musical gestures.

Additional notes:

Within some sections, the performers will often be listening to each other to find some cues; which are shown by way of dashed lines across the score. While these indicate a succession of events, the timing of these gestures does not need to be strictly exact. The entire mood of the piece favors a sense of heterophony.

The free time sections can last as much as the performers feel right, while there are time suggestions at the top of bars. These are meant to be used as a guideline, but if a musical moment feels like it should keep happening uninterrupted, going over these time suggestions is not only acceptable, but encouraged.

Performance Guidelines: Preparing the Kick Drum

Secure a guitar string across the face of the kick drum, placing a bridge near the middle of the membrane so that it may produce a pitch when plucked, struck or bowed.

Note on the original method of preparation:

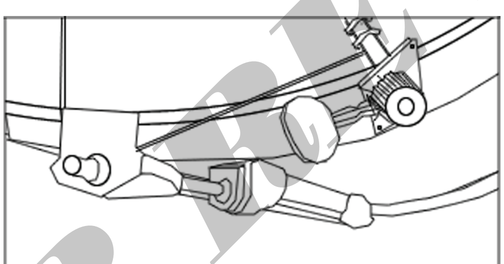
The materials and method used may be modified as necessary. The original method requires attaching a guitar tuning peg to the kick drum by making a small hole. However, the string can be tightened with the tension of the claw hooks alone.

Draw string under one of the claw hooks and pass the tip of the string through the loop at the end of the string to secure it. Pull on the string to tighten the resulting loop.

Draw the string under the claw hook at the other end and tighten until the string is slightly loose, but parallel to the membrane at the height of the rim. Tighten hooks.

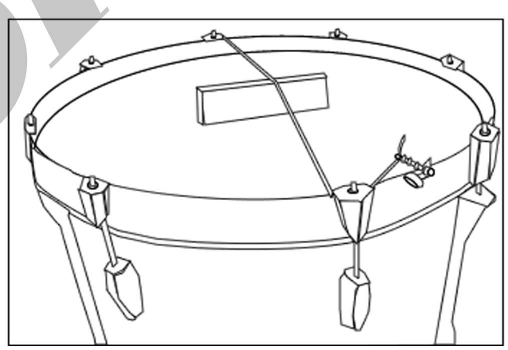
Place a thin wooden bridge near the middle of the drum head.
Original preparation uses a wood board 1/4" thick and 2.5" wide from the membrane.

Examples and notes on original preparation:



Ex #1: string and peg attachment

Original materials used:
String: 0.046" nickel wound guitar string.
Peg (optional): taken from electric guitar.
(no need to use these specific materials)



Ex #2: completed prepared drum

String should have playable tension.
The string can be easily set slightly loose but straight over the rim, placing the bridge from below to create this tension.

Performance Guidelines: Special Notations

General:

Sustain: playing note and holding for the length of the line (at player's discretion).

Breath: breathing through instrument (when applicable); pitchless wind sound.

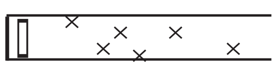
Improvisation: Improvising interpreting the verbal instructions given. The graphics serve as a visual guideline representing each of the verbal elements (open to interpretation).

Sustain glissando: playing note and holding for the length of the line (at player's discretion). Glissando following general contour of the curved line until the end of the gesture.

Winds:

Flutter tongue (fz): tremolo lines on wind instruments indicate flutter tongue.

Singing top note: play while singing. The higher/smaller notehead indicates singing, while the starting pitch does not need to be exact. The line provides a general contour for pitch variation (glissandi).



Key clicks (flute/clarinet): making a rumble sound with the keys.

Tongue pizzicato (flute): percussive sound with tongue while playing note.

slap

Slap tongue (clarinet): percussive sound with tongue while playing note.

Tuba:

Strike instrument: strike the body of the instrument percussively.

Tongue pops: percussive sound created by producing a thud with the tongue while blowing a burst of air through the mouthpiece of the instrument.

▽ **Low pedal tone:** a triangular notehead indicates to play the lowest pedal tone the performer feels comfortable with. Specific pitch not important.

Performance Guidelines: Special Notations

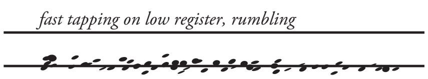
Pipa:

Zhai: percussive sound created by touching the string with the left hand and flicking the string with the right hand for a high-pitched, percussive harmonic.

Jiaoerxian: twisting two strings with the left hand (running one above the other), then plucking with the right hand to produce a distorted, unpitched sound.

Specific strings: — first string (thinnest), || second string, ≡ third string, X fourth string (thickest), ( ) any string chosen by performer

Guitar:



Tapping rumble: fast tapping with both hands on lower register, creating a rumble.

Bowed strings (and prepared drum, where applicable):

Unpitched bowing: Bowing as indicated (bridge, tailpiece, etc.), alternating freely.

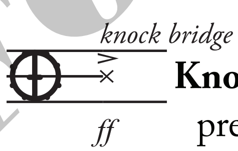
Harmonic glissando: glissandi touching the string with the left fingers at the position of the non-harmonic notes, but without pressing on the fingerboard.

Micotonal notation: 1/4 flat: 1/4 sharp: 3/4 sharp:

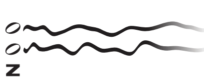
Free alternate bowing: freely bowing, alternating in direction, pitch, and pressure as desired by the performer.

Overpressure: overpressure bowing, following the general shape for intensity.

Prepared drum:



Knock bridge: knock the bridge loudly on the drum. Line through clef shows bridge presence or absence.

