Journal SEAMUS

Spring/Fall 2018

The Society for Electro-Acoustic Music in the United States

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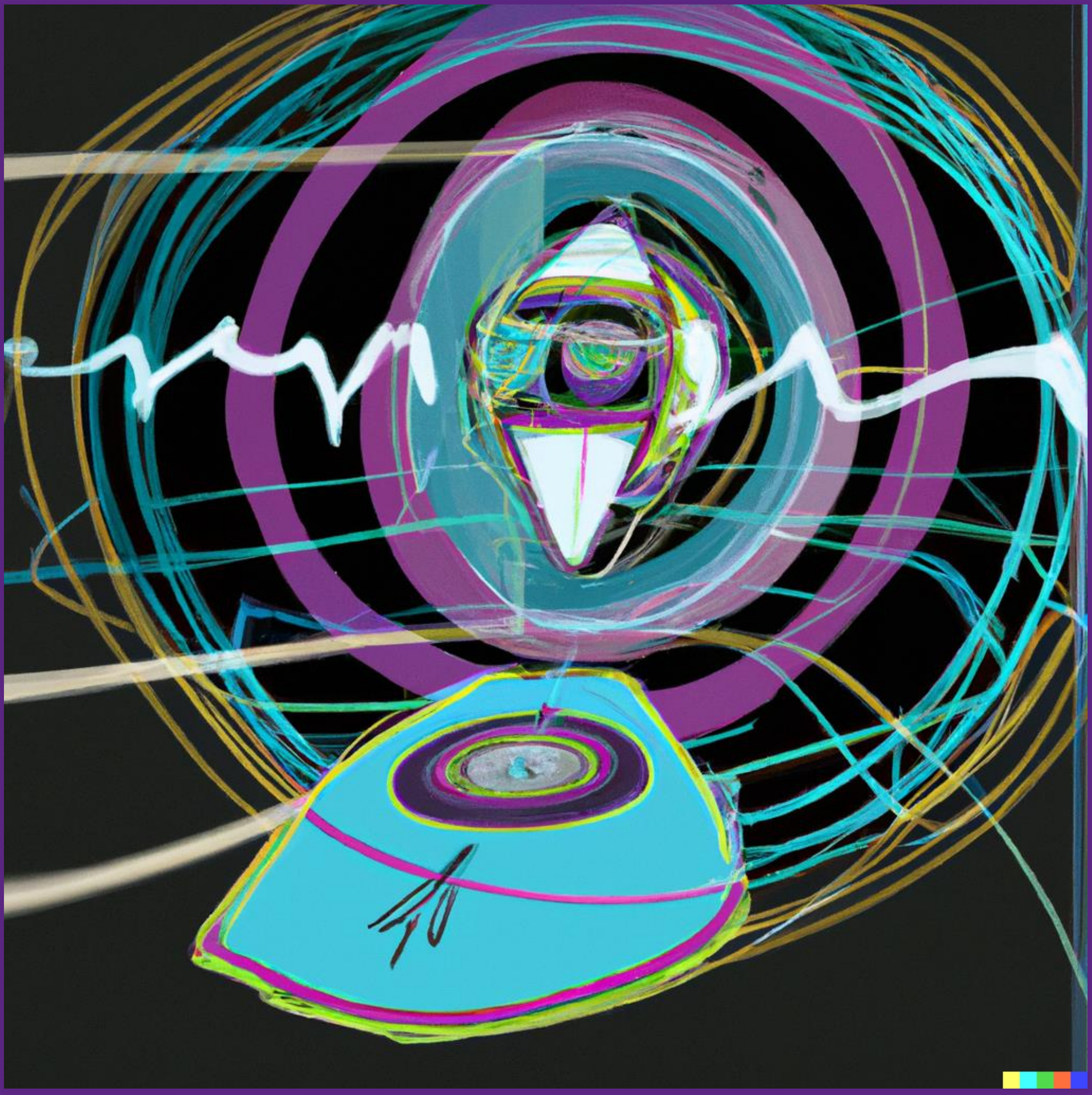

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Information for Contributors

Interested contributors should submit manuscripts electronically. Microsoft Word is the preferred format. If another word processor is used, files should be saved in rich text format (RTF) with an accompanying PDF version. Main articles are generally 2,000 to 6,000 words.

Editing Guidelines Please use Times New Roman fonts with font size 12. Manuscripts should be formatted and prepared using *The Chicago Manual of Style,* 17th edition (2017) as a guide. References should follow Author-Date format. Specific citations should be provided in text in parentheses. Footnotes should be used sparingly and reserved for explanation beyond the text of the article. All references should be listed after the text of the article in a section labeled "References." Any computer code should be placed in fixed-width format to facilitate readability. Images, figures, musical examples, and other graphics should be sent as separate attachments for ease of layout. The approximate location of each graphic should be indicated in the text by a (sequentially numbered) label and a brief caption.

Graphics Any artwork, graphics, photos, and flowcharts should be sent as separate individual files. We recommend uncompressed graphic files such as TIFF at 300 dpi.

Submission All submissions, including articles, reviews, review proposals, and items for *Tips and Tricks* should be emailed to the Editor-in-Chief, Drake Andersen: journal@seamusonline.org.

About SEAMUS

Founded in 1984, The Society for Electro-Acoustic Music in the United States (SEAMUS) is a non-profit national organization of composers, performers, and teachers of electro-acoustic music representing every part of the country and virtually every musical style. Electro-Acoustic music is a term used to describe those musics, which are dependent on electronic technology for their creation and/or performance. Many members of SEAMUS, like Jon Appleton, the guiding light in the conception of the Synclavier, are recognized world leaders in their fields. All are dedicated to the use of the most advanced technology as the tools of their trade.

SEAMUS seeks to provide a broad forum for those involved or interested in electronic music. Through its journal, newsletter, national meetings, and its national archive at the University of Texas, SEAMUS seeks to increase communication among the diverse constituency of the relatively new music medium.

The Society's objectives include:

To encourage the composition and performance of electro-acoustic music
To develop a network for technical information and support
To promote concerts and radio broadcasts of electro-acoustic music both in the US and abroad
To create an exchange of information through newsletters and other means of communication
To establish and maintain a national archive and information center for electro-acoustic music
To attract a wide diversity of members and supporters
To advocate licensing and copyright concerns

SEAMUS strives to address not only relevant technology but also the non-technical issues pertinent to the electro-acoustic music community. In a field usually dominated by technical concerns, it is refreshing to hear paper sessions devoted to aesthetics, collaboration, education, and of the ethical and social issues facing electro-acoustic musicians. The provocative sessions provide fuel for lively discussions during the national meetings.

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Contents

Journal SEAMUS

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From the Editor

It is my sincere pleasure to take on the role of Editor-in-Chief of Journal SEAMUS, and to announce the publication of Volume 29. I have always been impressed with the quality, rigor, and ingenuity of SEAMUS members' artistic and research endeavors—whether at conferences or in print—and I look forward to building on my predecessor Eli Stine's fabulous work in restructuring the journal, digitizing back issues, and sharing our members' scholarship and research with the SEAMUS community. I am also pleased to share my plans for the journal going forward.

First, and perhaps most obvious, is the switch to digital-only publication. Above all, this shift is intended to increase our readership, and provide new and greater access to our existing readers. This move acknowledges broader changes in the ways we read, create, and distribute research, and aligns us with peer publications who have adapted to the evolving digital landscape along similar lines. It is also my hope that by prioritizing digital publication, we can more closely and richly integrate multimedia, interactive elements, downloads, and other web-based content in future issues.

I am also pleased to report that the SEAMUS Board has approved Journal SEAMUS's transition to open access publishing. Once undertaken, this important step will have an enormous impact on both the accessibility and visibility of the compelling artistic and scholarly work being done in our community. Open access publishing also represents an affirmative step in support of SEAMUS's mission of greater inclusivity as an organization and as a steward of our musical and scholarly communities. The Board and Journal SEAMUS personnel continue to support and prepare for this transition in numerous visible and invisible ways, and we look forward to announcing a timeline soon.

I would like to take this opportunity to express my enormous gratitude to the individuals who have contributed their time and labor to Journal SEAMUS, including Digitization Manager Holli Wittman, Assistant Editors Michael Lukaszuk and Nick Hwang, and Copy Editors Nicholas Cline and Dave Mahony, as well as Board Members Abby Aresty and Becky Brown, Eli Stine, and the SEAMUS leadership.

Longtime readers will have noticed that Journal SEAMUS has experienced a bit of a backlog of late, and I am happy to share that further back issues are forthcoming throughout 2023. I am continually grateful for the extraordinary efforts and talents of our (volunteer) staff, and we all appreciate your patience as we return to normal service. To that end, I would like to invite any interested SEAMUS members to consider submitting your scholarship, articles, reviews, tutorials for the Tips and Tricks section, or other electro-acoustic music-related writing for publication in the journal. We are also interested in submissions of member-created art to be considered for future journal covers. (Inspired by this issue's content, the cover art for Volume 29 was produced with the AI tool DALL•E 2 using keywords from the article titles.) Please send all materials and inquiries to: journal@seamusonline.org

With all that out of the way, I hope you will enjoy this long-awaited double issue of Journal SEAMUS's Volume 29, featuring Caroline Louise Miller's fascinating study of electronic dance music subgenres, Sean Peuquet's critical examination of epistemological limitations in electroacoustic music, an overview of Taylor Brook's AI-powered improvisation system, and a thoughtful reflection on kinesthetic empathy in interactive and networked music by Ryan Ingebritsen, Christopher Knowlton, and John Toenjes. By highlighting the musical, the technical, and the philosophical, this issue truly showcases the extraordinary range of works, practices, and thinking that distinguish the SEAMUS community.

Drake Andersen, Editor-in-Chief

P.S. In my Tips and Tricks article, you will notice that I have made extensive use of in-text hyperlinks in an effort to more fully take advantage of Journal SEAMUS's new digitally native format—a trend I hope will continue in future submissions!

Articles

Texture, Materiality and Sensation in the Digital Production of Electronic Dance Music Subgenres

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Abstract

Since the late 2000's, there has been a generalized move in electronic dance music toward tactility and materiality (the labor, matter, processes, and histories from which things are created). Composers and producers use digital-ness in textured and tactile ways, sculpting musical surfaces that openly expose the labor undertaken in the studio and focus on haptic pleasure contained within sound. Through an exploration of digital glitch and other techniques that emerge exclusively in the digital studio, I address the question: how can data be touched or felt? I frame this discussion through alliances with Eve Kosofsky Sedgwick and Katrine Dirkinck-Holmfeld. Sedgwick configures tactile surfaces in terms of "texture" and "texxture," where two x's signify a material that is dense with freely offered information about how, substantively and historically, it came into being. Katrine Dirckinck-Holmfeld applies Sedgwick's tex[x]tures to the question of digital data, a highly manipulatable and malleable medium that doesn't necessarily embed specific histories. Working with these allies, my exploration of tactility in studio techniques is supported by analysis of works by three post-2010 electronica artists: post-dubstep artist James Blake, D.J. and French electro-house producer J.A.C.K., and instrumental hip-hop artist Flying Lotus. In the process, I identify fracture, rupture/suture, and decay as tactile affects that are distinctly qualified by digitally produced sound, and deployed by these artists to orchestrate haptic and material experience.

Introduction

How producers approach sound sources in the studio and apply digital techniques can be understood as a textural art—the creation of surfaces and spaces inhabited by sound objects that *often* (but not always) willfully *blur, weave, stitch, patch, glue, and blend* space, timbre, texture, frequency, harmony, amplitude, and other sonic elements, often taken from disparate sources, together. Some producers work hard to differentiate and retain the perception of individual sound sources. Other producers reveal the materiality (the matter, labor, circumstance(s), and process(es) from which a thing is created) of working in the digital medium by forefronting: "undesirable" artifacts potentiated through the conversion of analog to digital sound, abrupt and surgically precise shifts in sonic space that would be impossible to create outside the studio, fracturing and molding of individual voices into new envelopes and profiles, and the inherently social and networked practice of sampling pre-existing works (largely made possible now by the presence of the internet in the studio.)

While the practice of using pops, clicks, CD-skip stutters and other digital failures is a hallmark of experimental Glitch music of the 1990s (Yasunao Tone, Oval, etc.), the materiality of digital production does not belong to experimental Glitch music alone. Hip-hop music in particular has highlighted both analog *and* digital materiality for decades through practices such as record-scratching; chopped and screwed aesthetics that play with the envelope of the human voice; sampling in the service of various social, communicative, and musical motives; and using sampled loops that purposefully avoid smoothing pops and clicks at the start of each iteration.[1] The aesthetic and musical ramifications of these techniques, as well as the ones used in experimental glitch, have now permeated many popular genres of digitally produced music.

Digital audio production also makes possible the glossing-over of the means of production; one can edit or smooth over "undesirable" artifacts of playing and recording an acoustic instrument, add "natural" reverberation to enhance a space, erase a history of bad takes and slight mistakes, and create hyper-realities that sound realer than real, often more intimate than reality because of EQ-ing and spatial techniques that place a listener in an "ideal" listening space with no random environmental noises.

Examples are too many to name, but two that I think of for differing reasons are: Iron and Wine's album *Our Endless Numbered Days,* which creates a hyper-real, hyper-intimate sound through heavy production, the specifics of which are probably not detectable to untrained ears; and the recording of Hilary Hahn playing the Schoenberg Violin Concerto with the Swedish Radio Symphony Orchestra, in which natural transitory sounds for the violin part (between fast pizzicato and arco transitions, for example, are edited out almost *too* neatly.) Frequently one will encounter hybridized musics that include "glossy" layers (hyper-"natural" sounding tracks), mixed with "rough" layers, or tracks that reveal the digital-ness of the production.

To a trained ear, heavy digital production with a glossy sheen reveals its materiality, but it is still resistive in the sense that it "signifies a willed erasure of its history" (Sedgwick 2003, 14). Such production attempts to elude the qualitative associations of having been created by digital means. In the case of the Hahn recording (as well as glossing over the digital materiality by pretending the whole thing was recorded live in one take), the acoustic materiality of the body playing the violin—the bow and finger noises accompanying the virtuosic transitions written by Schoenberg—is largely erased from a listener's experience.

For support, I refer to Sedgwick, who uses Renu Bora's framework *texture vs. texxture* to describe the property of "glossiness" as applied to physical materials. For Sedgwick's (2003) purposes, *texture* resists revealing data about its history—in this context the numerous forces and bodies that have acted upon it over time—and *texxture* signifies a "kind of texture that is dense with offered information about how, substantively, historically, materially, it came into being" (14).

Discussing texture in the tactile realm, Sedgwick (2003) also recognizes that the *feel* of a thing is accompanied by a slew of speculations, both conscious and unconscious, as to what kinds of forces, dimensions, and properties are suggested by the surface being felt.

> I haven't perceived a texture until I've instantaneously hypothesized whether the object I'm perceiving was sedimented, extruded, laminated, granulated, polished, distressed, felted, or fluffed up. Similarly, to perceive texture is to know or hypothesize whether a thing will be easy or hard, safe or dangerous to grasp, to stack, to fold, to shred, to climb on, to stretch, to slide, to soak. Even more immediately than other perceptual systems, it seems, the sense of touch makes nonsense out of any dualistic understanding of agency and passivity, to touch is always already to reach out, to fondle, to heft, to tap, or to enfold. (14)

What Sedgwick illustrates is that these properties of touch are intrinsically interactive, raising questions and inviting experimentation. They also instantaneously evoke other forces—people, processes—that have touched that texture in the past, in its making or otherwise.

I wish to use Sedgwick's observations about tactile textures to address the material qualities of glitchy and digital sound as implemented in 2010s electronic dance music and its relatives. With the term *material*, I refer to that which can be touched, physically sensed, or physically manipulated. To reiterate, *materiality* for my

[1] The term "chopped and screwed" comes from Houston's DJ Screw, who pioneered the technique in the early 1990s. See also the music of artists/producers J Dilla and Madlib.

purposes refers to the matter, labor, circumstances, and processes through which a *material* thing, (a thing that can be touched, sensed, or physically manipulated), comes into being. Though all materials contain these histories of matter, labor, circumstances, and processes, Sedgwick's texxture, with its density of offered information, can be thought of as a property that *openly reveals* its materiality.

Applied to digital music production, Sedgwick's texxture points toward how we might understand data as having the ability to be material—how data *itself* becomes affective, able to be sensed. In that vein, my explorations revolve around how producers and composers of recent electronic dance music subgenres use digitalness in texxtured ways, sculpting musical surfaces that reveal the labor undertaken in the studio (by both human and computer) and focus on haptic pleasure. Since the late 2000s, there has been a generalized move in dance music (and its multitude of subgenres and offshoots) toward the integration of digital glitch; this has carried my interest far beyond the early experimental glitch artists of "clicks and cuts" and Microsound. In particular, I aim to centralize the role of *touch and the haptic*, both inside and outside the studio, as a mode for identifying potential affects of glitch and other materiality-centric studio techniques. Electronic Dance Music, with its purpose of affecting and moving bodies, is the ideal musical culture for this exploration.

Luis-Manuel Garcia has explored some of the tactile affects in EDM in his article "Beats, Flesh, and Grain: sonic tactility and affect in electronic dance music." He illustrates that certain frequencies, amplitudes, and qualities of sound can create an *intensely haptic* experience:

> EDM events tend to engender spaces of heightened tactility and embodied intimacy, and so it should not be surprising that their musical aesthetics also highlight tactility. Sound is by no means an intangible phenomenon; it entails vibrations and impacts that can be registered directly by the body's tactile and haptic sense organs. Moreover, sound can evoke touch through timbre and sonic texture, conveying something about haptic experience without being routed through representation (Garcia 2015, 60).

Garcia goes on to demonstrate the sonic tactility of EDM by discussing the corporeal impact of loud, percussive bass, the pervasive use of human body sounds (breathing, clapping, slapping, snapping, moaning, etc.), and production aesthetics that evoke material textures—Garcia uses Pierre Schaeffer's model of the *grain* to theorize this last point. *Grain* refers to the microstructure of sound, or the presence and quality of "irregularities of detail affecting the surface" of a sound-object (Garcia 2015, 67). These "details" are in fact attacks happening on a microscopic scale; imagine playing a guiro with a stick—imagine the sound it makes. Now run your fingers over the guiro instead. There is a direct, tactile connection between the sound and what you feel with your fingers. This is a way to think of Schaeffer's *grain* as a haptic property.

In addition to being intrinsically tactile, experiencing sonic texture means that qualities of information are "instantaneously hypothesized" (to refer to Sedgwick) as to their materiality (Sedgwick 2003, 14). The sound of a hand scraping the strings on a guitar on its way to the next fret, the crackle of static between radio stations, the crunching of dry leaves underfoot…elements such as distance, amplitude, frequency range, periodicity, timbre, and Schaeffer's *grain* provide data about our relationship to the sound and how the sound was produced; what kind of bodies interacted to form the sound, how we might modulate it, how it will interact with various substances and bodies, whether or not it is in our power to stop, and if so what kind of forces might be required to stop it. Sound that is rich(er) with this embedded information could be considered to be more texxtured.