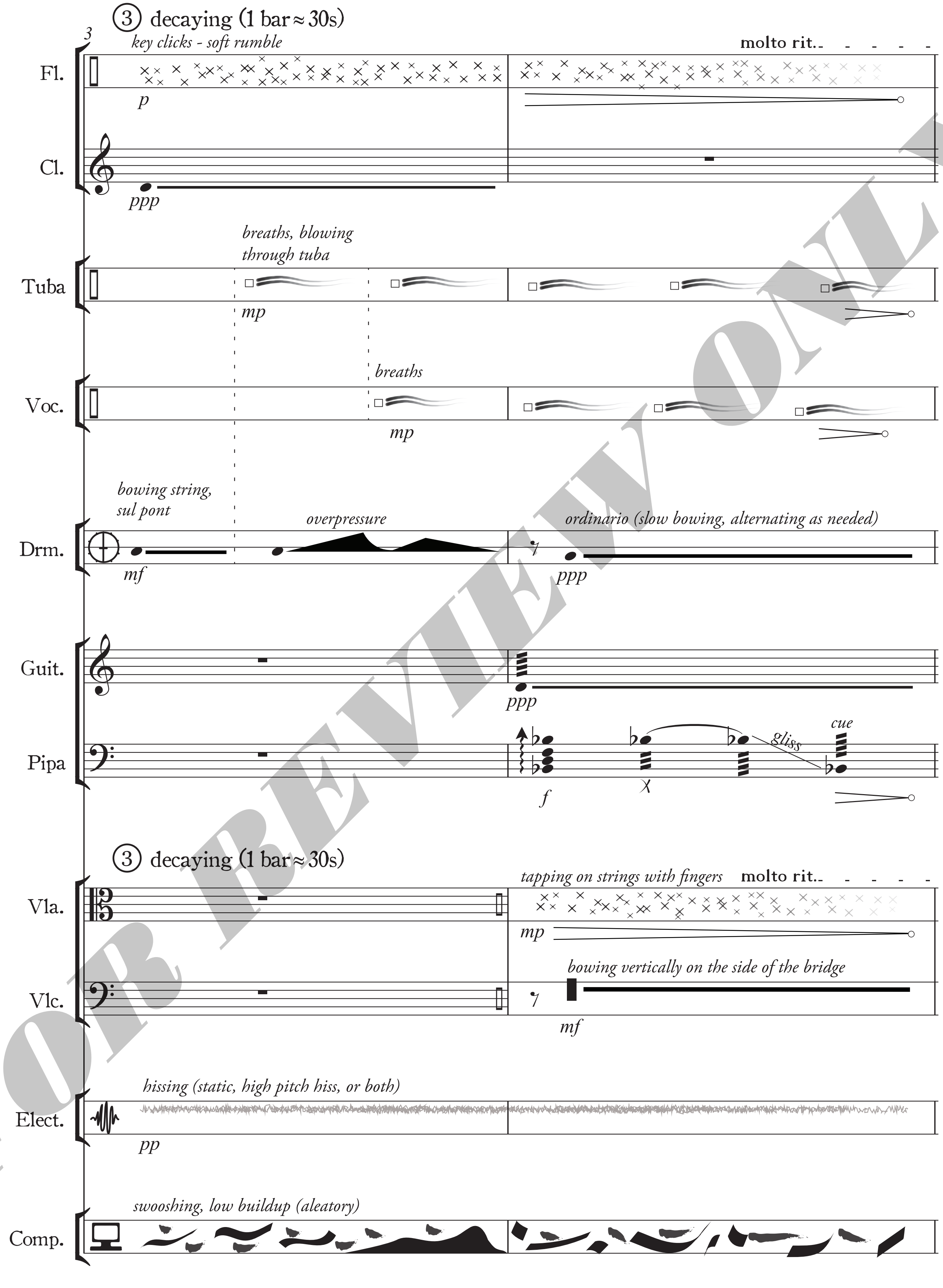


Finger roll: rumble fingers on membrane

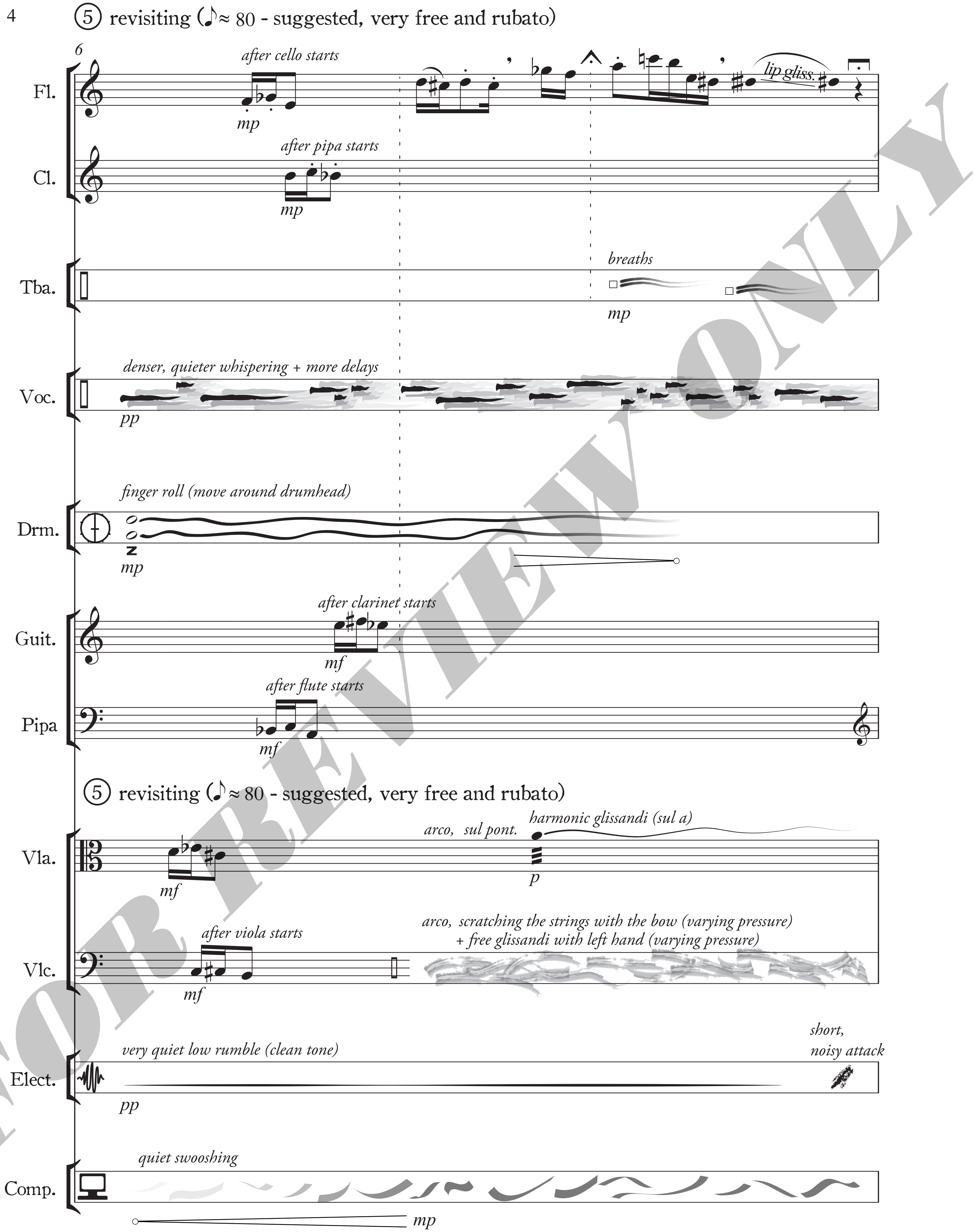
Conceiving Realities

(Transposing Score)