It is both texture, with its glossy erasures of various information(s), and texxture, with its richness of embedded information, that I am concerned with in this analysis. Drawing upon the observations of Katrine Dirckinck-Holmfeld, who discusses texture and texxture as applied to the digital (which is a highly malleable and manipulatable medium), I examine the works of three contemporary EDM artists who have employed digital materiality for various musical purposes: James Blake, Flying Lotus, and the French remix/mashup artist J.A.C.K.[2]

On the Materiality of Producing Music in the Digital Medium

In *Cracked Media,* Caleb Kelly describes a potential dynamic between a producer of glitch electronica and her/his computer's software, starting with the explosion of home studios in the 1990s:

> Glitch, as the genre became known, developed as a central initial part of this outburst of creation. Producers took these newly developed, or newly accessible, musical tools and extended their use well beyond what their designers intended, pushing them until they collapsed or simply stopped working. The cliche of the period, roughly 1994–2000, was the image of the bedroom producer hunched over his or her desktop computer trying various methods to overload its central processing unit (CPU) so as to produce a new digital tick, pop, or click that could be sampled and then sequenced for the next track (2009, 7–8).

What Kelly exposes in this description is that the presence of the producer's body is key in the production of digital materiality—coaxing out the limits of the technology being used to produce sound is a process that takes time, technique, and patience. Therefore, it is important to note that the materiality of glitch music arises not just from the computer itself, but also from a human user's interaction with the computer. I'll call this aspect of production "*workflow.*" Additionally, important but non-essential functions of the personal computer, such as having internet access, can inform aesthetic decisions alongside those that are suggested by a user's chosen audio software. These interactions between a human user and the environmental components of a computer are integral to the glitch aesthetic. To illustrate, I will explain a few key techniques for producing digital texxture.

I discovered composing with electronics in 2007, which could be considered an already post-digital time–in Kim Cascone's (2000) terms,

> The revolutionary period of the digital information age has surely passed. The tendrils of digital technology have in some way touched everyone. With electronic commerce now a natural part of the business fabric of the Western world and Hollywood cranking out digital fluff by the gigabyte, the medium of digital technology holds less fascination for composers in and of itself (12).

This was certainly the case for me as I wrote my first set of pieces in the software Digital Performer 5. The tools (software, plugins, samplers, etc.) were a means to draw out unexpected or heretofore unheard-of noises from the most mundane of recorded audio samples. My process might look something like: import a sample of a bike-bell; run the bike-bell through a number of plug-ins (individual audio-processing modules designed for a specific functions such as Equalization, delay, reversal, etc) to render it completely unrecognizable; and continue playing with the sample, guided by my ear, until it has all but disintegrated and only an interesting, unheard-before artifact remains. I spent a lot of time using plugins to produce sounds they weren't originally intended for. Frequently I sampled the resulting detritus; isolating some particularly interesting little segment and recycling it; only to subject it to a new cycle of splicing, dicing, crushing, squeezing, pulverizing.

Of this process, Kim Cascone (2000) writes, "In this new music, the tools themselves have become the instruments, and the resulting sound is born of their use in ways unintended by their designers. Commonly referred to as sound "mangling" or "crunching," composers are now able to view music on a microscopic level" (16). Audio workstations, for example, allow a person to zoom in on a sample of sound until the waveform itself is visible. On this micro level,

[2] EDM, commonly understood, seems to be a catch-all term that encompasses a broad range of dance music genres at various tempos and incorporating various influences.

just a few milliseconds of sound can be altered at a time if the producer desires it. Using software to dissect, mangle, squash, mold, and stretch digitally recorded sound, can be thought of as a sort of material crafting that is tactile and textural in nature. For the composer or producer who is in a direct and intimate relationship with the touching and sculpting of this digital sound, the materiality of the medium—the processes and human labor that went into the finished sound—is apparent no matter how "glossy" or "natural" of a finish the final product has. For the listener, who is removed from this process, certain techniques or sounds are more likely to reveal the substance of digital-ness. This substance is revealed through the computer's capacity for certain types of "errors" and impressions, as well as the human/computer interactions and labor undertaken to produce those sounds.

Because the specific glitchy sound being sought is sometimes unknown until discovered, sonic/tactile pleasure plays a distinctive role in determining which new glitches are worth sampling. In cases where producers already know exactly how to produce a certain type of glitch, the "feel" of the mix--or how small gradations in amplitude, applications of FX, envelopes, rhythm offsets etc. influence the music's affective capacity—remains a driving force behind production decisions. When asked about his compositionally loose rhythms in a 2010 interview, the experimental hip-hop artist and producer Flying Lotus replied, "It's organic. I just don't quantize the stuff. You do what you feel and that's what it is. You don't try to out-feel yourself." Flying Lotus suggest here that a particular knowledge of the body comes into play during production—perhaps the ultimate threshold for determining when a mix or composition is "just right" is simply that it *feels right.*

Fracture, rupture, and decay are mechanisms that reveal materiality in more than just digital manifestations. Think of a ripped sofa spilling out its feathered insides—the smooth encasing of fabric ruptures to offer up a new richness of information about its history. Similarly, we may be mostly in the dark about the nature of a flat smooth surface until we scratch it... with a fingernail, with a penny, with a rock; all of these experiments yield information and produce hypotheses about the substance in question. In the case of digitally recorded sound, the "scratching," "distorting," or "mangling" of a sound via digital glitch obscures the sound's history (collapsing into texture), while simultaneously spilling out rich new information (expanding into texxture) about the limitations of encoding that same sound into strings of 1's and 0's.

Some have pointed out that these 1's and 0's mean that digital media hides its making. Katrine Dirckinck-Holmfeld, in her essay "Affect Image, Touch Image," intersects this perspective (voiced by Bernard Steigler) with Sedgwick's texture vs. texxture to ponder this: if digital media hides its own making, does this mean it is void of texxture?

In Dirckinck-Holmfeld's (2015) words: "one may argue that if the digital image shows its texture, it is only in the sense that its history and making is always already hidden and subject to manipulation: it is nothing but stored zeroes and ones, resulting in the imprinting of something else, of something other than the 'this that was'" (52). Dirckinck-Holmfeld goes on to *dismantle* this perspective, explaining how the pixilation and blurry degradation of footage taken of early Syrian uprisings (circa 2011) can be understood as both texxtured and textured, or as a transition between the two.

For K.D.H, the *texxtural* imprint is that of the technical demands that internet databases (YouTube, in this example) make upon images in order to circulate them efficiently; the *stuff* here in this case is digital detritus from extreme pixilation and compression; low internet bandwidth forces a dramatic downsampling of video images. In this case, the decision to downsample was made for purposes other than aesthetic ones; alongside the usual compression demands of a space like YouTube, the situation of being in politically unstable territory often means that infrastructures aren't reliable, and upload times are slow.

For Dirckinck-Holmfeld, *texturization* of this video comes from the *partial erasure* of the uprising's history through the mechanical limitations of the cell-phone camera, which renders much of what is happening in the video unintelligible (though, Dirckinck-Holmfeld notes, a strong affect of uncertainty and fear is retained.) She notes that the detachment spurred by the degraded digital can be read as a kind of deterritorialization that marks "a newfound struggle over what is and what can be" rather than what was (quoted in Dirckninck-Holmfeld 2015, 57).

This loss of resolution could be compared, from a technical standpoint, to audio bitcrushing. Bitcrushing is the practice of reducing the bitrate and sampling rate of an audio file dramatically, which removes critical information and creates artifacts. Bitcrushed drums, for example, suffer a loss of resolution of the sharp attack at the start of a note, resulting in diffuse flurry of crackles in extreme cases, such as the first few measures of "Chemicals" by The Notwist. This flurry of crackles bears little resemblance to the original sound-source, much like K.D.H.'s pixilated video lacks indexicality.

Going back to the digital *texxtural* imprint, which is marked by detritus, one can think of audio glitch similarly. The medium of zeroes and ones is a nonspecific, shapeshifting substance into which origins of recorded sound dissolve temporarily, to be reassembled by the mechanical faculties of a computer. When this reassembly goes "perfectly," summoned in an ideal setting (nice headphones or speakers,) the sound registers as "intact", not revealing the material (digitally stored data) through which the sound is summoned. When hardware fails to reproduce what is encoded, we begin to sense there is something at play—built in speakers on a Macintosh laptop generally don't reproduce frequencies below 100hz, and this sounds fishy when you're listening to DJ Spooky—but this failure is mechanical. Our sense that *data itself* (hypothetically able to represent and store a recorded source perfectly) is what has been corrupted, fractured, and meddled with shows one clear pathway to sensing the texxture of the *digital.*

The person instigating these deteriorations and fractures of a sound coaxes out pleasing arrangements of data by using aforementioned audio tools and plugins in unintended ways. They navigate their way to new patterns of sound through trial and error, listening for unusual artifacts and sampling any resulting "breakage" (which, in this case, simply means the computer encoded something "undesirable"—drawing attention to the fact of digital-ness.) This creates a relationship between the producer and the medium of 1's and 0's—because of this interplay, one could *certainly* say that digital data *is* something that can be immediately sensed, it is material.

The aesthetics of digital glitch—of *sensing data*—have indisputably spilled over into the category of "desirable sound," as producers increasingly integrate these sounds into diverse genres of music. This has created a new economy of tools specifically designed to reproduce glitch techniques, somewhat abstracting the process of experimentation; although detailed listening, fiddling endlessly with these tools to draw out pleasurable, glitchy noises, and the skilled composition of the resulting noises remains a staple of production in Electronica. Caleb Kelly (2009) discusses this aestheticization of noise by citing Oval's music.

> Oval took Cubase and Sound Designer and used them to sequence their stuttering CD samples, looping and changing their pitch. Just how this was a radical break in the use of the software is not obvious. What was radical was the source material for their audio and how they arranged the glitching sounds to make them tuneful (274).

Oval's music was a reaction to a then-common way of using software such as Cubase—which was to rely on preset sample databases that were purchased. Kelly (2009) points out that Oval's decision to turn the CD skip into "something listenable, beautiful, and catchy" opened up new directions for digital audio production in which glitchy sound was desirable sound (275).

The music I'm analyzing; James Blake, Flying Lotus, J.A.C.K., falls firmly into this camp of using Glitch techniques in an aestheticized manner. As such, these artists can be thought of representatives of a collective movement toward an embodied desire for noisy, tactile, and material sound.

Examples of phenomena that reveal the materiality of the digital to a listener include:

1. *Aliasing*, which occurs when there are sounds in the mix that exceed half the

sample rate, creating sidebands that wrap back into the audible spectrum.

2. *Bitcrushing*, or reducing the bitrate and sampling rate dramatically, which removes information and creates artifacts.
3. *Distortion or clipping,* when audio gear or hardware reaches its input capacity and chops the signal at its peak amplitudes, turning the smooth wave into one with hard edges. Though usually indicating an overloading of something analog and electrical, a computer encodes these hard edges when such sounds are sampled or imported.
4. Amplitude pops, which occur when a signal "hops" to another amplitude instantaneously with no crossfade.
5. The sampling of the *noise floor,* a hiss that is added to recordings through the computer soundcard or other interface which the signal must pass through. *Noise floor* may also refer to background noise present at the time of recording a signal.
6. Other techniques common to the genre such as chopping, EQ sweeping, stuttering, and a plunderphonics or mashup aesthetic can be considered part of the *environment* and *workflow* associated with this genre of music and contribute to texxture in ways I will elaborate upon later.

To illustrate the effects of these audio techniques, I will describe the *texxturization* of a recorded voice via extreme degrees of timestretching. I import a short sample of myself singing two pitches (leaping up a about a minor 6^{th}, to be exact) into a digital audio workstation. Listening to the original sample, one can notice small increases in inharmonic breath-sound at the end of the first note, and another burst of throaty breath-sound at the beginning of the second note. I use the timestretching tool, which manifests in my software as the shape of a little hand, to stretch the sound sample to about twice its original length.

The result is an instantaneous metallicization of the pitched voice. It now sounds as if it has additional harmonics—subtle, but definite harmonics—that no voice in the extra-digital wilderness could produce. Approaching the white noise of the breath as it precedes the next pitch, the tool's patented algorithm utterly fails to reproduce a convincing timestretched version of the original. The small burst of white noise is replaced by a short series of gargling, pseudo-pitched, tremolo sounds that leap up and down seemingly at random, before settling back down upon the second metallic pitch, this time with little tics and dips upon its surface, made by the software's attempts to "correctly" analyze and re-synthesize my original sample. This kind of zooming-in, along with the resurfacing of "natural" sound samples with digital texxture, is one common example of a digital tool revealing its materiality. The once smooth and "natural" surface has become noticeably corrupted by the same medium through which it must pass to reach a listener.

Simultaneously, the original recorded sound and its history has been partially (or sometimes entirely) obscured. The original sources can never be recovered from that exact file, once written—the transformation is irreversible and cryptic, like that of a chemical reaction. However, this doesn't negate the fact that there is a raw materiality to the resulting sound, which has texxtural properties that reveal the oven in which it was baked. I contrast glitch musics (with all of its abundant manifestations and genres) with my aforementioned heavily produced, glossy musics (such as Iron and Wine); both skew and delete information—but glitch and its siblings use this deletion of information to produce texxture.

Aesthetic techniques that don't deal explicitly with digital error can also reveal materiality and method. The practice of "chopping," (altering a voice or other single sample by removing segments of transitional material, such as the breathy decay of a note or the attack) and "Mashup" (taking small bits of sound from many disparate sources and patching, stitching, or pasting them together) draws attention to the use of digital-ness. In this case, the flows between human producer, computer, and other networks such as internet communities and DJ/dance communities can be understood as enabling this practice. Jérôme Hansen discusses the relevance of the studio space in shaping the manner in which artistic practices are carried out in his article "Mapping the Studio (Fat Chance Matmos): The artist's workspace in sound and visual arts." He posits that although the studio *could* be seen as a private experimental space that is impermeable to external systems,

> the technologies that entered the sound studio in the last decades nonetheless imposes a reassessment of the entire network of humans and nonhumans gathered in the production and diffusion of sound works. Development of multi-track recording, possibilities of compatibility and real time composition allowed by industrial standards (MIDI), wider availability of digital samplers and sound processors, more powerful and portable computer, without saying anything of internet-based communication and its decentralized modes of collaboration—the list of new actors in the contemporary recording studio could go on forever (Hansen 2006, 4).

While Hansen's study primarily narrows in on the sociological functions of studios, I find his descriptions of the complex, mobile, and networked modern studio to be useful.

In Mashup*,* sound samples, whether downloaded/recorded improvisitionally from many disparate sources or painstakingly curated with layers of reference and allegory, are chopped into bits of various lengths and patched, pasted, or stitched (I choose the material descriptor depending on the "feel" of the transitions between bits) into a new work of electronica. These samples are taken from a variety of artists with a variety of producers who likely used different microphones, interfaces, and studio techniques. Each bit is imbued with its own sonic profile that no amount of equalization, filtering, or reverb can entirely neutralize. Even when glitch techniques are applied to these samples, the resulting artifacts leave traces, no matter how indecipherable, of what happened before.

This granularization and rearrangement of pre-existing samples can be considered digital texxture because, like pops, clicks, and quantization noise, it starkly reveals itself as a product of working in the digital medium; precise and often nearly microscopic ruptures in sonic space are the mechanisms that produce this richness of information. If the simulated "live performance" of musicians in multi-track recordings can be considered *textural* or refusing information about how it was created to its listener, the technique of mashup can be considered its *texxtural* counterpart; simulated co-presence in this case is usurped with sharp juxtapositions of sound snippets from many spaces, times, and musical lineages.

Remix artists frequently use this technique in conjunction with *chopping*. The practice of chopping is thought to have originated via the "chopped and screwed" turntable techniques pioneered by Houston's DJ Screw in the early 1990s, in which a song was slowed down on one turntable, then delayed and repeated on a second turntable (Bloomquist and Hancock 2013). Working on a computer rather than a turntable, digital chopping similarly enables a voice previously singing at one tempo to be readjusted for a new tempo, with an added "technologized" sound from removing sections of the sung notes on a nuanced, microscopic level previously unavailable through the analog technology.

As I'll discuss in my analysis of three contemporary electronica works incorporating glitch techniques; the histories of DJ culture, sampling, plunderphonics, hip-hop, dub, and house helped establish recorded music as potential compositional material in a way that is critical to the explosion of cross-genre glitch electronica being created today.

Analysis of Three Works: Intro

"Why don't you call me" by James Blake (2011)
"Tea Leaf Dancers" and "Table Tennis" by Flying Lotus (2007 and 2010)
"Living Ipod" by J.A.C.K. (2013)

Most authors writing about glitch have stuck to the straightforwardly experimental glitch (including turntable) artists such as Kim Cascone, Christian Marclay, Yasunao Tone, Oval, artists on the experimental glitch label *Mille Plateaux*, Ryoji Ikeda, and various artists who appear on the *Clicks + Cuts* compilation album. My interest lies more in the incorporation of these glitchy sounds, along with materialistic practices and effects drawn from the musical lineages of dub and hip-hop, into the sprawling, continuously inventive, continuously hybridizing blanket genre of EDM. EDM has spawned seemingly thousands of labels for niche subgenres, all extremely difficult to trace or study because most of the information about these micro-genres resides in online discourse. Fans and followers constantly invent new terms and labels accompanying the music and culture surrounding it. Arielle Saiber touches on this in "The Polyvalent Discourse of Electronic Music", noting, "...neologisms abound in discussions of this music. Even a mere 'sampledelia' of these 'teched-up' words, which attempt to convey everything from a 'noisenik,' 'intricatronic' 'disturbathon' to a 'panegyrical idylltronica' would be enough to convey the idea" (Saiber 2007).

My three artists; James Blake, Flying Lotus, and J.A.C.K. fall variously under the labels of post-dubstep, experimental electronica, R&B, hip-hop, glitch-hop, complextro, and electro-house, to name just a few! Each artist uses glitch techniques, implicitly or explicitly, to different musical affects. *Rupture/Suture (bursting or breaking and then stitching back together)*, *fracture (a crack, fissure, or split)*, and *decay (disintegration, deterioration)* in continuous sound and in spectral musical spaces will be illustrated in various capacities through the different works I have chosen. For James Blake, I look at the affect of *fracture,* or the splintering of musical material into discontinuity. For J.A.C.K. I look at the affect of *rupture/suture*, in which unlike materials are surgically glued or stitched together. For Flying Lotus, I look at *decay,* or the slow masking and deterioration of certain musical elements across time through the introduction of layers of noise and glitch.

It is important to remember that EDM genres such as dubstep are by-and-large live music practices, enabled frequently *not* by the songwriters/producers themselves, but by DJ's who put together mixes of many different artists on vinyl, compact disc, or digital playlist formats (Fraser 2012). Although Blake performs live shows, and songs from his debut album such as "Limit to your Love" are meant to be felt live in a club, the album "James Blake" is also indisputably, popularly listened to as a private endeavor; it can and has been purchased and downloaded and saved to innumerable YouTube playlists; listened to by people all over the world who have little knowledge of or access to the dubstep scene in London.