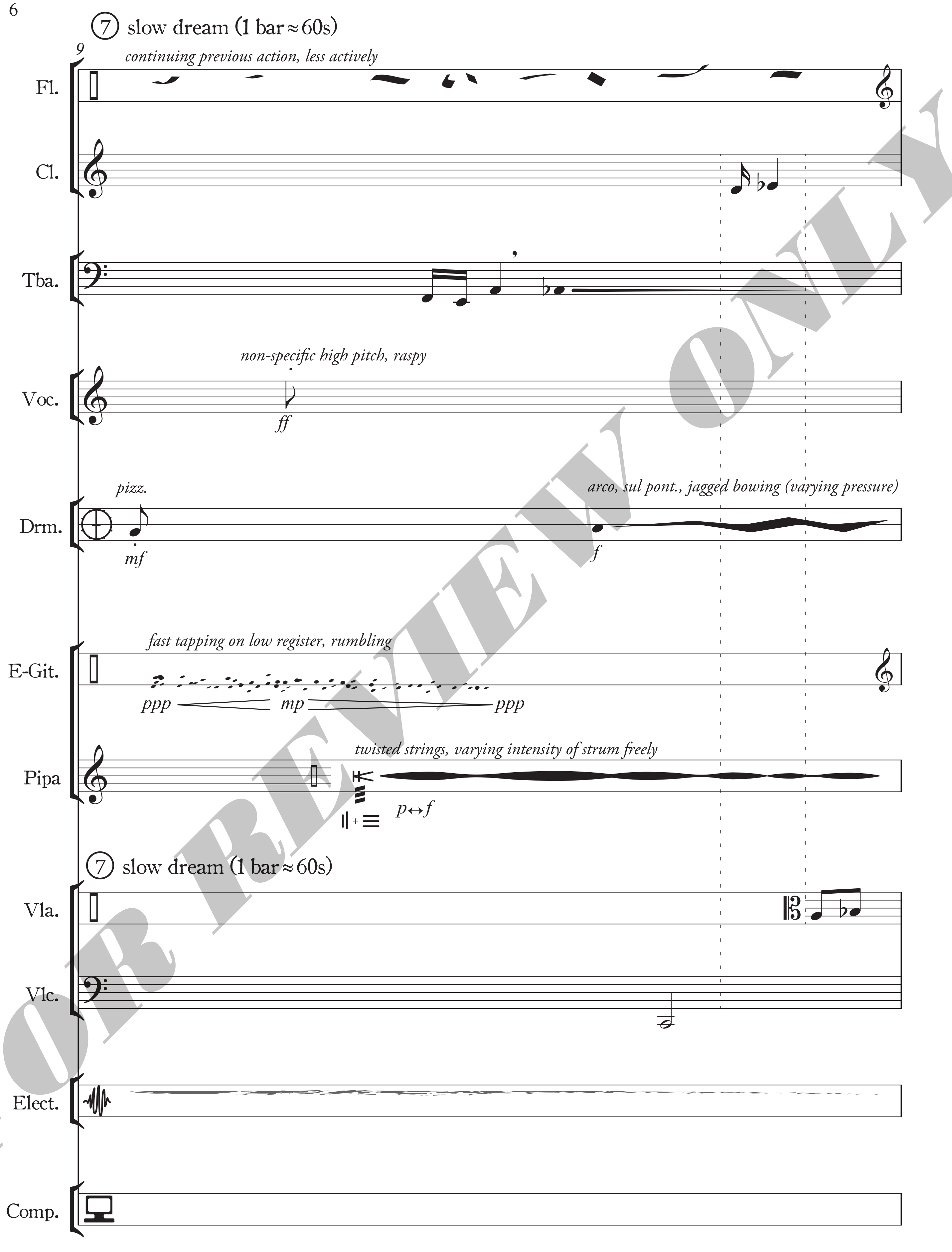
Miguel Espinel


3
3 decaying (1 bar ≈ 30s)
key clicks - soft rumble
molto rit. - - - - -
Fl.
p
Cl.
ppp
breaths, blowing
through tuba
Tuba
mp
breaths
Voc.
mp
bowing string,
sul pont
overpressure
ordinario (slow bowing, alternating as needed)
Drm.
mf
ppp
Guit.
ppp
cue
gliss
Pipa
f
3 decaying (1 bar ≈ 30s)
tapping on strings with fingers
molto rit. - - - - -
Vla.
mp
bowing vertically on the side of the bridge
Vlc.
mf
hissing (static, high pitch hiss, or both)
Elect.
pp
swooshing, low buildup (aleatory)
Comp.

4 creating (1 bar ≈ 60s)
5
improvising: pointillism, sporadic notes, tongue slaps
Fl.
mp
key click rumble
Cl.
percussive hits on instrument
(cue drum)
Tuba
p
ff
whispering (with delay pedal)
Voc.
p
knock bridge
Drm.
ff
improvising: scratching the strings, sustained soft notes
Guit.
p
improvising: pointillism, sporadic notes, percussive sounds
Pipa
mp
4 creating (1 bar ≈ 60s)
bowing the side of the bridge (alternating freely)
Vla.
p
improvising: soft sustained sounds: harmonics, sul pont. lines, bowing bridge
Vlc.
p
quiet static and rumble, building up to medium-low volume
Elect.
ppp
mp
high-pitched thin sweeping and swooshing
Comp.


5 revisiting (♪≈ 80 - suggested, very free and rubato)
6
Fl.
after cello starts
mp
lip gliss.
Cl.
after pipa starts
mp
Tba.
breaths
mp
Voc.
denser, quieter whispering + more delays
pp
Drm.
finger roll (move around drumhead)
mp
Guit.
after clarinet starts
mf
Pipa
after flute starts
mf
5 revisiting (♪≈ 80 - suggested, very free and rubato)
Vla.
mf
arco, sul pont.
harmonic glissandi (sul a)
p
Vlc.
after viola starts
mf
arco, scratching the strings with the bow (varying pressure)
+ free glissandi with left hand (varying pressure)
Elect.
very quiet low rumble (clean tone)
pp
short,
noisy attack
Comp.
quiet swooshing
mp

⑥ slower (1 bar ≈ 30s)
high pitched gestures, as glissando as possible
7
Fl.
mf
Cl.
mf
low pedal tone, as low as comfortable
Tba.
p
f
vocalise, microtonal to semitonal wobble
Voc.
reattach bridge
arco, sul pont.
Drm.
f
E-Git.
f
Pipa
f
gliss.
⑥ slower (1 bar ≈ 30s)
ord.
bowing tailpiece
Vla.
f
harmonic glissandi (sul d + a)
Vlc.
f
p
quiet high-pitched hiss with static noise
Elect.
pp
swooshing
Comp.