This tension between the social, live often *localized* dance culture of certain EDMs and the *fact* that these musics are also imbibed in private, individualized, but also networked settings (the internet) means that the intended function of this music is not always congruent with its use. Because of this discrepancy, I will be listening to James Blake, Flying Lotus, and J.A.C.K. from the vantage point of the self-curated experiencer who recognizes the social listening/feeling practices associated with these genres and lineages, and investigates how those practices shaped the music. In the case of James Blake and Flying Lotus, certain production decisions lead me to believe that these tracks are intended for this private listener, as both use carefully honed digital artifacts that would easily fall below the threshold of perceptions in a loud setting like a club. I imagine that J.A.C.K.'s tracks are meant to be felt live, although they are available on both YouTube and SoundCloud, due to the heavy amount of compression and the fact that he's a mostly a D.J. (based on his Facebook group.)

"Why don't you call me" - James Blake (2011)

> It was dubstep though that unlocked Blake's creativity. Beforehand, he'd found his own lyrics "cringeworthy" and disliked the way he sang: 'I felt like it wasn't my own voice; it was the product of everything I'd listened to.' That all changed when he started to try and make his own dubstep tunes. Instead of composing on the piano, Blake was producing songs using Logic software on a computer. 'I could record them and look at them, almost physically – graphically – and just chop up what I did like and I didn't like," he says [...] 'It didn't have to be all in one take, it could be something I designed from the ground up, visually. That process completely solved that problem for me' (Needham 2011).

I start out with a quote by Blake concerning his own process in order to frame my discussion of "Why don't you call me," a 1 minute and 36 second song on his self-produced debut album entitled "James Blake." The song seems to operate as a transparent illustration of this quote; it can be divided into three sections that progressively disintegrate the first "raw" recording of Blake's singing voice through autotune, pitch-shifting, and a blunt take on chopping that results in amplitude pops, revealing harsh edits between the piano tracks, vocal tracks, and samples of the resonant reverb tail used on at the last few seconds of the song. The song operates as a brief interlude in the arc of the album, which is starkly, minimally produced; amplitude pops caused by ruptures in sonic space and rough, transparent looping of the vocal material, as featured in the track "I Mind," are forefronted rather than blurred over by additional layers. While the track I examine is more Soul-influenced, the album and its production is heavily influenced by dubstep.

James Blake grew up in Enfield, an area north of London. Around the time of the release of his first few singles such "Air and Lack Thereof" (2009, *Hemlock)* he conceived of himself as a dubstep artist, but later he posited that his geographical/cultural distance from the area where the genre originated, Croydon in South London, is responsible for the marked difference in his sound compared with "real" dubstep artists working in the early 2000s (see Needham 2011). Other musical lineages and artists he references as formative include R&B, soul, and experimental disco: in particular, Destiny's Child, D'Angelo, and Arthur Russell (Blake 2011).

Though the influence of these artists is indisputably apparent in Blake's vocal stylings, it was early dubstep, discovered by Blake in 2007, through which he was drawn into his current production aesthetic and where he made his popular debut. "The DJ played a Coki track called Haunted, and it took me so far into my own head that I couldn't work out how it was happening" (Needham 2011).[3] Listening for reference, "Haunted" has a stripped-down, almost lo-fi, almost-inaudibly-low-but-extremely-loud synth rumble beneath a lilting drumkit loop. Occasionally there are mid-range pinging noises that swim in a reverb reminiscent of early Jamaican dub; the slow tempo reflects this as well. Blake's first dubplate, "Air and Lack thereof" echoes this track's aesthetic, using low-fi, fuzzy samples as well as what sounds like bitcrushed synth pads and subterranean bass lines. It also includes abrupt, repetitive, electronically altered clips of Blake singing single phrases. This same minimalist approach to vocals ties together the post-dub tracks in "James Blake" with the slower, more soulful tracks, such as the one I'll be examining.

"Why don't you call me" uses the glitchy sound of amplitude pops to create a fractured soundworld where Blake's voice slowly recedes into layers of effects that blur, if not entirely erase, his original vocal inflections. Fracture can be thought of as a cracking or splintering of one material into discontinuity, separated by some substance that marks, tactilely, where the splinter occurred. In this song, we get the textural impression that there was some continuous musical process happening that was splintered into large chunks and pasted together in a slightly different order. The substance marking these fissures is these momentary amplitude pops. This need not be a metaphorical discussion; as these sounds point clearly to this exact technique of fracturing tracks and takes, carried out in the environment of Audio editing software.

The song in its entirety seems unfinished—if one listens closely, the first split second contains the tail end of a piano chord, almost but not quite edited away, drawing our attention immediately to a condition of listening to recorded music: we are in a space other than the one in which this was made. The small section beginning at 0:37, bridging into the last iteration of the single melodic phrase, features tiny subsections of contrasting vocal and piano material that are abruptly cut off (again, with those harsh, popping cuts), as if Blake changed his mind about the direction of the song halfway through and decided to include these splintered traces of his compositional process. This small section acts as a bridge to the last, long section starting at 0:51, in which Blake iterates over and over the single phrase "Why don't you call me what we both know I am." This time, pops consistently appear at the beginnings of the words "call," and "both,"

[3] Coki and Mala are the two members of the early dubstep group Digital Mystikz, also known as DMZ.

and the word "me" is fractured through the vowel. This theoretically gives a consistent rhythm to the amplitude pops; but it is difficult to hear them this way, as each one is placed slightly differently, making it always feel a bit abrupt.

Alongside these harsh cuts, which unequivocally point toward the labor undertaken in the studio, the manner in which Blake obscures his own voice is a conscious pointer toward the materiality of the digital. In the "raw" first take, Blake's voice and the piano seem to essentially sound in the same space; a hiss of background noise is present. There are pitch fluctuations and "imperfections" in his singing tone. In the second iteration (0:20) marked by a pop starting with the word "why," Blake has conspicuously autotuned his voice.

Alongside these vocal transformations, the piano subtly transforms. Listening closely again to the first take, a detuned rattling is present after the first few piano attacks, suggesting maybe a vibrating piece of paper on the piano stand, or some imperfection in the piano's strings. It is nearly imperceptible, but present. The second round more clearly recalls this extraneous vibration that was present on the scene at the time of recording. It could be that Blake intentionally amplified this artifact, or even sought to tease it out from the piano resonance. This use of digital glitch to highlight and amplify the producer's presence in the recording as well as the way in which digitalness interacts with physical properties of the resonating substances being recorded (the piano, Blake's voice) can be configured as texxture.

J.A.C.K. Influences

The musical sensibility of the French remix artist J.A.C.K. can best be described as stemming from the practices of French Electro-House, Complextro, and Mashup. Electro-house has many nuanced European manifestations and can be traced from the traditions of Chicago house and Detroit Techno; Complextro can be seen as one of the many subgenres branching from this polyvalent tradition. Mashup is a plunderphonics practice that both draws from and generates a broad range of aesthetics. It is possible that different manifestations of mashup evolved convergently from the practices of sound collage and sample-based hip-hop although it would be difficult to pinpoint these influences in a world where most information resides in blogs, tweets, and music posted in online databases such as Soundcloud and Youtube (Grobelny 2008, 229–30). Before diving into a description of J.A.C.K.'s aesthetic, I will provide a brief account of musical influences of each practice I've discussed above.

The Electro-house/Disco Connection

Hillegonda C. Rietveld notes that Electro-House is commonly punctuated by references to disco and funk. She describes a personal encounter with a 2007 DJ set in Rotterdam, Netherlands, curated by Chicago House DJ Larry Heard. In this DJ set, Heard used a blend of old and new tracks from various offshoots of House to "make fresh, nomadic, connections within the archival memory of contemporary electronic dance music" (Rietveld 2011, 13). Rietveld explains that this archival memory has strong influence from disco, contextualized brilliantly in Heard's set.

In particular, a 2006 track by Grand High Priest called "Mary Mary" piques Rietveld's interest, and she enfolds a detailed description of the social motivations and influences that caused the Chicago artist to incorporate samples of Aretha Franklin's, "Mary Don't You Weep." Infusing this description is her position that

> house music is forever in a state of becoming. From around 1985-86, house music's DiY aesthetic spilled to West Europe and beyond, to develop into a generic cosmopolitan dance formula across global club and party dance floors, picking up influences and mutilating in the process (Rietveld 2011, 7).

Rietveld (2011) illustrates through these positions that through house music, the "musical memories of disco are inscribed and re-enacted, embedded and embodied" (7). The DJ set, which has the potential to temporarily build meaningful, contextualized relations between past and present, is the assemblage through which these memories materialize.

Alongside its various uses of disco samples and sounds, a notable feature of Electro-house is the aesthetic of the bassline, which frequently uses Sawtooth waves in conjunction with pitch-gliding (the EDM version of a glissando). Sawtooth waves have a crunchy, gritty quality due to their jagged shape; it's a form of distortion. As the pitch gets lower, the series of pops caused by this distortion become more salient as a rapid string of attacks, creating the illusion that we can hear lower than humanly possible. The Electro sawtooth bassline assumes a tactile salience through this quality of roughness.

Complextro

The term Complextro is a portmanteau of "complex" and "electro," coined by Porter Robinson in 2010. The genre is marked by glitchy, disjunct basslines, dubstep-influenced bass drops, and fast shifts between a multitude of different synth sounds and effects. According to a feature in *Nashville Scene,* Porter Robinson's 2011 EP *Spitfire* incorporates 19th century classical harmonies, video game sounds, and intentional detuning of synth sounds (Hurt 2012). Listening to the title track on *Spitfire,* another notable element is an extended interlude in the middle of the track that uses a soft, airy string pad to voice a series of classical chords in painfully straight rhythms, with synthesized bells undulating above as an inverted pedal tone. Notably, the bassline here moves contrapuntally to form chord inversions rather than sticking to root position. This peculiar interlude serves to highlight the following section, which is composed of disjunct, Electro-house influenced gritty bass synths (often in triplet figures), chugging away on the tonic, sharply punctuated by whining, stuttering 8-bit-style synth sounds.

Mashup

Mashup is more of a practice than a particular sound. Most simply, the producer takes samples or key elements from two tracks, usually popular music, and fuses them into one piece of music. More complexly, a mashup might use many more than two artists, incorporating fragments of the plundered songs into different horizontal and vertical musical layers. The "bedroom" producers doing the mashing are often anonymous or under a certain threshold of popular visibility due to copyright laws.

Although the sampling, collaboration, bootlegging and combining of popular musics existed well beforehand, the contemporary practice can be viewed as digitally-driven, becoming widely popularized in the early 2000s.[4] According to Michael Serazio (2008), "For the mash-up to proliferate, two key technological developments were necessary: an abundance of available source material, which, by the late 1990s, had amassed on the Internet, and cheaper music software that facilitated the deconstruction and reconstruction of songs" (81).

One common element to this deconstruction/reconstruction is the squeezing of different materials into the same key and tempo, which is enabled by Digital Audio Workstation softwares such as Acid Pro. Users with little to no musical background can use such tools, alongside tools that enable illegal downloading and "recording" (Soundflower or Blackhole for example) of musical content posted online. Serazio discusses a number of optimistic and critical perspectives on this, ranging from notions that mash-up is the ultimate corporate-industry-subverting democratization of music, to the lament that mash-up ushers in a devaluation of the DJ's role as curator of the underground, to the observation that the late-capitalism music industry quickly appropriated mashup, originally an underground genre.

Serazio doesn't discuss (or only touches upon as an aside) the forces of desire and the physical materiality of the music itself; the labors, desires, and pleasures that went into creating it, and the bodies that take pleasure from musical/tactile results that are shared. The mash-up's potential to be flippant, ironic, and overly referential doesn't negate its material qualities, which are rich—Mashup has things to feel.

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[4] Michael Serazio (2008) cites Aerosmith's "Walk this Way,"(1986) as well as Evolution Control Committee's "Rebel Without a Pause"(1994), which combined Chuck D's rapping with Herb Alpert's Latin brass sound.

"Living Ipod" - J.A.C.K. (2013)

The first few seconds of the song play like a parody of the entire genre of EDM. These moments contain much of the musical information found commonly in EDM—a synth pad pulsating beneath a kick drum for example—but the affective power of the sound is greatly diminished. J.A.C.K. accomplishes this by lowpass-filtering the series of chords that are sidechain pumping along with the kick drum.[5] Much of the sharpness and presence of a given sound is contained in its higher frequency information; lowpass filters tend to create a murky quality by eliminating this spectral zone. In Luis-Manuel Garcia's (2015) discussion of the affective impact of beats, he notes that impactful, percussive sounds have a prominent *transient,* "that is, a brief, spectrally rich burst that is substantially louder than the rest of the sound" (62). This transient is *key* to the percussive, physical impacts that Garcia discusses as critical to EDM's tactility.

Through the first 16 seconds of "Living Ipod," the filter makes a sweep from the low-range, through the throaty mid-range, into the hissy upper range of frequencies, fleshing out at the end to theoretically let through everything—although this "everything" comes in the form of heterogeneously spectral, fine-tuned gradation and control of individual synth samples and plundered musical samples. The new texture starting around 16" breaks sharply from the initial kick-drum/pad pumping, and is punctuated by glitchy, spectrally rich percussive sound. The introduction of the song, with the help of Garcia's tactile percussive impacts, can therefore be thought of as intentionally withholding sensation before releasing the listeners to the full sensation of impacts, fleshy sounds (human voices singing, often configured through J.A.C.K.'s manipulations as exclaiming), and grains (via rough, glitchy sound.)

Supporting these fine-tuned tensions and releases, driven by tactile sensation, J.A.C.K. has created a rough patchwork of 0.5-2 second samples from a list that appears beneath the YouTube upload of the song. This patchwork ultimately results in an affect of *rupture/suture.* The samples are subjected individually to a multitude of differentiating effects, such as pitch shifting, bitcrushing, distortion, EQ sweeping, and filtering, all of which change the haptic qualities of the original samples, and then glued or sewn together. As each sample is conspicuously from an entirely different source, this creates the impression of a "wound" or "rupture" between samples that is mediated, or "sutured" by the common tempo and pitch adjustment that is so endemic to mashups, as well as J.A.C.K.'s orchestrations of gesture—where samples are often made to "complete" each other's incomplete phrases. The traces of previous producers in the mix, combined with willfully drawing attention to the conditions under which this music was made (the economy of plundering made possible by the proliferation of content on the internet), is an example of how Mashup is a texxtured art.

In addition to the texxture emerging from the conditions of "Living Ipod's" making, the choice to differentiate each sample through various glitchy effects *before* pasting them together creates an affect very distinct from simply pasting the samples together on their own. Instead, it reveals and establishes fine-tuned control over the impactful and tactile elements of the mix. J.A.C.K. uses lowpass filters, as previously discussed, to "suck away" transients, reducing the haptic grain, while using bitcrushing and distortion tend to transients—crunchiness. Frequently, J.A.C.K. will entirely "trash" a sample, rendering it nearly unrecognizable (see 2:48) by either crushing it into oblivion or interpolating it rapidly with glitchy interjections, momentary silence, or thinly textured sound. This often results in a momentary blip of clean synth or untouched sample surrounded by trashed, dirty, and noisy sounds or samples.

This orchestration of tactility is further exemplified by a synthesizer interlude at 1:36. J.A.C.K. starts the section by using a melodic lead synth that sounds akin to a square wave,

[5] Sidechain pumping is a common hip hop and EDM technique in which the pattern of compression attenuation generated from something with a sharp attack, such as a kick drum, is used to shape the envelope of a more continuous sound such as a voice or a synth pad on another track.

which is often described as having a "hollow" sound, somewhat akin to a clarinet. At 2:02, the lead synth abruptly shifts to a sawtooth wave, which is the more common choice in Electronic Dance Music due to its "dirty" or "gritty" sound. This shift to the sawtooth wave precipitates a return to the previous iterated dirty, noisy, patchwork soundworld at 2:11.

These carefully orchestrated shifts and drops in tactility, negotiated through levels of glitchy-ness or smoothness, along with fine-tuned suture of plundered samples, marks the intensive labor – the sculpting, texturization, carving of sounds--undertaken in the studio, as well as preserving traces of the past labor that went into each plundered sample.

Flying Lotus – "Tea Leaf Dancers" (2007) and "Drips/Auntie's Harp" through "Table Tennis" (2010)

Flying Lotus (Steven Ellison) is a Los Angeles-based producer and composer of experimental hip-hop. As noted by several sources, he is the great-nephew of jazz musicians Alice and John Coltrane and the grandson of Motown musician Marilyn Mcleod. Although genres such as drum 'n bass and hip-hop were formative for him, his music often samples jazz or references the harmonies, materials, and structures therein. He attributes his crazy beats partially to hip-hop artist J Dilla, who, in his view, knocked everyone in the LA scene into creative "overdrive," and whose music he finds to be "soulful" and "spiritual" (see Zadeh 2014).

Ellison frequently cites and samples Alice Coltrane especially. During the production of his third album *Cosmogramma,* which was written in the wake of his mother's death, he cites listening to Alice's music for inspiration and solace:

> I can honestly understand why she made the music she made after John Coltrane died. I can see why she'd be inspired to make those sounds. Those specific sounds with those specific instruments totally made sense to me. I feel like she was grieving through the music, understanding his passing. I know it must have shaken her entire universe. I know what she went through. I get it. I'm not the kind of person to shy away from my family connection, we're all really close. I wanted to feel part of that thing (Flying Lotus 2010).

The album *Cosmogramma,* from which I take the songs "Drips/Auntie's Harp" through "Table Tennis," (which play as continuous tracks) is a busy, dense kaleidoscope of glitchy blips and bleeps, layers of noise ebbing and flowing, jazzy riffs on various acoustic instruments (the record includes saxophone samples from his cousin Ravi Coltrane), long lush pads of slightly detuned harp and strings, and video game sounds. The song "Intro: A Cosmic Drama" seems to directly reference Alice's harp playing and contain a strong resonance with her 1972 Album *Lord of Lords,* the title track of which is a dense wash of harp glisses, glittery percussion, and tumbling melismatic strings. Flying Lotus, in his style, has added a layer of rhythmic glitches floating in the spectral background. This resonance is unsurprising, as Flying Lotus cites *Lord of Lords* as a major influence.

Before I get to *Cosmogramma* and "Table Tennis," I wish to address FlyLo's (as he is colloquially known) dramatic use of sidechain pumping in a 2007 track called "Tea Leaf Dancers." Sidechain pumping is both an analog and digital production technique that involves taking the compression output for a rhythmically active channel, that is—one containing sharp attacks—and using the resulting envelope to shape a sustained instrument sound in another track, usually some sort of synth pad (as heard in the very beginning of J.A.C.K.'s "Living Ipod.")