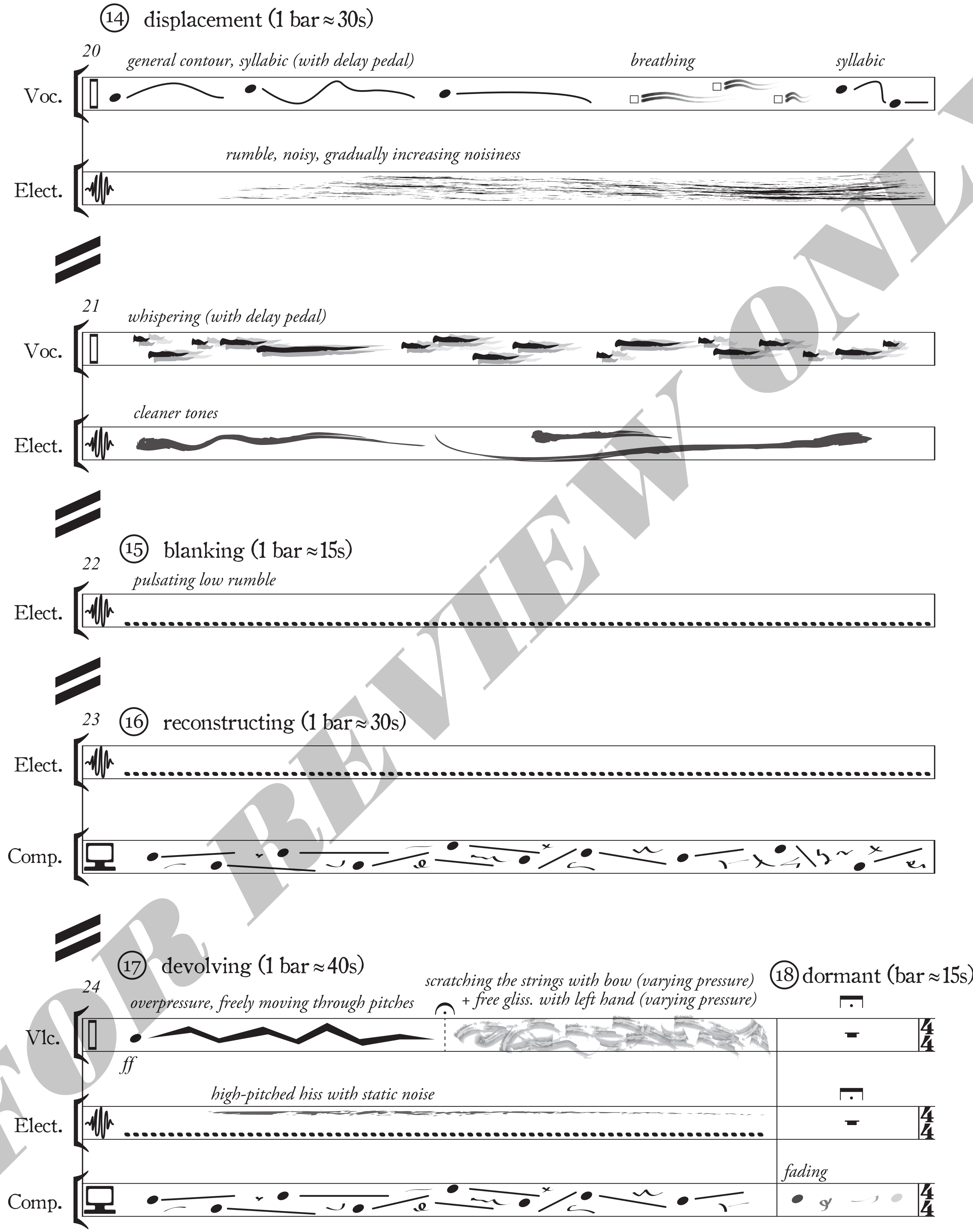

7 slow dream (1 bar ≈ 60s)
9
continuing previous action, less actively
Fl.
Cl.
Tba.
non-specific high pitch, raspy
ff
Voc.
pizz.
mf
arco, sul pont., jagged bowing (varying pressure)
f
Drm.
fast tapping on low register, rumbling
ppp
mp
ppp
E-Git.
twisted strings, varying intensity of strum freely
p↔f
Pipa
7 slow dream (1 bar ≈ 60s)
Vla.
Vlc.
Elect.
Comp.


8 revisiting (♪≈ 80 - suggested, very free and rubato)
10
Fl.
after clarinet starts
p
Cl.
after pipa starts
p
Tba.
mp
after cello ends
Voc.
after tuba starts
Drm.
with palms
ff
E-Git.
after voice starts
after tuba starts
p
Pipa
after guitar starts
8 revisiting (♪≈ 80 - suggested, very free and rubato)
Vla.
pizz.
after flute starts
mf
Vlc.
pizz.
after viola starts
mf
Elect.
low rumble, noisy
Comp.


9 mundane (♩≈40 - moderately rubato)
11
Fl.
Cl.
f
mp
p
Tba.
3
mf
f
p
Voc.
p
fingertips roll
with palms
to vib.
Drm.
mf
ff
E-Git.
Pipa
mf
9 mundane (♩≈40 - moderately rubato)
arco
Vla.
mf
ppp
mp
arco
Vlc.
mf
p
Elect.
Comp.