The result is usually a sort of cadence where the sustained instrument assumes a rhythmic quality, rapidly fading in on an offbeat or in between beats. Used to a grotesque degree, this can be dizzying, as heard in "Tea Leaf Dancers," where a human voice is the sustained signal being shaped. Flying Lotus's irregular beats with varying volumes (which trigger the compression differently) contribute to the disorienting sidechain pumping in this song. The result is a choking effect, or affect, maybe; because a human voice is being used and it's being modulated at lilting intervals, catching different vowels and consonants (sometimes so dramatically that it sounds as though the front of a word is chopped off), we *constantly* sense the interruption of the continuous signal by the sidechain compression.

Jay Hodgeson (2011) draws an aesthetic distinction between sidechain pumping and ducking in an article exploring these techniques: "...side-chain pumping alters the dynamic contour of tracks and, in the process, transforms pads and ambience into rhythmic upstrokes. Ducking, on the other hand, increases the textural density of tracks, and extends their temporal envelopes." As an example, he notes that common usage of ducking in hip-hop and electronic dance music is for the purpose of controlling automating the mix volume of reverb and delay lines. By temporarily "ducking" these effects beneath the generating signal, the clarity of attacks in song or speech comes through at the front, while the delay and reverb "catches up" at the tail, adding the desired texture to the sound while maintaining clarity.

All these effects can be heard exquisitely orchestrated, along with aestheticized layers of noise and glitch, in "Drips/Auntie's Harp" through "Table Tennis," near the end of *Cosmogramma.* Taken altogether, these effects work on the material of the music (particularly the vocal lines) to produce an affect of *decay* or disintegration. This is hinted at in the beginning of "Drips/Auntie's Harp," where a lush soundscape of strings and harp, seemingly distant, is layered over with a fine-grained texture of pops and clicks. This suggests that we are listening to something from the past—evoking the sound of a scratched vinyl record.

Right off the bat in "Table Tennis," the ducking of the delay line on Laura Darlington's vocals is apparent. The delay itself has an affect of decay—a measured, gradual distancing from the input signal. As FlyLo adds additional layers, many of which are full spectrum or noisy, the voice gradually recedes away from the foreground. One need only make a cursory comparison between the opening five seconds and anywhere in the middle of the song to realize this masking effect. Alongside masking the voice, FlyLo subtly disintegrates the quality by—I think—adding light sidechain compression, using the extremely low pulsating bass as the source signal. The addition of vocal delay textures on higher pitches starting at 01:17 gives the impression of diffusion, of scattering particles. Furthering this impression, the voice begins to blend with the swarming glitchy sonic particles—at 1:30 a human-like envelope of hissing white noise seems to momentarily fill in the lyrics. This impression of decay, of denaturing or unraveling *literally* manifests as the voice splits in two at 01:41. Alongside this splitting, the voice(s) begin to stutter and fracture in CD-skip fashion until the end of the song.

Noise and glitch in Flying Lotus's work often manifest in complex layers that mask each other in complicated ways, ebbing and flowing to let through certain amounts of a given sample or signal. He often uses slightly detuned sounds as well, as in the case of the of "Do the Astral Plane" from *Cosmogramma* and "Me Yesterday//Corded" from *Until the Quiet Comes.* These clouds of sonic particles, mostly comprised of glitchy pops and crackles, are often placed carefully in different levels of reverberant and panning space, lessening the immediacy of haptic qualities (reverb tends to take the sharp "edge" off transient sounds), but allowing the affect of decay (which is greatly *assisted* by reverb and distance—since we are sensually attuned to how sound decays through space) which is so prevalent in his music, to persist.

The placement of glitchy noises behind a sheen of reverb tends to reduce their salience as texxture—as their immediacy is somewhat abstracted away. Texxture in Flying Lotus's music seems to emerge from consistent references to and resonances with his family's rich histories of jazz. Using samples of Ravi Coltrane and composing in a similar style to Alice Coltrane in *Cosmogramma,* he explicitly recognizes that his labor is the product of many others' labor. This is displayed through carefully carving the samples and referencing their own spaces in the mix, so that they resonate as themselves—distinguishable as relics.

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The Scuffed Computer Improviser: The Aesthetics of Imprecision in Artificial Intelligence Musical Improvisation

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Abstract

This paper introduces the Scuffed Computer Improviser (SCI), a piece of artificial intelligence (AI) software designed to generate music in dialogue with a live human performer. While some of the technical details are described in this paper, the central focus is a consideration of the musical motivations and aesthetics of the SCI.

The design concept for the SCI challenges the optimist-utopian perception of AI through a purposely imprecise and transparent design. The SCI is an audio-corpus-based computer improviser developed by the author in 2020 using the visual programming language MAX. This paper begins by considering the artistic goals of developing the SCI in the context of the recent research in improvisation and live algorithms, along with relevant technical details of the software. The paper concludes by proposing future improvements for the SCI and computer improvisers in general.

The Scuffed Computer Improviser

The Scuffed Computer Improviser (SCI) is an audio-corpus-based software improviser developed by the author in 2020/2021 in the visual programming language MAX. The focus of this paper concerns the musical motivations and aesthetics of the SCI, touching upon technical aspects as necessary. The development of the SCI was guided by my desire to create software that could function as a convincing musical participant in the context of an interactive musical performance, reflecting Michael Young and Tim Blackwell's proposal regarding live algorithms for music:

> Live algorithm research is not concerned with systems that imitate human behavior; genuinely novel outcomes are sought, a product of renewed forms of human-computer interaction. We propose a pragmatic approach, placing machines in a functional, social setting of improvised music-making, where semantics are imprecise and behaviors (or system outputs) must be assimilated on-the-fly. We hope that this practice can further our understanding of artificial creative intelligence (Young and Blackwell 2016, 508).

The SCI is intended for musical situations where thematic ideas, stylistic features, and musical structures emerge through the communal effort of humans and machines. The SCI is designed to pressure human musical partners away from habitual tendencies by asserting a unique performance style and process of musical interactivity rather than attempt to emulate human behavior. While the machine-like artificiality of the SCI is highlighted, it is also distinguished from automatic mechanical processes like delay lines, harmonizers, and filters by asserting an impression of intelligence and spontaneity.

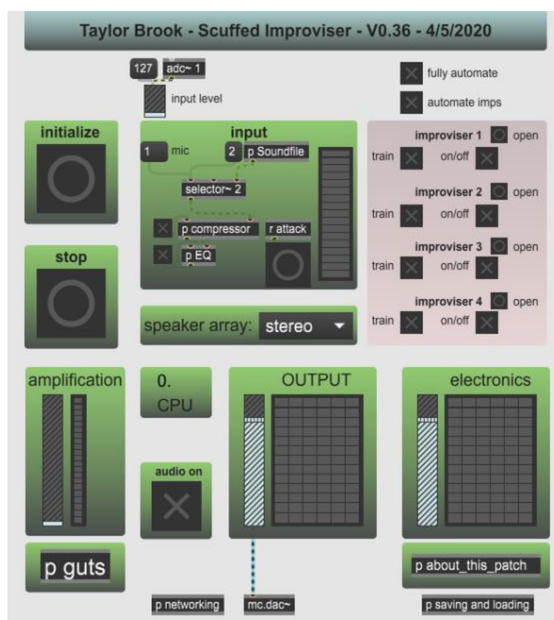

Fig. 1. User interface for the SCI

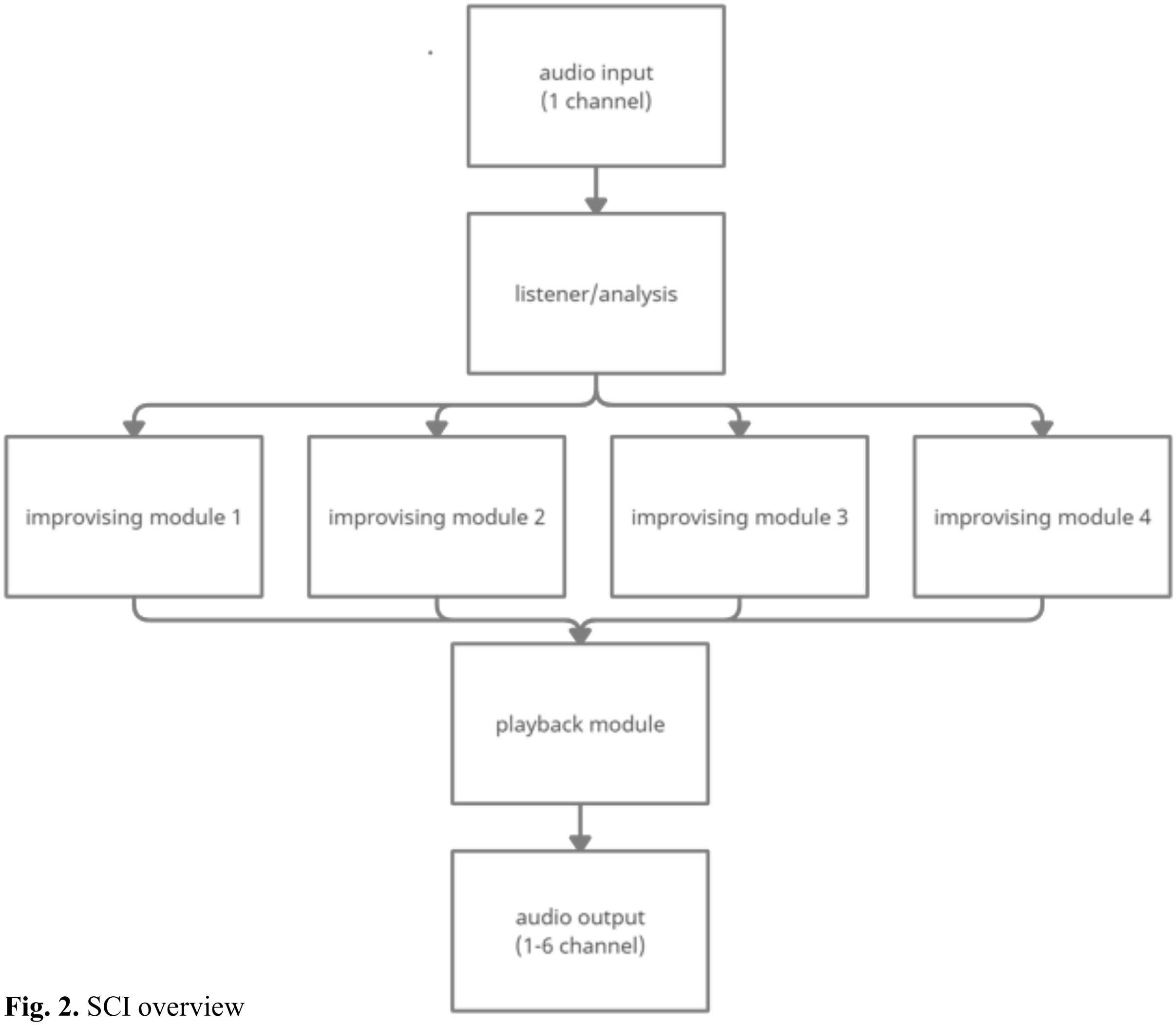

Fig. 2. SCI overview

The SCI and Improvisation

Improvising musicians cultivate a lexicon of musical devices, patterns, techniques, and modes of interactivity, resulting in an identifiable "personal sound" that remains spontaneous and broadly unpredictable in detail. In developing the SCI, my approach to designing a convincing partner for improvisation was informed by reception theory, a literary theory that has gained prominence since the 1970s, which argues that the reader and the text itself, rather than the intentions of the author, create meaning (Holub 1984, 6). For the SCI to be a successful creative contributor, it must project a fully actualized "personal sound" and contribute dynamically to how a spontaneous collective performance unfolds. A computer that repeatedly completes a process accurately projects a machine-like character, exposing the lack of creativity. When software is trained to identify if a traffic light is green, yellow, or red in an image using machine learning, we generally understand this as completing a task rather than exhibiting intelligence, even if behind this process is a neural network that emulates an intelligent process. However, when the identification of traffic lights combines with other functions and reacts to inputs in real time, an impression of intelligence may arise. In the SCI, a combination of artificial intelligence techniques undermines the predictability of underlying tasks to project creativity and intelligence.

In the context of live algorithms for music, the impression of intelligence may be derived from a projection of creativity. Cognitive

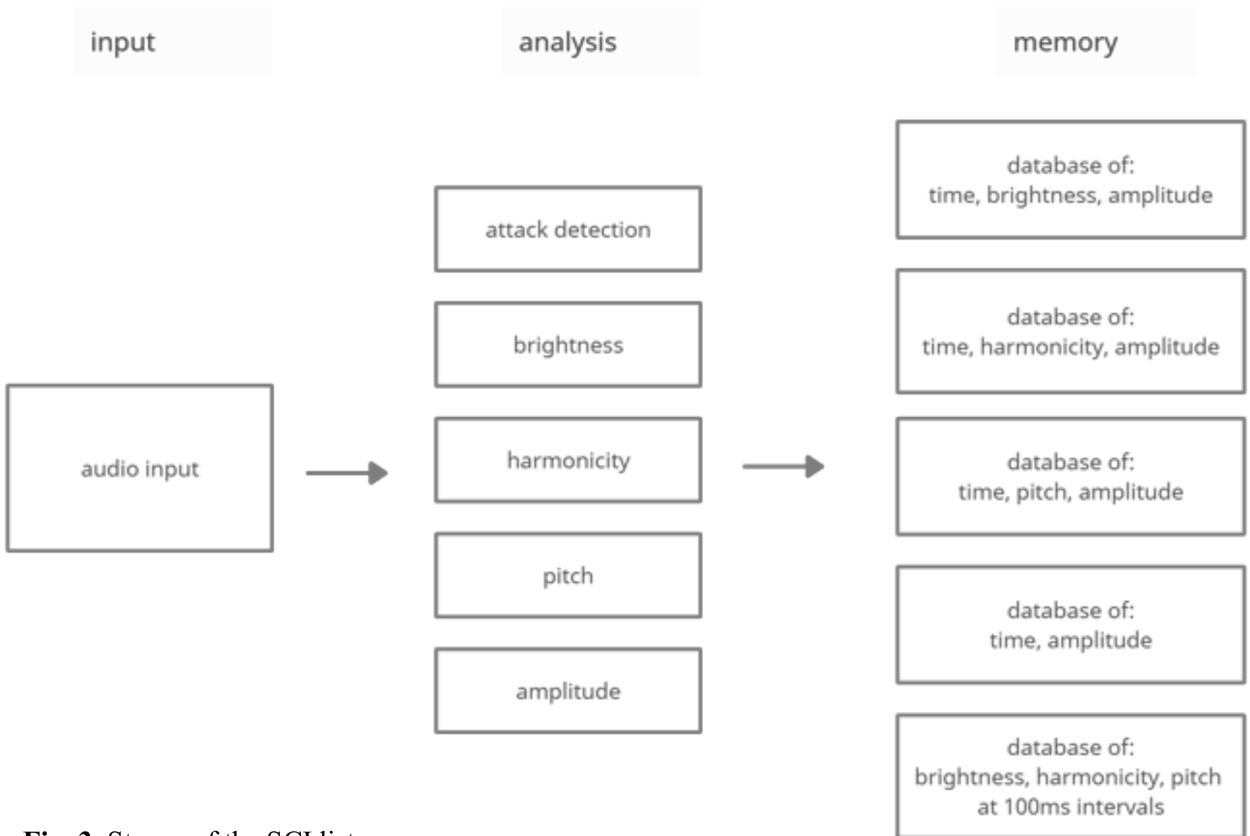

Fig. 3. Stages of the SCI listener

scientist Margaret Boden posits three avenues to creativity: unfamiliar combinations of familiar ideas, the exploration of conceptual spaces, and the transformation of existing styles and concepts (Boden 2004, 3–6). While all three methods are represented in the SCI, Boden's first pathway to creativity – unfamiliar combinations of familiar ideas – is most clearly represented in the programming of interactive musical behaviors. Each musical behavior (see below) programmed into the SCI does not bear the burden of projecting creativity alone, but combine and recombine to create complex meta-behaviors. These meta-behaviors have shared qualities, being built from the same pool of behaviors, and thus cohere musically and contribute to the impression of a "personal sound."

The Guts of the SCI

The SCI contains a machine listener, which interprets incoming audio in real time, and improvising modules, which trigger audio playback through interactive behaviors. The SCI contains four improvising modules, each requiring a learning stage, where it analyzes and records incoming audio. Fig. 2 provides an overview of the SCI.

The Listener

The machine listening portion of the SCI analyses pitch, amplitude, brightness, and harmonicity at the onset of a detected attack. The SCI listener has some similarities to the listening and analysis functions of the computer improvisers Audio Oracle and CatOracle (Einbond et al. 2016, 141–47) insofar as building a database from an audio input, which is then used as basic material for generative, interactive behaviors. While a SCI improvising module is engaged, the analysis of the incoming audio signal is delivered to the improvising behaviors. The databases built during the learning phase (see Fig. 3) are used in a variety of ways by the improvising modules, which will be detailed later on.

The onset detection of the SCI is programmed to identify musical gestures and short phrases. This feature of the listener has major implications on the improvising behaviors, at times playing back gestures and phrases in their complete form and thus carrying some phrasing and stylistic characteristics from the audio recorded in the learning stage. This design decision aligns with what I perceive a musical event to be, and the conviction that the computer improviser should parse musical events similarly.

Playback Module

The SCI playback module produces audio in six channels, sampling from the audio recorded during the "learning" phase. The playback module is sent start time, duration, playback speed, and amplitude to produce audio, with a negative duration interpreted as playback in reverse.

Improvising Modules

The four improvising modules in the SCI are programmed identically, each containing ten behaviors:

1. Doubler I
The Doubler I triggers quasi-random playback when an attack is detected by the listener. Playback duration and direction are determined by the register of the incoming audio.

2. Doubler II
The Doubler II also triggers simultaneously with detected attacks in the incoming signal. Playback duration is randomized between 500 and 3500 milliseconds and relies upon the databases built during the learning stage to play audio segments that shift incrementally through an ordered form of the pitch, amplitude, brightness, or harmonicity with each new attack, depending on the register of the incoming audio.

3. Doubler III
Doubler III is a variation of Doubler I but with a greater variety of playback durations.

4. Reactive I
Reactive I listens for attack onsets in the incoming audio stream, and if none are detected after a given time, the software triggers playback at regular time intervals that approximate the rhythmic regularity of the human improviser. In practice, this creates an impression of a dialog between the incoming sound and the SCI.

5. Reactive II
Reactive II is a more rhythmically active version of Reactive I.

6. Leader I and
7. Leader II
The Leader I and II behaviors generate music by recalling patterns in the analyzed audio from the learning stage while mostly ignoring incoming audio. In other words, these two behaviors generate music with minimal interactivity with the human improviser(s).

8. Markov Imitator
The Markov Imitator uses a fourth order Markov chain to generate music that is stylistically similar to the analyzed audio from the learning stage. Like the Leader behaviors, this behavior does not react to incoming audio.

9. 3-variable Matcher or Contraster
This behavior uses the CIE76 color matching algorithm to query the audio from the learning stage for the overall closest and farthest match to the live input according to pitch, brightness, and harmonicity. In other words, this behavior can match or contrast with the sound of the live input using the audio corpus.