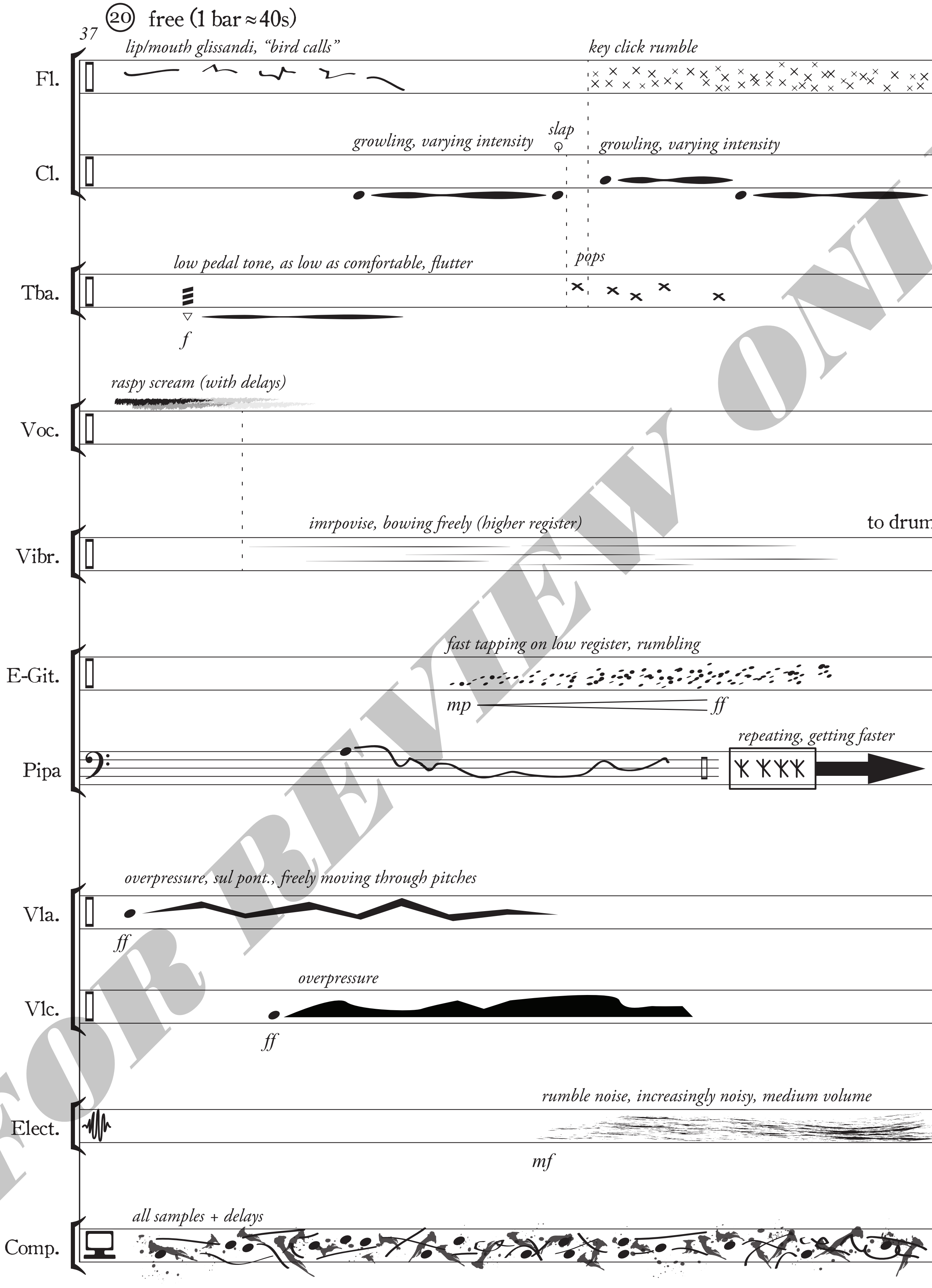

10 melt (1 bar ≈ 15s) 11 emerging (1 bar ≈ 30s)
15
Tba.
improvising chromatically and unevenly around given range
ff
f
Vlc.
long tones, free glissandi, each one fading out gradually
mf
f
Elect.
low sine tone pair (constant, close frequencies creating slight wobble)
Comp.
tuba sampler, regular tones
12 reshaping (1 bar ≈ 30s)
17
Cl.
singing upper voice (suggested contour, sung pitches do not need to be exact)
Vibraphone
bowing
to drum
Vib.
Elect.
low sine tone pair returns
begin meandering in frequency independently
Comp.
tuba sampler, singing, growling


13 evolving (1 bar ≈30s)
18
tongue pizz.
tongue pizz.
short gestures, use gliss when possible
Fl.
mp
mf
mf
mp
Kick drum
sul pont., very light pressure (alternating bowing as needed)
Drm.
p
mp
glissando, general contour
tremolo rit.
Pipa
mf
f
autoharp sampler, timbral effects, bowing
Comp.
19
combine bird calls, blowing through instrument, tongue pizz., key clicks
Fl.
mf
keep bowing sul pont., begin pressing lightly on membrane to lower pitch
to vib.
Drm.
mf
glissando, general contour
Pipa
p
f
Comp.