10. Contrast
This behavior measures the amount of activity coming into the listener, resting when there is a lot of activity and playing when it hears little or no activity. The music generation process is similar to the one used for the two "leader" behaviors.

None of the improvising behaviors represent an innovative approach to computer improvisation and are better understood as building blocks for meta-behaviors that combine and switch between behaviors dynamically. When an improvising module is engaged, one to three of these behaviors are initiated. If an engaged improvising module detects no attacks for three seconds or longer, a coin flip decision is triggered to decide if a change of behaviors will occur. These settings were decided upon heuristically with the goal of achieving a sense of musical continuity and consistency while avoiding immersion-breaking moments of overt predictability or total randomness. This reflects my desire to develop a computer improviser that projects creativity, reflected by Jon McCormack et al when they write, "One of the main attractions of working with generative computational systems is their capacity for agency and autonomy. Systems that can surprise and delight their authors in what they produce are undoubtedly an important motivation for working with computer generated creative systems" (McCormack et al. 2019, 39).

Design Concepts

Now that a general understanding of the design of the SCI has been established, we can return to the reasoning and musical motivations behind this design. The goal of the SCI was not to implement the most advanced artificial intelligence concepts; instead, I sought the simplest means to explore my personal musical interests and work within my own artistic and technical limitations. My approach in designing the SCI was based upon a consideration of what I find to be musically engaging while creating music spontaneously with others and how improvised musical situations are capable of pushing boundaries of style and learned musical tendencies. This approach reflects what George Lewis writes regarding his computer improviser Voyager, "Musical computer programs, like any texts, are not 'objective' or 'universal,' but instead represent the particular ideas of their creators" (Lewis 2000, 33–39). With this in mind, the SCI can be understood as a text through which I am expressing a personal musicality, perhaps more accurately considered as a singular "piece" rather than general-use software. This distinction may be largely conceptual, but it emphasizes the particularity and narrowness of the SCI that makes it unique.

Uniqueness and Style

The SCI was built from the native objects available in MAX without the use of third-party libraries, with the exception of ML.star (Smith 2021), which was used to realize Markov chains. Developing the SCI in this way forced me to consider many details that might otherwise be obscured. The MuBu library developed at IRCAM (Schnell et al 2009), a powerful toolbox for multimodal sound analysis, would have simplified the development of the SCI listener module and potentially made it more precise in terms of analyzing and segmenting incoming audio during the learning phase. However, through designing my own computer listener I was able to consider and represent how I listen in more granular detail. A clear example of this is provided in the implementation of attack detection in the SCI, which combines percussive attack detection with some consideration of pitch change in such a way that whole musical gestures or short musical phrases are considered single musical events. This approach is contrasted with more precise forms of attack detection that seek to identify every rhythmic impulse and pitch change as it would be represented in Western musical notation.

Reflections and Future Development

In 2020–2021, the SCI has been included in public performances by four musicians: Marina Kifferstein (violin), Adam Vidiksis (percussion), Keith Keirchoff (piano), and myself (electric guitar). Several other musicians have experimented with the SCI but have not yet brought it to a public performance. Future development is based upon reflections and feedback from these performances.

Memory

The SCI currently has no memory of what it plays, and so there is no intentional consideration for large-scale form. Instead, shaping a performance becomes largely the responsibility of the human improviser and how they choose to deploy the SCI. The primary solution that I have employed in my performances with the SCI has been to integrate the learning phase of the SCI into the performance, gradually adding each of the four improviser modules over the course of the first few minutes and then turning them off toward the end of the performance. This approach encourages a form that gradually builds in musical activity and then dissipates toward the end. Marina Kifferstein and Adam Vidiksis have experimented with another approach, where the SCI is trained in advance of the performance.

Corpus Storage and Libraries

The audio corpus and associated analysis cannot be saved and recalled without playing the audio back through the listener again. The ability to build larger corpuses that can be loaded into the SCI would allow for greater versatility. While the current approach promotes spontaneity, the benefits are unlikely to outweigh the limitations.

Embodiment and Visual Interaction

The SCI cannot participate in the visual communication that often occurs between human improvisers through body movements, eye contact, posture, presence, or any other physical expression. The visual elements of the SCI are limited to printing playback data in the MAX console combined with buttons, toggles, and audio meters in the MAX patch. This visual communication provided by the SCI does provide meaningful information, but does not represent the depth of visual communication of a human partner, where the physicality of a performance may develop and become more subtle over time. Additionally, as the SCI has a listener that informs how it improvises, a camera input that watches and interprets the human performer may present an opportunity to increase responsiveness and interactivity.

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Electroacoustic Music, Pluralism, and the Intractability of Epistemological Limitation

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Introduction

Kyle Gann described music pluralism well in his Rey M. Longyear Lecture from 2008. In the lecture, Gann, who considers himself first and foremost a composer (as do I), identifies pluralism through a critique of academic musicology. "By turning toward gender studies, vernacular musics and oral and nonwestern traditions, and the history of audience reception—all those telling fields of evidence that traditional musicology had pointedly excluded—[musicologists] broke away from the stifling Great Man narrative and revitalized the field" (Gann 2008, 144–45). Yet, as Gann states further, art music composition has continued to progress. The musicological turn away from the narrative of Western classical composition does not mark the end of the American and European narrative of composed music. Rather, it appears commensurate with the emergence of multiple compositional styles and a diverse web of *narratives.* After the rise of minimalism in the late 60s and early seventies:

> the word *pluralism* began creeping into the conversation. Minimalism grew more popular, but not everyone converted to it. Almost as a reaction against it, a noisy scene of free improvisation grew up around John Zorn and Elliot Sharp in New York City. Personal computers made it possible for any teenager to make music from samples of other recordings. Orchestra composers discovered New Romanticism and, exploiting the nonlinearity of style quotation, ventured into postmodernism. Serialism morphed into New Complexity around the cult figure of Brian Ferneyhough. DJs started making art music by spinning discs. Twenty years later, all of these styles are flourishing, with no one of them gaining particularly more of the market share than it had at the time. … At some point, everyone eventually looked back and realized that Leonard Meyer had been right. There *was* no dominant new style (Gann 2008, 143–44).

Gann ultimately sees the contemporary hallmarks of pluralistic compositional practice as the arrival of Leonard Meyer's speculative, and ultimately prescient, prediction that the musical style of the future would be "'characterized not by the linear, cumulative development of a single fundamental style, but by the coexistence of a multiplicity of quite different styles in a fluctuating and dynamic steady-state'" (quoted in Gann 2008, 143). In fact, Gann's description necessarily leaves out a host of other differences of compositional practice, some of which are even internal to the stylistic movements he cites.

Given our focus on electroacoustic music as technologists, composers, and performers, we too must recognize that the musicological turn that continues to influence and reframe our efforts is both a testament and implicit acknowledgement that the diversity of electroacoustic styles and techniques have both proliferated and grown increasingly niche. Consider for a moment how the narrative of early electroacoustic music has shifted— away from stylistic schools and methodological debates of total serialism vs indeterminacy toward the cultivation of particular technology-specific disciplines: acousmatic fixed media, machine listening, algorithmic composition, spatial audio, HDLAs, and live diffusion, interactivity, mixed music, network music, sonification, visual music, controllerism, sound art, and on and on. As my past mentor and co-inventor of the Synclavier, Jon Appleton, recently said: "it's all so technical now." I argue that the proliferation of a technology-oriented 'dynamic steady-state' in electroacoustic music enables composers to 'niche down' independent of any pretension toward a specific stylistic, programmatic, or extra-musical agenda. A pluralist technological landscape of choices for the production of electroacoustic music enables us to conveniently ignore the ideological presuppositions inherent to our acceptance of pluralism itself. To reveal that ideological baggage, we must simply ask “what knowledge enables the composer or the consumer to make a qualified musical choice, to know the effect of (ostensibly) ‘new’ electroacoustic music under the conditions of pluralism?” Or perhaps more concisely: “how do we know the way or ways that ‘new’ electroacoustic music is actually new?”

Reactions to Pluralism

On one hand, we’d like to endorse pluralism whole-heartedly in terms of its consumer-oriented benefits. A pluralistic compositional universe is one of possibility, choice, and freedom. In such a place, the range of audiences for a wide range of music continues to expand and make way for new stylistic differences, technologies, and socio-cultural significations. However, such acceptance begs a very important question: are we accepting musics as they appear on the basis of understanding what the *actual differences* are, given a knowledgeable meta-perspective? Or, are we accepting *distinction* for distinction’s sake as a form of cultural tolerance, because we have no way of knowing otherwise, which is to say, of knowing the difference? Is pluralism really just a shared commitment to a “you do you” mentality? This is my fear.

Culturally, I think we demonstrate a willingness to embrace different stylistic branches of musical activity, which pluralistically appear to follow their own path, without much consideration given to how the branches differentiate, exist in relation to each other, and perhaps even hybridize. If we begin to consider such branching we may view pluralism according to a second, more radical, *relativist* perspective: all distinctions of musical style are of equal value precisely because we cannot know how or why that style appears the way it appears from a perspective outside of the socio-cultural context that values it. This idea underlies Jacques Attali’s (2003) assertion that, “outside of a ritual context or a spectacle, the music object has no value in itself. It does not acquire one in the process that creates supply” (106). Music has no objective cross-cultural exchange value. So given the current stylistic differentiation of electroacoustic music, how do the various (sub)cultures that value any one technological approach comport, vis-à-vis each other? If we maintain that any new approach is correlative with the potential emergence of a subculture or commodity market that values the style, then the absolute value of one approach relative to another cannot be obtained. To value differentiated musical practices differently is akin to valuing the people who appreciate that music differently.

Ultimately, these two reactions to pluralism can be summarized in the following way:

1. Pluralism is to be embraced because “more choice is always good”. We benefit as both composers and listeners from the unmitigated extension of choice and freedom to indulge in a multitude of styles, technologies, and aural experiences.
2. Pluralism is a situation we are forced to accept because we have no way to know what any given music is outside of the context of listeners who value it and, therefore we cannot be anything but accepting of a listener’s prerogative to listen differently— pluralism is the horizon of our musical experience because of the *relativism* inherent to any perceived aural difference.

Increasingly, the first reaction appears to no-longer comport with consumerist experience; too much choice can indeed be a problem, as the psychologist Barry Schwartz has described in his 2004 book “The Paradox of Choice”. His idea is homologous to what we now often discuss as “decision fatigue”. Harder, though, is to confront the second perspective. The remainder of this paper grapples with the intractability of the relativist interpretation, in search of a chink in its philosophical armor.

Pluralism and Postmodernism

It is important at this point to make clear that the relativist perspective and postmodernism go hand-in-hand. Postmodernism is one name for the set of contemporary (socio-)linguistic and bodily considerations that Alain Badiou (2009) has circumscribed and called 'democratic materialisms'; materialism, because "the individual as fashioned by the contemporary world recognizes the objective existence of bodies alone"; and democratic because, "the contemporary consensus, in recognizing the plurality of languages, presupposes their juridical equality" (2).

If we identify Stravinsky's neo-classicism as the exemplary postmodern event in music, we see how the historicizing of musical consumption itself is integral to that which is produced. When we consider the vast range of historical musics and electroacoustic technologies that one may choose as a condition for compositional activity, then what knowledge do we have to inform such a choice? This question articulates the postmodern electroacoustic composer's task: to choose in full acknowledgement of the fact that any choice is made under the condition of insufficient knowledge concerning the range of possible choices and their possible interpretations.

In thoroughly rejecting the notion of absolute mastery, or knowledge of a universal aesthetics (viz. modernism), postmodernism places the composer securely within a particular frame of reference inside the discursive territory that preconditions any compositional activity. The postmodern composer is cut off from an objective view of the Musical, from knowing how her work will be heard; she is required to acknowledge her position of limited knowledge (perspective) on the (often primarily technological) territory her work aims to affect. As Kyle Gann (2009) has described elsewhere as "reflexive self-effacement", the contemporary composer often presents herself as *genuinely* ironic towards the musicality of her work; she is forced to act *as if* she does *not* believe in the 'Great Man' narrative of Composers, while nevertheless composing, often with increased technical rigor, in the hope that her propositional music will affect Music's broader discourses.

Epistemological Limitation: Three Encounters

Encounter 1: Social Consumption and Production

The sociological tendencies for electroacoustic practices under the condition of postmodern, relativist thought reflects, following Žižek (2009), "an exact inversion of Marx's formula [for the German *ancien régime* that 'only imagines that it still believes in itself']: today, we only imagine that we do *not* 'really believe' in our ideology—in spite of this imagined distance, we continue to practice it" (3). The *not*-Composer still produces work, but only in such a way as to accentuate her everyman status—to leverage a degree of false modesty against her nevertheless operative ideology of becoming a Great Composer.

Žižek (by way of Maynard Keynes) provides us with a precise articulation of how contemporary compositional activity engenders self-relating. If we consider how the production of music (composition) is conditioned by our consumption of the territory we seek to affect, we may draw a direct analogy with free-market enterprise, whereby:

> expectations are part of the game: how the market [for music] will react depends not only on how much people trust this or that intervention, but even more so on how much they think *others* will trust them—one cannot take into account the effects of one's own choices. Long ago, John Maynard Keynes rendered this self-referentiality nicely when he compared the stock market to a silly competition in which the participants have to pick several pretty girls from a hundred photographs, the winner being the one who chooses girls closest to the average opinion: "It is not the case of choosing those which, to the best of one's judgment, are really the prettiest, nor even those which average opinion genuinely thinks the prettiest. We have reached the third degree where we devote our intelligence to anticipating what average opinion expects the average opinion to be." (1) So, we are forced to choose without having at our disposal the knowledge

> that would enable a qualified choice, or as John Gray put it: "*We are forced to live as if we were free.*" (2) (Žižek 2009, 10)

If we consider the economics of musical consensus-making as homologous to Keynes' depiction of the stock market, this "third degree" echoes the very conditions of groundless self-relating which arise between the composer and her own investment in composition as a means of achieving a successful (useful) intervention within the field; her investment is founded upon not the 'real' territory of composition, but rather, the composer's map of others' maps of composed music, as it all immanently appears to her. Here, we incur Baudrillard's notion of the *precession of simulacra* or "the generation of models of a real without origin or reality: a hyperreal [, whereby] the territory no longer precedes the map, nor survives it" (Baudrillard 1988, 166). When we reflect upon the reality of the compositional procedure, it becomes impossible to even think in terms of absolutes anymore. We are instead faced with a multitude of differentiated appearances and interrelations that precede any definition of what composition actually *is*; we are staring at nothing more than a "desert of the Real"— a void.

What is of utmost significance in Žižek's use of Keynes is how this third degree, the extension of relations into a 'hyperreal' or a virtual space divorced from objective determination, is presented as an 'epistemological limitation'. We are "forced to choose *without* having at our disposal *the knowledge* that would enable a qualified choice." Or, to put it in compositional terminology: the composer is forced to pursue a particular compositional prerogative without having the knowledge to determine what makes such a choice objectively verifiable as a 'good' choice; we can merely "anticipate what average opinion expects average opinion to be." The horizon for composition is thus to compose in an attempt to maximize the comportment between one's own listening and the intersubjective norms that condition one's own listening.

If modernism's failure is an inability to universalize esthesic access regarding the formalized procedures of poiesis, then postmodernism appears as a full embrace of the impossibility of ever doing so, of the discursive reality of the map without recourse to any territory (ground). What any given composition is is conditioned by what the composer thinks others will think the work to be; the inability of the composer to take all perspectives into consideration, to *know* the totality of music's possible appearance, is an epistemological limitation, a limitation on knowing the 'real' effect of any given compositional choice. The composer cannot herself be the model for the listener (consumer) she imagines composing for.

Encounter Two: Music Semiotics

Music semiotics also presents a way of understanding the structural limitations on a composer's ability to *know* the reality of the effect she may cause.

The history of music, as well as my own personal compositional history, is littered with attempts to represent, model, imitate, and even allegorize extra-musical subjects. From early liturgical music up to contemporary pieces exploring data sonification and cellular automata, there is a demonstrated compositional preoccupation with representing the extra-musical. As interesting and sublime as the result of these efforts may be, there is a disjunction between intention (on the part of the composer) and interpretation (on the part of the listener).

Consider the example of Beethoven's "Pastoral" Symphony and its fabled program of representing the 'countryside'. "Referring to conversations that he allegedly had with Beethoven himself, [Anton] Schindler claims that Beethoven intended to affix programmatic titles to all of his compositions – after the fashion of the Pastoral Symphony – in order to make his intentions explicit" (Kirby 1970, 606). This point belies a pre-suppositional acknowledgement that music is by definition more varied than text in its meaning, and thus amenable to (if not requiring of) explication. The necessity with which the ambiguous notion of 'countryside' (as a place of normalized experience) appears in the 6th Symphony forces us listeners to confront how meaning is conveyed through music. To do so brings us into the territory of music semiotics.

In approaching the question of *what* and *how* music means, we stumble upon the "tension between the apparent validity (at the level of listening) and the apparent invalidity (at the level of empirical analysis) of music's symbolic capacity" (DeNora 1986, 84). We all attest to music's ability to make us *feel* something, but the sketchiness with which we are able to localize this feeling or in fact define the structure(s) through which it operates suggest that music may very well be, as Patricia Tunstall (1979) asserts, rearticulating Saussure: "not a system of signs but a system of signifiers without signifieds" (54).

Tia DeNora has made the argument that our confusion regarding the complexity of musical meaning stems from the misinformed assumption that the linguistic premise of an "ideal speech situation" serves as an appropriate model for understanding music as a system of signs. In an ideal speech situation, "what is said is equal to what is meant is equal to what is understood" (DeNora 1986, 88). Yet, such a speech situation is truly ideal, as it is not reflective of any real-world linguistic exchange, let alone the conveyance of musical intention. Quine's Indeterminacy of Translation, Gricean Maxims, and the notion of Common Ground in psycholinguistics all serve to confirm the premise that such an ideal speech situation is impossible. Language users select words and comprehend their significance according to a multiplicity of meaning and a reliance on context. For example: saying "it's hot in here," may in fact be understood as a hint that someone open a window. In terms of semiotics, it is therefore necessary to reassess the referentiality of language as an ideal model for music. The listener actively constructs meaning out of the signs with which they are confronted. Meaning is in this way achieved rather than received.

If the multiplicity of subjective and contextual meanings invariably come into play, is it futile to try and make compositional intent explicit? DeNora says no, but her discussion belies the larger ramifications of the argument she presents. If we, as listeners, are searching for musical meaning, then:

> to find meaning in an object is *believing* that the object in question is inherently meaningful and that it deserves to be taken seriously, that it is significant. The primary object of study, when focusing on musical meaning is to examine the way in which belief is inspired so that the listener listens 'in good faith' and thus, cooperates in fleshing out the sketchiness of the music so that it appears to mean something (DeNora 1986, 91).

Hence, the listener who gazes into the object for meaning finds only the listener. This shift in focus underlies what Leonard Meyer (1957) has called the "preparatory set," or the framing of an experience such that our belief that we should expect an encounter with musical meaning ensures that we find it; we are pushed towards finding meaning based around our set of expectations for meaning, which are informed by attuning ourselves to the "contextualization cues" of music (see Gumperz 1977 and DeNora 2000).

These cues are often performative, social, gestural, and even architectural. The phenomena surrounding music act less as a ground than as an integral and interactive component of the object they frame. DeNora (1986) hints at this stating: "perhaps the main reason we have so little trouble making sense out of just about anything...is that we go to 'work' at meaning construction 'given the materials' at hand, i.e. the perceived context of which the phenomenon is also a part and with which it reflexively reacts" (90–91). In other words, the extra-musical is always-already a part of phenomenal musical experience. Framing the listening experience helps to make explicit its semantic reference and to make such reference appear necessary because it is always-already grounded in experience. Again, we find that any pretense to musical objectivity is purely ideational; it is retroactively constituted through the subjective lens of the listener.

If we consider the semiotics of listener agency from the perspective of the composer-as-listener, the object of aural perception (the sign) becomes even more complex. The composer, in listening to her own work, is a listener towards the meaning she intends. So once her compositional activity becomes *about* framing a subjective listening experience (rather than attempting to encode objective meaning into the object itself) the explicitness of musical reference is moot; experience itself becomes objectified as that which should be meaningful. The frame for such experience is nothing other than how the composer has sought to contextualize her own listening. This is to say, that the composer's gaze itself becomes both the subject and object of any meaningful listening.

It is here where we explicitly re-encounter epistemological limitation, as derived from semiotics, which undercuts any pretense toward universalizing composer intention: the composer cannot *know* if or how the average listener will achieve meaning in her work, because she herself is part of the process of reading meaning into it. Any consistent totality of meaning is therefore compromised because she cannot take into account how her own listening imbues the work with meaning, a meaning that may or may not comport with an average listening. Her only recourse is to consider the responses (critiques) of her peers and to subsequently attempt to frame (with recourse to rhetoric and the work's contextualization cues) a particular listening for herself without any hope that she may *know* the actual effect on others, given her intent.

Encounter Three: Philosophical Reflexivity

In both of the previous encounters, self-relating behavior has reared its head to severely limit a composer's ability to know her music. The problem that relativism poses to musical knowledge is, in fact, structural, and is most fully revealed by cultivating an understanding of philosophical reflexivity vis-à-vis *place*.

Composition and listening must *take place.* We may discuss each term here (symbolically) in the abstract, but insofar as we are talking about activities that happen in the world, they must be situated in both space and time. When outlining the spatial characteristics of sound, Yi-Fu Tuan (1977) made a passing aside to Roberto Gerhard's notion of form in music: "form in music means knowing at every moment exactly where one is. Consciousness of form is really a sense of orientation" (15). This remark of course reflects Jonathan Kramer's (1988) notion of "linear" time as it appears in music with functional harmony. The relationship between place and music is thus immediately framed as a matter of *self*-relating, of knowing "exactly where one[self] is." Insofar as knowledge is a matter of thought, we incur the problem of thought attempting to gain traction on *being* (under the guise of where one *is*).

To consider music and place is, therefore, to consider the relation between thought and being, a consummate philosophical problem. As Ray Brassier (2011) concisely notes: "thought is not guaranteed access to being; being is not inherently thinkable. … The fundamental problem of philosophy is to understand how to reconcile these two claims" (47). Addressing this problem directly may provide us with some insight as to the full weight of the limitation on our ability to know *anything*, let alone the reality of the music we write.

To begin outlining how musical meaning may be known, we should allow Brassier to frame the problem further:

> For we cannot understand *what* is real unless we understand what 'what' *means,* and we cannot understand what 'what' means without understanding what 'means' *is,* but we cannot hope to understand what 'means' is without understanding what 'is' *means.* This much Heidegger knew (Brassier 2011, 47).

The appearance of Heidegger in this context is important. Philosophically, we may identify Wittgenstein and Heidegger as "the two emblematic representatives of the two principle currents of 20th century philosophy: analytic philosophy and phenomenology" (Meillassoux 2008, 41). Both the analytic and phenomenological currents, which extend from Wittgenstein's focus on language and Heidegger's focus on consciousness, are premised upon the subject's inability to talk about, let alone access, a world independent of the subject's gaze; the subject is *always-already* immersed in the world, a world predicated upon the subject's correlation to it. Here, the word "correlation" is not of passing significance; it is the heart of the matter. Quentin Meillasoux (2008), in his increasingly notable book, *After Finitude*, identifies *correlationism* as "the idea according to which we only ever have access to the correlation between thinking and being, and never to either term considered apart from the other" (5).

Meillassoux's notion of correlationism may be further understood as a term that encompasses issues of *reflexivity* or our finite relation to the world we *always-already* find ourselves in. Reflexivity describes the intractable condition of being a finite Being situated in the world with a necessarily limited perspective and horizon of experience. As a consequence of this condition, our being in the world mitigates any claim we make about the world. Any claim regarding language is expressed through language, and any claim about the properties of objects themselves is constituted through the subjective appearance of those objects as given to sense. We cannot gain an absolute perspective over objects, let alone ourselves; for the more we strive toward objectivity, the more it implicates the subjectivity inherent to our access of those very objects we strive to know in and of themselves.

Reflexivity reflects the deep philosophical problem facing us today, a problem that is the core tenant of our postmodern, relativistic crisis: the un-tenability of thinking the reality of objects in and of themselves, independent of their givenness to us. As Hilary Lawson (1985) describes it, "to insist that we are confined by the limitations of our own problematic, is to be confined within those very limits" (9). This horizon of thought, which appears in Kant as a consequence of the dissolution of dogmatic Metaphysics (rejection of the ontological proof), remains predominate across theoretical discourses within the humanities, ranging from anthropology to art. Thus, identifying reflexivity as operative, given our electroacoustic interactions with the world, only reinforces the limitation it imposes upon our ability to *know* our subject. Our contemporary, postmodern condition is epistemologically ungrounded, for we cannot find a Ground upon which to ensure that our thought carries any significance with regard to the objects of our thought. Claims to objectivity are treated as untenable. We are therefore forced to engage in the whole-sale endorsement of its converse: the subjectivization of phenomenal appearance, and the relativistic "juridical equality" of any given appearance in relation to another. Such subjective prioritization begins and ends with the individual, and when expanded and viewed as operative within a larger social, discursive space, it is contingent upon a balancing of inter-subjective agreements.

The consequence of finding ourselves in this "desert of the Real" is not merely that art becomes ungrounded, but that science itself presents no threat to correlationist thinking; one need merely assert that scientific principles and mathematical laws appear *for us* as absolutes. To think the being of universal laws is thus to reaffirm the priority of thought over that which appears. Therefore, science becomes just another form of discourse; and even our technical electroacoustic research is ultimately reduced to a matter of inter-subjective agreement regarding not only the perceptual results of new electroacoustic tools, but also the core tenants of any purported scientific methodology (controlled experimentation, falsifiability, etc.).

On the Possibility of Electroacoustic Music Beyond the Limitation

If electroacoustic music is perhaps most threatened by the epistemological perils of reflexivity and finitude, given the expanded domain of technological research and the accompanying proliferation of choice, then it is also perhaps the domain most capable of inverting the problem and proposing an alternative to our relativist woes. How then might we proceed in consideration of a music that may function as pluralism's difference? I have some ideas, but perhaps its best to leave the theory behind for a moment and proceed with a 'speculative' example, an example of an electroacoustic piece that does not appear to be limited epistemologically.

A 'speculative' example: Max Neuhaus' *Times Square* (1977–1992; 2002–present) seems to provide us with just such an example—a work of art that appears not to be dependent on knowledge regarding either its poietic procedure or even its existence. In Neuhaus' own words, here's a description of the *Times Square* piece:

> The work is located on a pedestrian island: a triangle formed by the intersection of Broadway and seventh avenue, between forty-sixth and forty-fifth streets, in New York City's Times Square.
>
> The aural and visual environment is rich and complex. It includes large billboards, moving neon signs, office buildings, hotels, theaters, porno centers, and electronic game emporiums. Its population is equally diverse

> including tourists, theater-goers, commuters, pimps, shoppers, hucksters, and office workers. Most people are in motion, passing through the square. The island as it is the junction of several of the square's pathways, is sometimes crossed by a thousand or more people in an hour.
>
> The work is an invisible, unmarked block of sound on the north end of the island. Its sorority, a rich harmonic sound texture resembling the after ring of large bells, is an impossibility within its context. Many who pass through it, however, can dismiss it as an unusual machinery sound from below ground.
>
> For those who find and accept the sound's impossibility through, the island becomes a different place, separate, but including its surroundings. These people, having no way of knowing that it has been deliberately made, usually claim the work as a place of their own discovering (Neuhaus 1992).

Neuhaus took knowledge out of the equation. The work itself has no meaning for us to *know*. Nor can there be any expectation for the listener to even know of its existence. To encounter *Times Square* is to encounter the possibility of listening. We may decide upon and categorize the object we hear or we may possibly fail to hear anything at all. The work means nothing beyond one's own mediation of the object's contingent existence, its *being* anything at all. If we begin to consider our aural experience of the world, we may ask: what are the possibilities for a composed aural experience to function similarly?

If a composer is limited in her ability to specify a particular understanding of the composition she composes, then perhaps she should reconsider the presupposition that the composition is itself whole or in any way complete. In order to reconsider this presupposition we must develop a theory not of epistemological limitation, but rather of *ontological incompleteness* in relation to music and aural experience. I propose that, in a functional affinity with many of Robert Irwin's 'site-conditional' pieces, the work of Max Neuhaus (and specifically a reconsideration of *Times Square*) must serve as a point of departure for developing a more speculative line of inquiry into the possibilities and interdictions of technologically informed and ontologically incomplete musical practice.

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Embodied Strategies for Kinesthetic Empathy in Remote and Interactive Performance

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Introduction

The definitions of kinesthetic empathy differ in scope between fields of performance studies and interactive design. In performance, kinesthetic empathy has been compared to "vicarious performance" (Bahn 2001, Cone 1968) in music or "inner mimicry" or "muscular sympathy" in dance. (Reason 2010) Kinesthetic interaction describes a unifying concept for the body in motion as a foundation for designing interactive systems (Fogtman 2008). In this context, kinesthetic empathy represents a situation where multiple users can encode and decode or sense one another's input (Fogtman 2008). Such a situation innately arises when dancers move together or musicians play with one another in a room. These artists rely on several modalities including reverberation within the physical environment and visual feedback from movements and gestures of other performers. These modalities are often missing or blocked in online communication platforms (Woszczyk 2005). Though a networked musical performance can never fully re-create the exact situation of in-person performance, there may be other means through which kinesthetic empathy could be achieved by focusing on specific senses.

This paper introduces three recent examples of performer-to-performer connection in remote music performance that use alternate sensory modes made available by the design of each system to aid in the development of kinesthetic empathy. We will then dissect which elements of each example allowed for successful performances and identify possible prerequisites to achieving kinesthetic empathy in each. Finally, we will look at three case studies where attempts were made to address an embodied pedagogy for these prerequisite skills. We will then look more closely at one of these systems, the *Body Sample Player,* looking at ways it has been used to demonstrate kinesthetic empathy between remote players as well as ways it could be used to objectively demonstrate a kinesthetic relationship between multiple performers and performers and audience.

Background

Definitions of Kinesthetic Empathy

Kinesthetic empathy is a term used in many contexts in the fields of live music and dance performance as well as kinesthetic design. The term kinesthesia is defined as awareness of the position and movement of the parts of the body and is a combination of proprioception (stimuli from inside the organism) and exteroception (stimulation from outside the organism) (Reason 2010). Empathy is generally defined as a sympathetic response held in the muscles or body (Martin 1936). Fogtman et al define kinesthetic empathy as a situation where multiple users can encode and decode or sense one another's input (Fogtman 2008). In live performance, it describes the empathetic response an audience feels while listening to live musical performance, or "vicarious performance" (Bahn 2001, Cone 1968). It is also used in describing the physical response audiences have watching live dance alternately referred to as "muscular sympathy", "metakinesis", "contagion" and "inner mimicry" (Reason 2010). In interactive performance, Fogtman's definition has been used to describe a situation where multiple performers sense one another's movement via technologically mediated sonic or visual feedback (Ingebritsen, 2020). Kinesthetic empathy between remote performers would represent a successful performative connection centered on the interactions between humans rather than their interactions with technology.

Challenges in Remote Performance of Music

Despite decades of significant advances in research and technology, musicians and other performers still face substantial challenges in remote networked performance. In live acoustic performance, musicians use aural, visual, proprioceptive and haptic cues to attain a sense of ensemble. This connection can be difficult to achieve when performing remotely for a number of reasons. Audio latency over a standard internet connection averages 100ms and can increase with higher quality audio formats, poor local connections, and increased internet traffic (Kleimola 2006). While audio latency can average 67ms between players on opposite sides of an orchestra (Kleimola 2006), maximum tolerable latency in live musical performance is generally 50-65ms (Chew et al. 2004) with minimum tolerable latency being 10ms due to the speed of sound through air (Chaffe, 2004). Many video conferencing platforms filter and compress audio to optimize speech and reduce background noise, thereby distorting and compressing musical sound in undesirable ways.

Two-dimensional screen interfaces limit the transmission of multi-sensory cues between individual players, which inhibits modes of connection that musicians take for granted in a live setting (Rottondi, 2016). Due to the high spatial sensitivity of human hearing (Middlebrooks 1991), sound spatialization and room reverberation can contribute to a sense of presence in a virtual environment (Larsson 2008, Kobayashi 2015), though the techniques may not necessarily foster a sense of realism (Hendrix, 1996). Researchers and practitioners have attempted to mitigate these difficulties transmitting high bandwidth multi-channel audio, video, and haptic channels (Woszczyk 2005), however immersive, three-dimensional virtual environments that attempt to mimic live performance settings rely on expensive equipment and networking infrastructure out of reach to most musicians due to socio-economic or geographic constraints (Fife, 2002).

Alternative Forms of Remote Music Performance

Given these design challenges, it is worth exploring alternative and more accessible solutions to creating successful, effective remote performances and achieving kinesthetic empathy between networked performers. Since the inception of the first personal computers in the mid-1970s, artists have experimented with networked performance (Duckworth 2005). The League of Automatic Music Composers (1977) used KIM-1 computers to share tone generating algorithms to create "automatic music". The composers involved in these early experiments began to tweak their algorithms in real time.

Since then, networked "bands" or online music making environments such as The Hub (1986), Netjam (1990), RocketNetwork (1994), Machover's *Brain Opera* (1996), Web Drum and Music World (1997), and GPS-Trans (1999) emerged, followed by a plethora of experiments in the twenty first century. (Duckworth 2005) Most early experiments in network performance used some low bandwidth proxy for actual sound such as MIDI data (Netjam, 1994) or UDP packets (GPS-Trans, 1999) with higher bandwidth audio processing occurring only locally. Rather than simply translating acoustic music practices to digital formats, these historical examples emerged from a culture of electronic and networked music that embraced alternate modes of human-machine interaction native to the functionality of the technology itself. Furthermore, replicating the performance environment may not be necessary to achieve successful performance. As Renaud et. all states:

Although it is clear that in a standard performance situation the types of interaction between musicians are inherently multi-modal (aural, visual, proprioceptive) it is likely that in a networked condition sound becomes the most critical source for shared performance cues due to its immediacy, specificity and for being after all the mode that musicians are trained to develop (Renaud 2007).

Current Cognitive Research on Entrainment in Musical Performance

Cognitive research suggests that entrainment — a high correlation of movement between two human subjects — can occur between two musicians playing together or via audio recording (Demos 2018). This situation is a bi-directional anticipatory system that displays a baseline level of asynchrony when aural feedback is present and is replaced by more synchronous anticipation when aural feedback is removed (Demos 2019). After a significant amount of delay is introduced, entrainment breaks down.

In an experiment conducted in 2017 by Demos et. al, two trombonists playing a piece of music together were observed using motion tracking to determine the amount of correlation between their movements as well as between their movements and the movement of 26 observers. (Demos 2018) Each observer either witnessed or listened to a performance by the trombonists during which time their motion was also tracked. Afterwards, they were given a survey to determine their perception of "expressiveness" during the performance. It was shown that when their perception of expressivity was higher, the correlation of movement between performer and musician was also higher, suggesting that entrainment exists consistently between performer and audience and that there is a link between the level of entrainment and perception of expressivity. This result remained consistent for both performances that viewed the performance live or heard only in a recording.

By thinking of networked performance systems as kinesthetic interaction designs focused around the aural sense, it has been theorized through the experience of creative artists that kinesthetic empathy can be achieved between one or more interactive performers as well as interactive performers and audience when the audience is given embodied experience of the system itself through pre-show demonstration or an exhibition experience (Ingebritsen 2020). In Demos' work on entrainment, we see experimental evidence that musical communication is embodied as well as aural and that this embodiment seems to be specifically tied to the aural sense. If we use Demos' observational data as a baseline, we can investigate how different situations affect both the perception of expression and entrainment between bodies when engaging in and viewing the performance of interactive and remote instruments in a number of different situations.

Three Examples of Remote Performance

During the summer of 2020, three different technological solutions were employed to facilitate remote performance that accommodated kinesthetic empathy between players. The first is a remote multi-player performance graphic user interface called *Sentient Object*. The second is a multimedia performance piece entitled *Layered Sound* that involves manipulation of the sound from an amplified canvas. The last is a system to facilitate different forms of non-synchronized live instrumental music performance in remote locations using the *ListenTo* plugin. In all cases, performers reported musically satisfying experiences showing evidence of kinesthetic empathy between performers.

Sentient Object: Simple Remote Performance Platform for Multiple Players

S*entient Object* is a multi-player performance environment that allows players to use a laptop to control parameters of a randomized tone generator including speed, duration, pitch, volume, and panning of each note. Performers are instructed to try to distinguish their part from that of the others as a means of developing a variety of musical textures by either blending with or contrasting the sound of other players. The system is designed in Max/MSP (Cycling '74, Walnut, CA), using OSC protocols to send parameter data to a central computer that controls the playback of all tone generators. In the remote version, control data is sent to all participants remotely via their individual internet protocol (IP) address and then the tones for each part are generated on each local machine. Because the data being transmitted is very low bandwidth, latency is kept at a minimum.