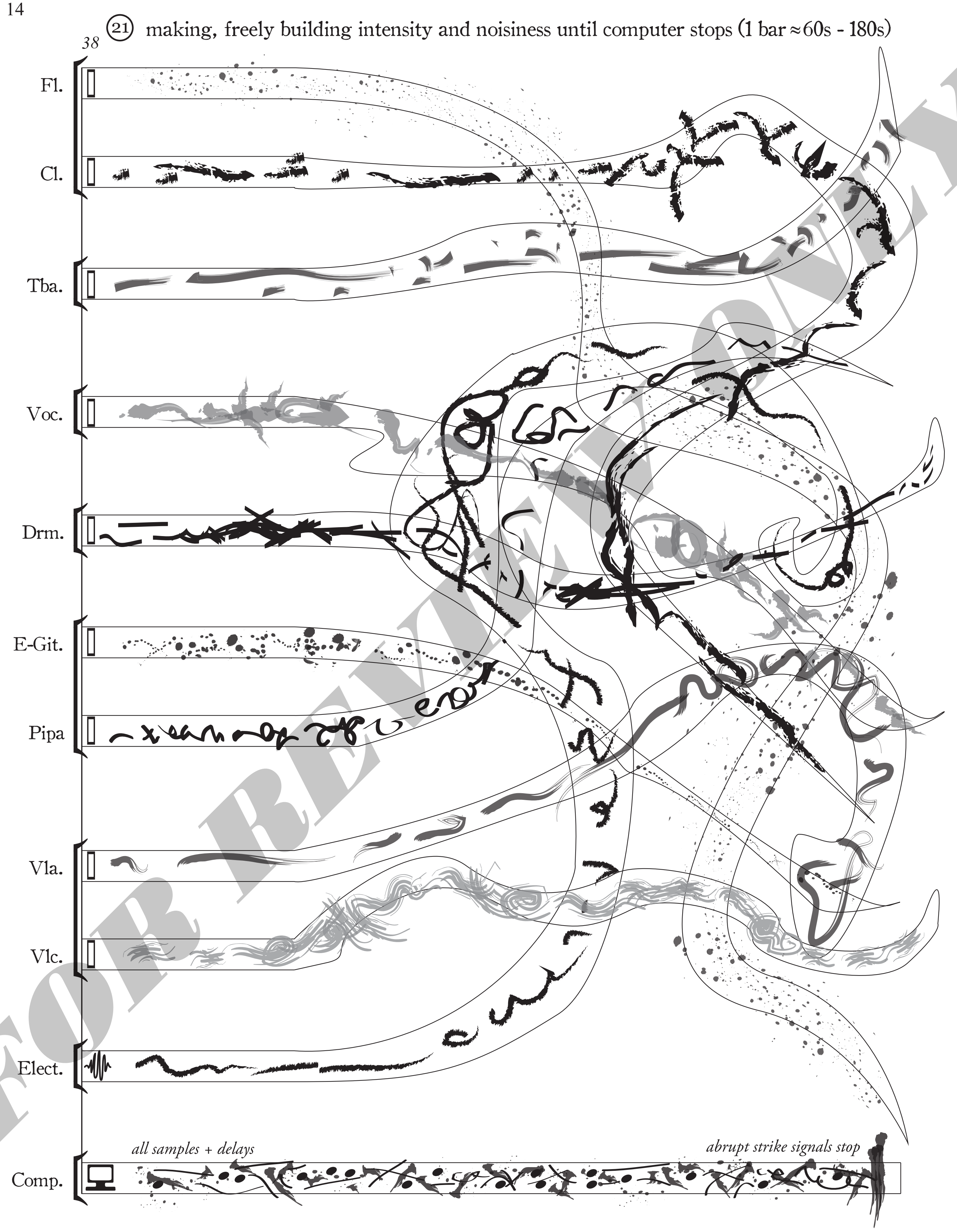


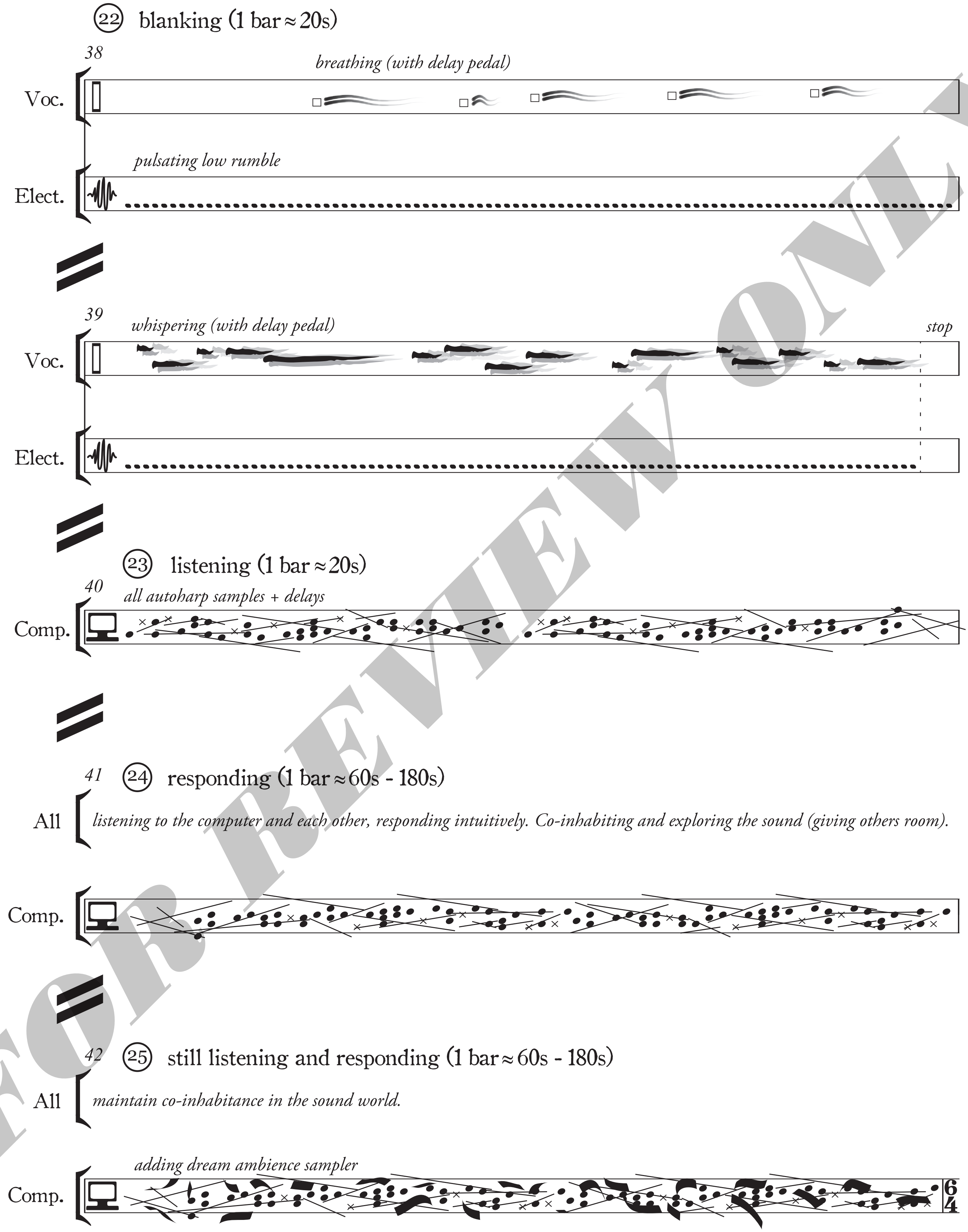
14 displacement (1 bar ≈ 30s)
20
general contour, syllabic (with delay pedal)
breathing
syllabic
Voc.
rumble, noisy, gradually increasing noisiness
Elect.
21
whispering (with delay pedal)
Voc.
cleaner tones
Elect.
15 blanking (1 bar ≈ 15s)
22
pulsating low rumble
Elect.
23
16 reconstructing (1 bar ≈ 30s)
Elect.
Comp.
17 devolving (1 bar ≈ 40s)
24
overpressure, freely moving through pitches
scratching the strings with bow (varying pressure)
+ free gliss. with left hand (varying pressure)
18 dormant (bar ≈ 15s)
Vlc.
ff
high-pitched hiss with static noise
Elect.
fading
Comp.


19 rapidly (♩ ≈ 100)
26
Fl.
Cl.
Vibr.
mf
mf
f
30
pizz.
pizz.
Vla.
Vlc.
33
Fl.
Cl.
Vibr.
arco
arco
Vla.
Vlc.