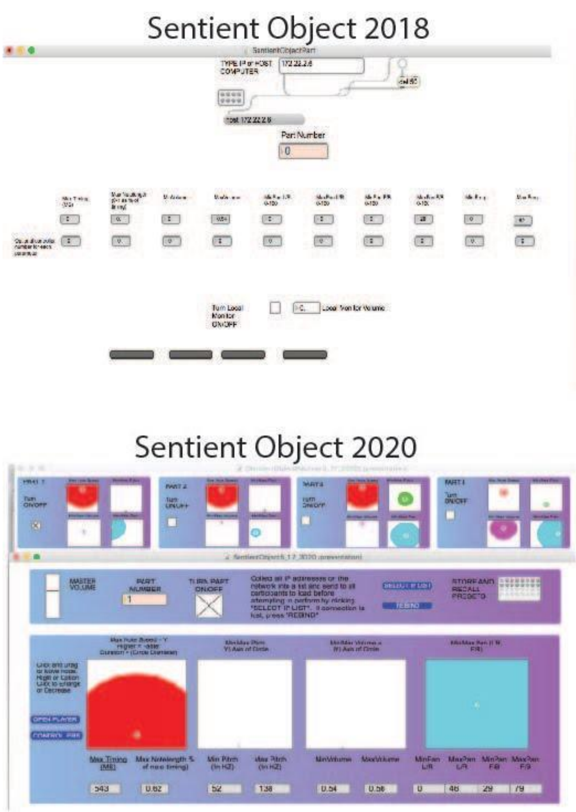

Figure 1. Original 2018 Patch vs Patch Revision for Remote Performance

Sentient Object was originally premiered at the 2018 Network Music Conference in Krakow, Poland. The fully remote version was premiered as a part of Senso 520 on May 13, 2020, with members of Grouplab, as well as a test including the first and third authors on July 8, 2020. In all cases, players were asked to answer a set of questions describing their experience after the performance.

In the premiere performance, the participants struggled with a technology that was still being devised and optimized for usability. Though these performers were in a room together, no great sense of connection was achieved. In contrast, the remote version of the patch was revised to create a more fluid mode of interaction requiring fewer gestures to transform parameters, better visual feedback, and the option to use a preferred MIDI controller instead of a mouse or trackpad. Most players reported that the relationship between control gesture and resultant sound was intuitive, allowing them to listen to other players. One participant stated that it felt like they were actually playing music, an experience "not felt since the beginning of the pandemic". Another participant stated:

> I started with very extreme sounds to determine which was mine, and then worked inward to blend with others. Timbral qualities like softness with reverb or harshness allowed me to semi-differentiate each persons' sounds. I don't know if I was ever able to completely discern a single player's sound trajectory...it felt more about contributing to the overall sonic experience…[I] felt the experience was collaborative.

In performances on the remote system, it is likely that by providing a way to manipulate graphic representation for the ranges of each parameter, this allowed for a quicker mapping between physical input and aural response so that players could focus their cognitive energy on listening and responding rather than simply figuring out how the machine worked.

***Layered Sound*: Sonified Live Painting Performance**

Layered Sound is a live painting performance developed by the first author and painter Melanie Brown beginning in 2018. It began with a desire by Brown to explore how painting with an "amplified canvas" would influence her gestural painting style and grew into a performance piece involving a live painter and electronic performer. As the performers' experience was almost entirely mediated by their sonic connection even in person, the piece translated well to an online format. A canvas is fitted with two contact microphones that capture the sound of brushstrokes that are then manipulated using various transformable audio effects and convolution processes. In the remote version, the microphone sound is transmitted via conferencing software to the electronic performer, then the resultant transformed sound is transmitted back to the painter using the ListenTo plugin (Audiomovers, Dover, DE, USA).

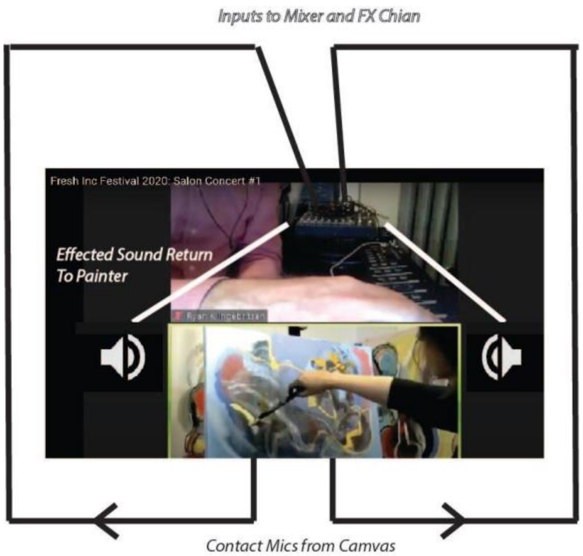

Figure 2. Layered Sound configurations for both in-person and remote performance.

Layered Sound has been performed live many times since its inception in summer of 2018 and was performed remotely at the Fresh Ink Festival 'Online Edition' in June of 2020. For both performers, the piece itself lives in the interaction between gesture and sound that the audience receives such that the resultant painting and sound recording become artifacts of the actual performance. As Brown (2020) stated: "What the performance is to the painting is like a tesseract is to a cube."

The performers expressed a clear sense of consistent mapping in repeated performances. Brown explained:

> The placement of the gestures are ways that I can… directly influence the sound… I know that nearer to the microphone means a bigger signal and that multiple marks using harder tools also increases the input...Hearing the gestures as I make them has changed the way that I make marks. I can hear the dynamics as well as see them.

For the first author, using a very familiar configuration of electronic components to respond to the painter's kinesthetic gestures allows for a free-flowing, nearly subconscious state in performance. Brown also indicated that receiving audio feedback through headphones made the connection between performers feel "more intimate". In this case, the remote situation actually seems to enhance a sense of connection between the players.

Remote Performance of Acoustic and Electro-acoustic Music Using the ListenTo Plugin

Due to the global COVID-19 pandemic, Chicago's Fifth House Ensemble moved their scheduled spring 2020 Fresh Ink Festival to an online experience leveraging the idea of "remote performance" to challenge composers to devise works that would use the innate limitations of remote conferencing tools as potential creative devices. As platforms such as Zoom were prohibitive for remote musical performance, a solution was employed using the ListenTo plugin (audiomovers, Dover, DE, USA). The configuration required a digital audio workstation (DAW) session with one "send track" in which the ListenTo plugin was applied to send the performer's sound to others and several receive tracks through which participants could monitor and mix their fellow players. This facilitated high quality sound between players for works that did not require precise time synchronization.

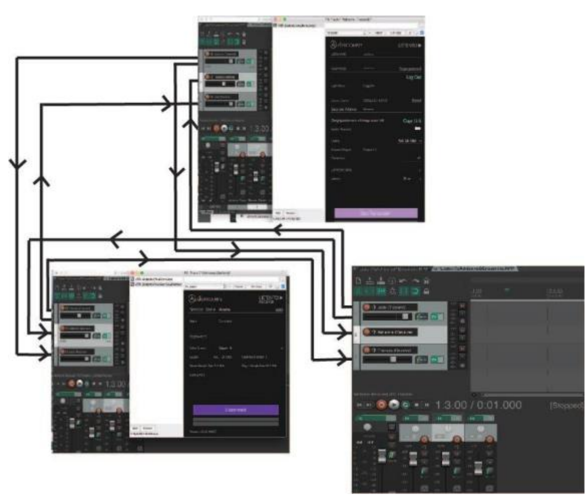

Figure 3. Configuration of Remote Performance Space using ListenTo.

Performances utilizing this method were presented in June of 2020 on festival concerts. Participants were coached by a team of composers, performers, and technologists in a series of rehearsals and a wide range of approaches were employed by composers and performers. Participants answered a series of questions regarding their experience playing within the system after the festival was complete. One piece that had a very successful outcome was *Colorful Clouds* by Spencer Arias. Performers were shown a video of clouds passing and changing color while a pre-recorded electronic track played with an instruction to change their mode of playing in response to subtle shifts in the colors of the clouds while also reacting to cues from the electronic track and their fellow players. This activity caused a profound shift in the way the performers listened to one another. The addition of a video component to the score created a multi-modal prompting including the visual sense that was not inhibited by the remote situation. One player noted:

> [This piece] helped [us] reach a deeper understanding of what it means to be connected as an ensemble...we had to understand how each of our distinct instruments fit into the electronic track and each other's sound at a moments notice...the result was a deeper connection that will persist as we continue to make music together in person.

Identifying and Developing Prerequisite Skills for Kinesthetic Empathy in Interactive Performance

Prerequisites for Kinesthetic Empathy in Traditional and Interactive Performance

All of the examples presented here show situations where human players felt one another's presence through some form of technological mediation, primarily using the auditory sense. To understand what makes this possible, we must first dissect what makes this possible in traditional musical performance. In standard performance situations, the types of interaction between musicians are inherently multi-modal (aural, visual, proprioceptive) (Renaud 2007). Though these senses facilitate communication, specific sensory cues in both music and dance are culturally specific and map to some familiar set of modes present in the specific cultural context (Reason 2010). In most cultural forms of music making, this sense is generally developed through an embodied understanding of the physical mapping of the instrument itself combined with an aural understanding of a musical system or its underlying theory. While the first form of knowledge is overtly embodied, the second allows musicians that play different instruments to share a common embodied understanding of modes and conventions present in a culturally specific form of music (scales, phrasing, intonation systems). As in "vicarious performance", the more familiarity the player has with the musical context the more vivid the empathetic experience between players can become (Bahn 2001). By Fogtmann's definition of kinesthetic empathy, musical performance can be viewed as a kind of technologically mediated interactive system in which the "technology" is the musical system that has been established over thousands of years of aural tradition or the codification of a theoretical musical system.

But what are the prerequisites to achieving kinesthetic empathy between players? The answer may lie in the concept of the "body schema" as proposed by Head and Holmes as "postural models of the body that actively organize and modify the impressions produced by incoming sensory input in such a way that the final sensation of position or locality rise into consciousness, charged with a relation to something that has happened before" (Head and Holmes, 1911-12). These schemas are seen as pre-conscious functions that "compare present posture to past posture, operating as a standard against which subsequent motor changes are measured, intervening before the change of posture enters consciousness."

One commonly referenced "body schema" is the experience of driving an automobile, a skill that becomes more or less automatic allowing the brain to engage in higher cognitive functions. In dance, performers learn to feel certain body positions using mirrors while they practice or a drummer can practice by "air drumming" patterns and even note when they have "screwed up". In virtual reality (VR) systems, a phenomenon known as the “Proteus effect” emerges when there is embodiment in first-person perspective and visuomotor synchrony. When this visuomotor synchrony is convincing enough, our brain adopts the virtual body as our own, no matter how different it appears from our own. This can cause changes in our perception at the attitudinal, behavioral, physiological, and cognitive levels (Slater 2017, Yee 2007). This is an example of a body schema that includes a purely virtual representation. Might a similar phenomenon be possible through forms of audiomotor synchrony? By the definition of kinesthetic empathy in interaction design, body schemas that provide an embodied understanding of the interactive system may be seen as a prerequisite for kinesthetic empathy. Here we propose a new term, “auditory kinesthesia”, as a part of the body schema involving a direct mapping between auditory and sensorimotor system.

Each of the examples had methods that helped participants develop this auditory kinesthesia related to the artistic activity. *Sentient Object* is a very simple GUI with a direct relationship between physical manipulation of objects on screen and sonic results allowing auditory kinesthesia relating fine motor movements to specific changes in sonic reaction. The *Layered Sound* project grew almost completely out of a desire to amplify the existing auditory kinesthesia of the painter. In combination with the auditory kinesthesia of the electronic performer with sonic reactions being mapped to fine motor skills used to turn knobs on a mixing or control device, the duo developed a joint body schema with bi-directional communication that could change incrementally with each performance (Hollnagel 2002). Finally, in the case of the piece *Colorful Clouds,* the players were instructed to focus on minute shifts of color and auditory prompts in a pre-recorded soundtrack to prompt sonic responses. Once this technique was practiced, the players were joined by alternate sensory inputs of both sound and vision, thus facilitating the same kinesthetic relationship that occurs naturally between players in a room.

Strategies for Developing Auditory Kinesthesia with Interactive Systems

All of the examples presented here include observations that were made after real world performances where the strategies for creating connections between the performers were either devised intuitively or emerged naturally from the instincts of the performers. The design of the video and audio score for *Colorful Clouds* focused the performers listening in particular ways, the interaction design of the system for *Sentient Object* trained the players to develop auditory kinesthesia and kinesthetic empathy through practice and improvisation, and in *Layered Sound,* the system was built around the existing auditory kinesthesia of the painter which then extended by proxy to the electronics performer. Though these examples all clearly demonstrated kinesthetic empathy between players, there was no systematic method of developing this kinesthetic empathy or the pre-requisite auditory kinesthesia. Further, each system's unique design, structure, and modes of interaction would have required quite different methods of training.

In the summer and fall of 2021, three case studies were done to examine specific interactive systems (Ingebritsen 2022). In these case studies, each system was first analyzed in terms of the modes of interaction, identifying who the interactive performers are, what modes of interaction exist between performer and system or between multiple performers, and where opportunities for auditory kinesthesia exist in these modes of interaction. From these analyses, strategies to instill the appropriate auditory kinesthesia and resulting kinesthetic empathy were proposed using two methods. The first method was to adjust the design of the interface itself, focusing on the specific modes of interaction and using principles from usability design. The proposed adjustments to the interface design had the intention to both increase the ease of use for the performer and to accentuate the main modes of interaction in order to develop a kinesthetic relationship between gesture and sound.

The second method was to create a series of exercises or etudes to help performers develop an embodied awareness of the connection between their gestural input and the sonic results. Once these modifications were made and exercises devised, performers were asked to interact with each of the systems. After a brief introduction to the functionality of the system, the performers were asked to engage with it on their own for a few weeks and then to do a "performance" of the piece or improvisation. The performance was recorded and the performers were asked to do a brief survey and interview to ascertain how much control or expressivity they felt while engaging with the system. After this initial performance, they were then given a series of "exercises" and were then asked to repeat the process, starting each practice session with a few of the exercises.

The three case studies included a performance of Kaija Saariaho's *Prés* for cello and live electronics by Raphael Maranon on the 2021 Fresh Inc Festival, A performance of Ryan Ingebritsen's *Reparametrization 1* for flute and real-time electronic manipulation by flutist Shannon Budd and electronic performer Ryan Ingebritsen, and improvisations with Ryan Ingebritsen's *Body Sample Player* system by electronic performance duo *Mega Laverne and Shirley.* Raphael Maranon was a student Cellist with very little experience performing modern music and no experience with live electronic performance. Shannon Budd was the flutist who premiered *Reparametrization 1* in 2008. The members of *Mega Laverne and Shirley* who include Andrew Tham (Mocrep, Parlour Tapes+) and Mabel Kwan (Dal Niente) are both experienced electronic performers with Andrew Tham being a designer of his own interactive performance systems focused around an electronic drum kit.

In each of the three cases, a major shift was noted before and after the intervention of the exercises in both the experience of the performers, as well as in the resulting performances.

Kaija Saariaho's *Prés*

In Rapheal Maranon's performance of *Prés,* he began with no concept of what he was supposed to be listening for in the electronics, simply playing the notes and struggling to make extended techniques speak. After the exercises, he noted that he could not "really tell the difference that [his] playing made with the electronics. The electronic response and my playing felt like two separate things" After the exercises, he noted:

> I started to feel like I had more subtle control over the nuance of the electronic sound and felt more of a 'radiance' with the electronics…I felt like I knew what I wanted to hear and felt, particularly in the exercises with the glissandi, I realized the connection between the way I played and the 'radiance' of the effects… This helped me especially in the last few gestures starting at cue 10 [harmonizer-delay effect] where I tried to make each gesture a bit different (Maranon 2021).

He also noted that after the exercise, certain extended techniques that he was going to consult his cello instructor about started to simply make sense as he was instilled with the awareness of his agency over the electronic sound. By simply playing to the electronic response rather than only the sound coming out of his cello, he developed a sense of how he wanted the full sound to emerge and gained the road-map he needed to understand the extended technique Sarriaho was asking for.

The performance itself occurred online in front of a remote audience over a live stream. The response to his performance was overwhelmingly positive and comments such as "these gestures are so haunting" and "such rich presence and tone, just beautiful". Despite being inexperienced with both electronic and contemporary music performance, developing connection of auditory kinesthesia with the electronic response in this piece helped Raphael overcome his trepidation and give an outstanding and expressive performance of the work.

Ryan Ingebritsen's *Reparametrization 1*

In Shannon Budd's performance of *Reparametrization 1,* the exercises actually had a disrupting effect on her playing. In this piece, the player manipulates two pedals, controlling effects volume and the speed of an automatic envelope generator effect respectively that then feeds into a variable isochronic delay. As the piece progresses, some of these functions lock into place allowing the player to simply play the flute with the effects continuing without the intervention of the pedals and locking into a tempo in a long delay to create a layered texture. As she had played this dozens of times over the course of many years, she had developed a muscle memory for how each gesture was supposed to be played. After doing the exercises, she began to discover that there were many more expressive possibilities for each gesture than she had originally suspected and by giving her permission to interpret the work in the same way she would an acoustic work, she began a very long process of experimentation which prompted her to ask for more time between the first and second performances. "I feel like I am thinking more about my feet now. Though I see the potential to play certain sections more expressively, my desire to have greater control has made certain phrases much more difficult to play."

In other sections where the effects lock into place, she felt far more connected to and in control of the "symphony of sound" that she was creating through her playing. This heightened sense of connection also led to an embodied realization of the input of the electronics performer in certain sections and inspired dialogue between flutist and electronic performer about how these sections should be played by both parties. Even though the connections between the two performers are more indirect, the heightened auditory kinesthesia on the part of the flutist revealed the possibility of kinesthetic empathy between the two.

The case studies above both resulted in online performances of the pieces. The work of Alexander Demos shows that entrainment between audience and performer occurs when the performance is noted to be "expressive" even when the performance is pre-recorded. Therefore, it should be expected that an online audience will have the same reaction if they feel that the performance is expressive. In both cases, the audience felt a clear sense of expressiveness as noted in their comments.

A third case study was conducted with the *Body Sample Player* system performed by *Mega Laverne and Shirley*. As this system was also used to demonstrate the possibilities of kinesthetic empathy in remote performance, I will talk about the two cases together.

Further Investigations using *Body Sample Player*

Body Sample Player is a body-controlled interactive instrument developed in several phases by Ryan Ingebritsen and user experience designer Hugh Sato for the music and dance piece *Mycelial: Street Parliament* (2018) in collaboration with choreographer Erica Mott (Ingebritsen 2020). *Body Sample Player* uses eight joint positions from a body tracking interface to control the relative volume of looping sound samples, which allows performers to act like embodied DJs. This mode of interaction is a direct example of auditory kinesthesia. It requires an intimate physical connection to each sound sample as the body itself controls what parts of the sample are heard or emphasized. By broadcasting the joint position data over a network, several players can immediately hear the effects of one another's movement engaging in a performance quite similar to in-person performance with the exception that their bodies are physically separated.