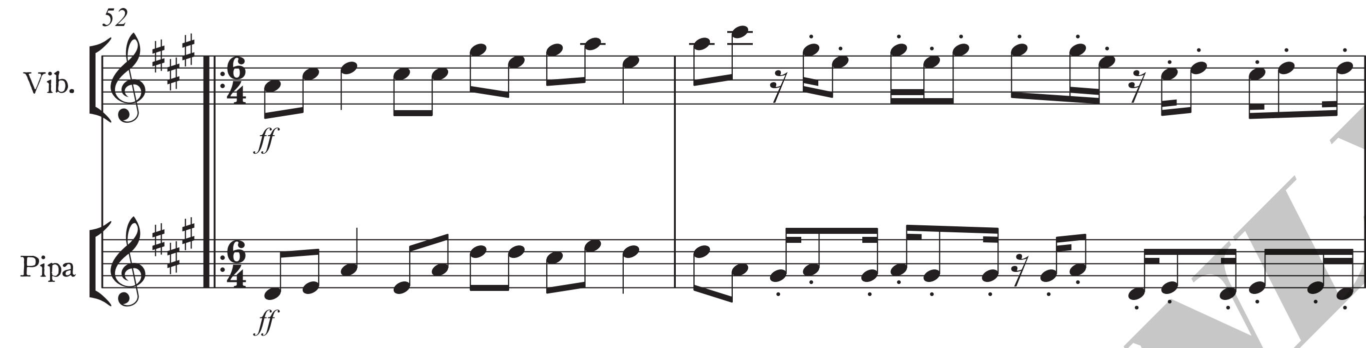


20
free (1 bar ≈ 40s)
37
lip/mouth glissandi, "bird calls"
key click rumble
Fl.
growling, varying intensity
slap
growling, varying intensity
Cl.
low pedal tone, as low as comfortable, flutter
pops
Tba.
f
raspy scream (with delays)
Voc.
imrpovise, bowing freely (higher register)
to drum
Vibr.
fast tapping on low register, rumbling
E-Git.
mp
ff
repeating, getting faster
Pipa
overpressure, sul pont., freely moving through pitches
Vla.
ff
overpressure
Vlc.
ff
rumble noise, increasingly noisy, medium volume
Elect.
mf
all samples + delays
Comp.

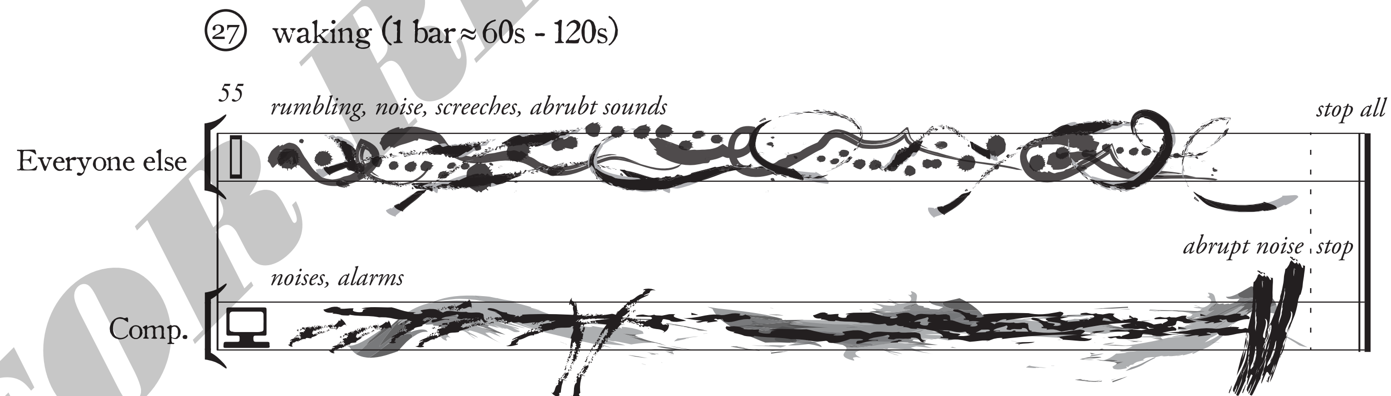

38
21
making, freely building intensity and noisiness until computer stops (1 bar ≈60s - 180s)
Fl.
Cl.
Tba.
Voc.
Drm.
E-Git.
Pipa
Vla.
Vlc.
Elect.
all samples + delays
abrupt strike signals stop
Comp.


22 blanking (1 bar ≈ 20s)
38
breathing (with delay pedal)
Voc.
pulsating low rumble
Elect.
39
whispering (with delay pedal)
stop
Voc.
Elect.
23 listening (1 bar ≈ 20s)
40
all autoharp samples + delays
Comp.
41
24 responding (1 bar ≈ 60s - 180s)
All
listening to the computer and each other, responding intuitively. Co-inhabiting and exploring the sound (giving others room).
Comp.
42
25 still listening and responding (1 bar ≈ 60s - 180s)
All
maintain co-inhabitance in the sound world.
adding dream ambience sampler
Comp.
6
4


26
moving (♩ ≈ 90)
43
Vib.
ppp
mp
Pipa
ppp
mp
45
♩ ≈ 95
Vib.
Pipa
47
♩ ≈ 100
Vib.
mf
Pipa
mf
49
Vib.
Pipa


52
Vib.
Pipa
ff
ff


54
Vib.
Pipa
repeating until the end


27
waking (1 bar ≈ 60s - 120s)
55
rumbling, noise, screeches, abrubt sounds
stop all
Everyone else
abrupt noise
stop
noises, alarms
Comp.