A test with Ingebritsen and Knowlton was performed to determine if a satisfying remote performance was possible and to compare the experience to in-person performance. Both players reported being able to sense one another's presence simply by listening after around 30 minutes of experimentation. As this system has a long history and an existing community of experienced players, we felt it was a good system to use to test the level of connection between performer and audience and between interactive performers. To this end, there are several questions we are interested in. Is it possible to feel the presence of another performer remotely purely using the auditory sense and can we infer from this the presence of the prerequisite auditory kinesthesia? Is the same relationship between perceived expressivity and entrainment present in remote or interactive performance as exists in acoustic performance? Does this sense of perceived expressivity increase when the observer has a first hand embodied experience with the system itself, experiencing the same

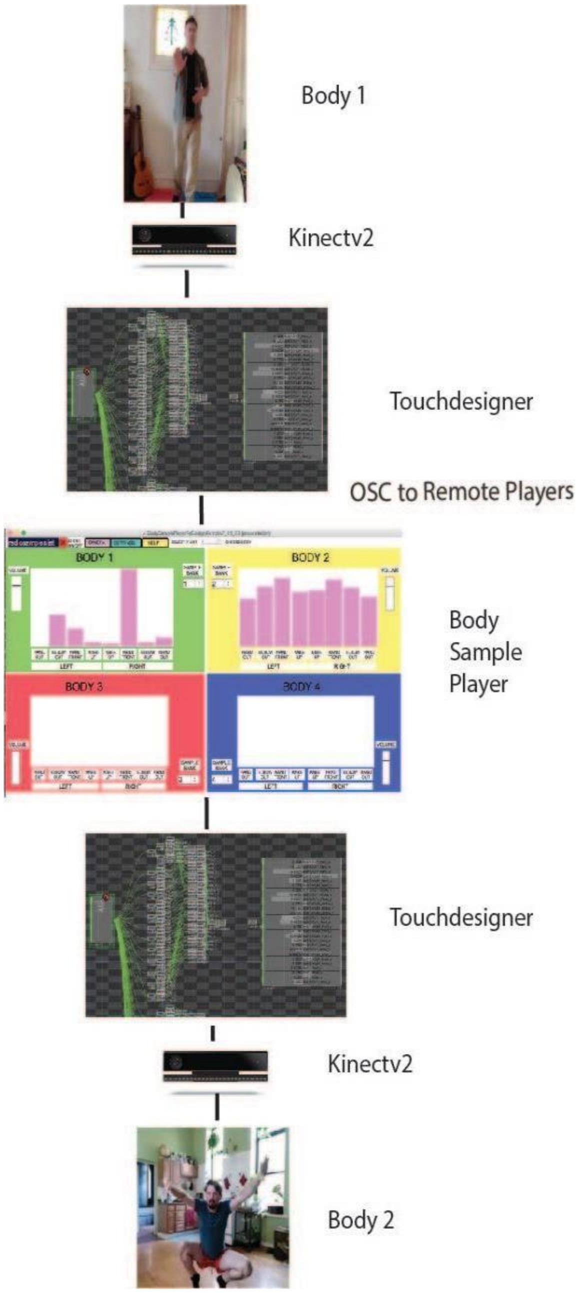

Figure 4. Remote Body Sample Player Diagram

mode of auditory kinesthesia the performer has developed?

We have started the process of asking these questions in a couple of ways. First, by giving public demonstrations where participants are allowed to experience the system first hand, and then polling observers of a live performance who are both experienced and inexperienced with the system to gauge if embodied experience with the system has an effect on perceived expressivity. Though no formal study has been conducted, informal surveys after performances at conferences in the spring and summer of 2022 suggest that even a trivial embodied experience with the system itself increases the sense of connection and expressivity. In future, we will use body tracking data to determine whether there is a corresponding increase in entrainment to accompany this heightened sense of expressivity.

Second, by using different training methods, both explicit and implicit, we can determine if there are certain methods that are more effective in helping users develop a sense of auditory kinesthesia. This was carried out as a third case study in the series of case studies outlined above.

In the winter of 2021-2022, electronic duo *Megalaverne and Shirley* engaged in improvisation with the body sample player system. For this case study, we recorded three sets of performances and did corresponding interviews and surveys for each session. The first was when I initially introduced the system to them and showed them the functionality. The second was after two weeks of practicing with the system, and the third was after they engaged with a series of exercises. Both musicians initially felt some confusion when working with the system. Kwan described the connection to the sampled sound as “chaotic”, while Tham explained:

> When I am playing electronic music, I usually use devices that ‘trigger’ sound from the beginning of a sample each time I press a button or hit a drum pad. With this I still have that idea in my body…but in this case, I am just turning up the volume on a sound that is looping by itself. It takes some getting used to.

After a few weeks of engaging with the system on their own, they both expressed a major shift in this experience with Kwan expressing a great sense of control over the samples after she had time to understand and embody the sonic shape of each sample. Tham stated that “once you understand the sound sample and develop the adaptability to respond to it, you have a much wider range of expression and it feels much more natural. I find I am ‘thinking’ way less about my body than in traditional performance”.

Figure 5. Body Sample Player Before and After Usability Re-desgn. The newer design better facilitates usability and the development of auditory kinesthesia through more intuitive graphical displays

Though both Mabel and Andrew had a very immediate and direct sense of embodied connection to the system even before the exercises, there were also some surprising reactions after they practiced with them. First, both players expressed a much greater sense of control of volume after the exercises. By simply establishing the lower boundaries for each joint position, trying to make the most subtle gestures possible, they were able to develop this control in their bodies.

The first two exercises seemed to help reinforce fundamentals while the third and fourth seemed to challenge them. “I thought that after our first performance my connection to the system was really strong”, said Andrew. “The first two exercises helped refine this sense of control, but when I did the third and fourth exercises, where I was asked to really try and internalize each sample and accentuate them in specific ways, it was like I realized there were more levels of mastery to attain, like I could continue to explore subtler musical possibilities by understanding the samples more”.

After doing the last four exercises that were intended to be done together, they both expressed a sense that their communication with one another could come completely from the sound coming out of the speakers. They both stated that they could feel what the other performer was doing just by listening and could respond almost unconsciously. This suggests a kinesthetic empathy between players based purely on the auditory sense, similar to that expressed by Ingebritsen and Knowlton in their experiments with performing with the system remotely.

It is interesting to note that after the exercises, the sense of strong connection to the sampled sound was challenged, with both players discovering another level of nuance and expression than they had sensed before. For Mabel, discovering the greater nuance of volume opened new expressive possibilities and made her feel like there were more exercises she could create herself based on this realization. Andrew felt that digging more deeply into the samples (exercises three and four) gave him a deeper appreciation for the intricacies of each sample and that he could leverage this to create a more interesting performance. By doing these exercises, both players began to perceive the potential to develop greater virtuosity. It also suggests that both auditory kinesthesia and kinesthetic empathy are not merely tokenized skills that one either possesses or does not, but rather, aspects of musical understanding that can always be improved.

Conclusion

Though it may one day be possible to emulate most aspects of live performance in a remote situation, it is unlikely this will ever occur without some perceptual shift on the part of participants. By viewing remote performance systems as kinesthetic interaction designs that employ artistic intention as intrinsic parts of the interaction, we can use various creative methods to create musically satisfying performance situations that engender kinesthetic empathy between remote participants in the same way that live musical performance would. By showing correlations between the development of the prerequisite auditory kinesthesia associated with a performance system and the perception of expressivity when hearing a live performance using that system, we hope to gain insight into best practices for both devising and training users for remote and interactive performance systems.

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Gesture Mapping with a Neural Network in Max

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Many of Journal SEAMUS's readers are familiar with machine learning and artificial intelligence tools for music making in one form or another. Indeed, Taylor Brook's excellent article in this volume offers an under-the-hood look at one such sophisticated system. However, I wanted to reach out to those who might be interested in using these tools but are unsure of where to start by offering a brief tutorial using the popular software Max. Click here to download the patch bundle.

While machine learning and artificial intelligence continue to be discussed in the media as tools for creating content—whether ChatGPT, Bard, DALL-E, or MusicLM—this usage is really only scratching the surface of what is possible. Rather than focusing on content creation, I want to discuss how to use the fundamental component of these systems—a neural network—to recognize human gestures in the context of a live electroacoustic performance. The method I describe below is simple by design, prioritizing reinforcing basic concepts through transparency and straightforward coding over efficiency and the use of cutting-edge tools.

Gesture recognition—the interpretation of human gestures by computers—is an important topic for the application of machine learning methods. Of course, what constitutes a "gesture" can vary widely depending on the context. But for the sake of argument, let us imagine a live electroacoustic performance in which the computer recognizes the performer's physical gestures and maps them onto sounds, whether triggering samples or sonic transformations.

Before we get started, I want to emphasize that I am by no means an expert in this area, though I have used and developed machine learning tools in my own musical practice for a number of years. I would like to call out a few resources that have been enormously helpful to me, in the hopes that they might also provide useful context for interested readers. Some of the best conceptual (and mathematical) resources I've come across include Andrew Ng's video series on machine learning and 3Blue1Brown's Youtube channel. I also found it useful to dive into previous research using machine learning for music. For example, the work of David Cope and Roger Dannenberg (here and here) is especially helpful in framing and evaluating research questions pertaining specifically to music. This paper surveying AI methods in algorithmic composition provides a nice overview of the field as well.

The basic idea for this patch is that each gesture will be represented as a list of numbers. When training the neural net, the user will specify a gesture label, which will then be associated with the particular sequence. I will use eight distinct labels, though this is easily modifiable. Over time, the idea is that the neural network can generalize what is distinctive about each gesture. Once the training is complete, the neural network will be able to categorize incoming gestures by assigning them existing labels.

There are many different ways of defining gestures. For example, gestures can be dynamic (moving) or static (not moving). I'm especially interested in dynamic gestures, since their beginnings and endings can be recognized to automatically tell the computer when a gesture is starting or ending. In this patch, I'll be imagining the movement of a hand, fingertip, or other single point in a vertically oriented, two-dimensional plane. (Imagine tracing a shape on a steamed-up bathroom mirror.)

To keep things simple, I will divide up the two-dimensional plane into eight columns and characterize each gesture according to the average values in these columns. The user will sweep their hand back and forth across the plane horizontally, with the variation in vertical position defining each gesture.

To get started, make sure you have the ml.star library by Benjamin Day Smith downloaded in the Package Manager (File → Show Package Manager). We'll use a very simple type of artificial neural network called a multilayer perceptron. A perceptron is a function that attempts to represent the relationship between its input and output by weighting corresponding nodes. While all perceptrons contain an input and output layer (the data to be evaluated and the evaluation, respectively), multilayer perceptrons are unique in that they contain one or more hidden layers that are weighted during the training phase. We'll use a multiplayer perception object called [ml.mlp] included in the ml.star package.

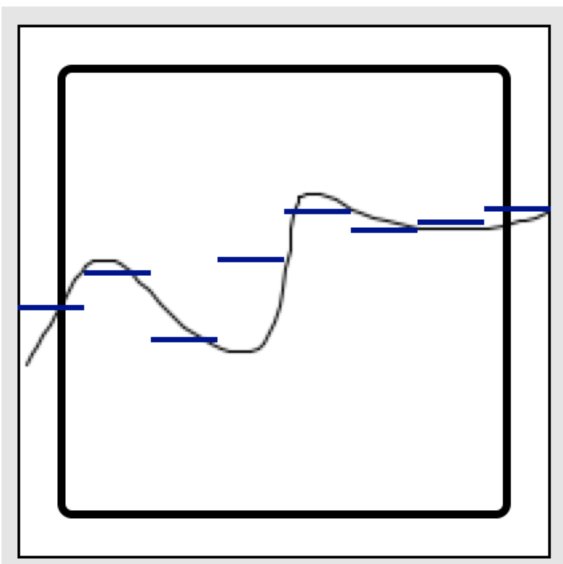

Fig. 1. Visual representation of a gesture

Figure 1 illustrates a typical gesture as represented through the system, with the continuous human-generated gesture given by the black line (an [lcd] object), and the mean-based simplification given by the eight blue bars (a [multislider]).

Gesture recognition characteristically involves a lot of pre-processing because you have to transform human gestures—which are typically complex and time-based—into an input format that a neural network can recognize and work with. In this case, the eight vertical columns are the eight data points that make up the input layer of the neural network. The output layer will have eight points as well, but these will represent the eight possible gesture categories. These categories, it should be emphasized, will be completely user-defined: whatever the user labels "Gesture 1" will become gesture 1, etc. (The fact that I have eight labels for gestures and eight columns of gesture data is entirely coincidental—these do not have to be the same number!)

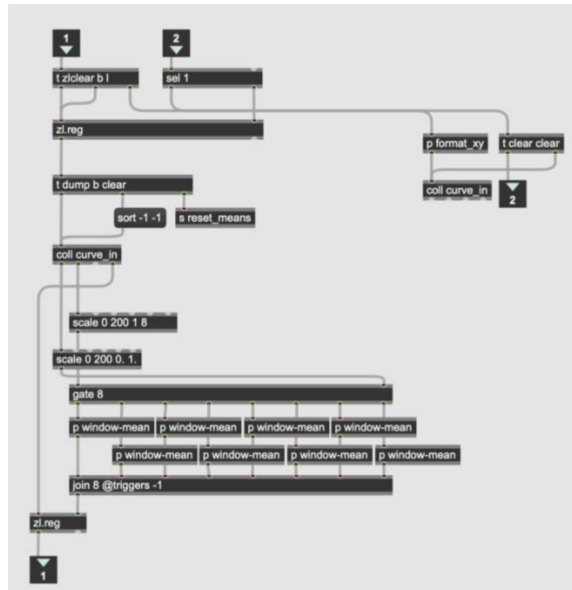

Fig. 2. Pre-processing section of patch

There were a handful of other minor processing details. For example, the [lcd] object used for drawing the line counts y values from the top down. I flipped this by running the xy coordinate list output through a [vexpr] object with a simple expression. I also had to calculate the mean of each segment separately, which involved sorting the values from the "dump" output of the coll object storing the line's coordinates into eight bins of equal size. I ended up solving this by scaling the x values to the range of one to eight and using them as the control for an 8-outlet gate, with each output leading to a separate [mean] object. Figure 2 depicts some of this pre-processing.

Figure 3 offers a view of how the various subunits of the patch are connected. The workflow begins when the user presses "Train" button, which initiates the training phase and specifies its duration (either in epochs [i.e. rounds] or until a minimal error value is reached). Next, the user chooses a training label to associate

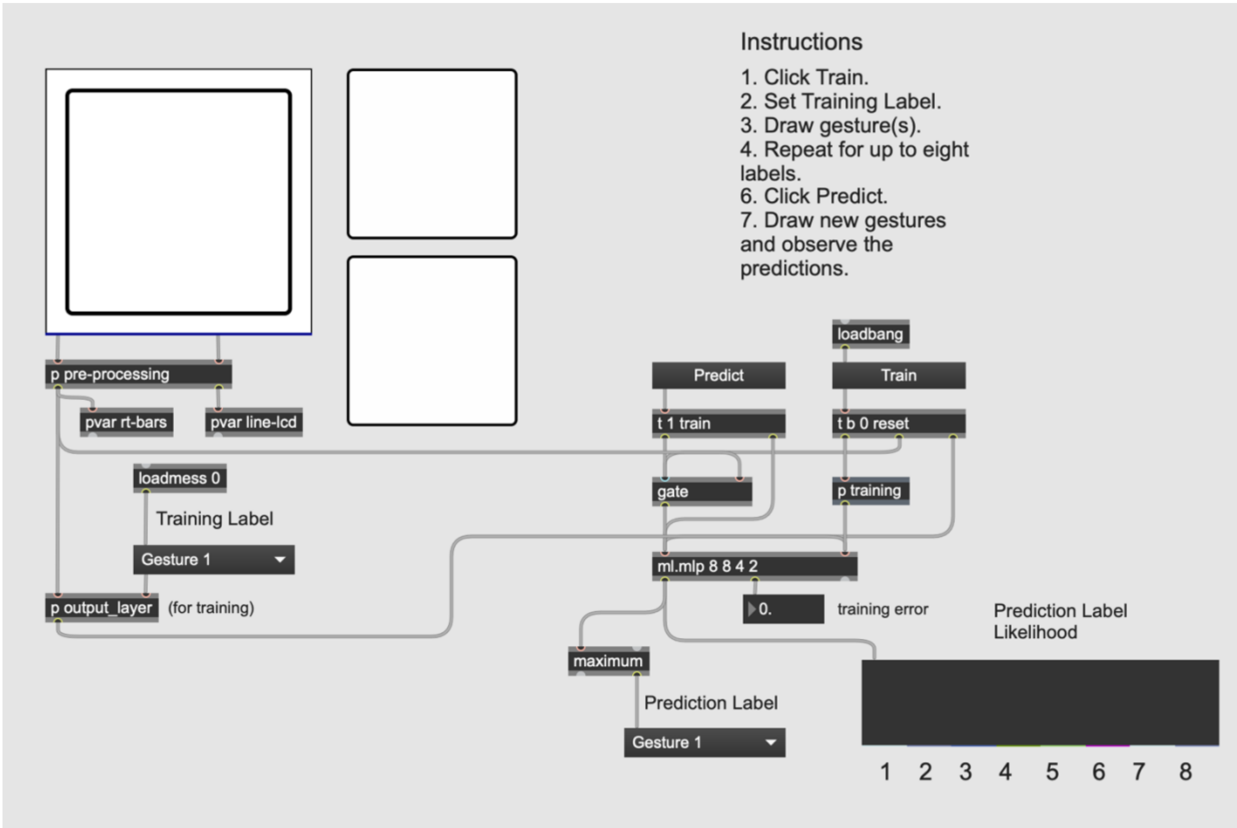

Fig. 3. Overview of patch

with the gesture they are about to draw. After drawing the gesture, they can repeat this process for up to eight labels. Once the user is done training the model, they can click the "Predict" button and draw gestures to see the neural network's prediction. When in prediction mode, the patch gives not only the most likely label for a gesture, but also the likelihood for each label (as a multicolored [multislider] object).

To integrate the patch into a real-world system, simply insert your own source of x-y coordinates into the patch—either into the [lcd] object or directly into the pre-processing sub-patch. A click-based gating system is used to define individual incoming gestures within the pre-processing sub-patch, but you can also populate the "curve_in" [coll] object directly.

The final version of this patch, while functional and easy to use, also has plenty of room for improvement. For example, the inner workings of the neural net remain hidden to the user so as not to clutter the interface, but this also prevents the user from adjusting the inner structure to produce better predictions. The patch would also benefit from some gesture "filtering," by which gestures are not recognized unless they pass across all eight columns. This will become especially important in real-world applications.

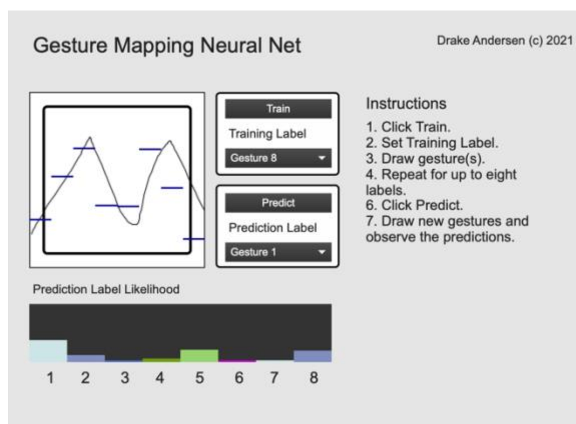

Fig. 4. User interface

Explore the patch bundle yourself. The patch bundle is available for download at: https://drakeandersen.com/wp-content/uploads/2022/01/gesture-_map_-mlp.zip

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