UNIVERSITY OF CALIFORNIA SAN DIEGO

PrismaSonus: Bridging Acoustic and Digital Worlds in Flute Practice and Performer-Composer Collaboration

A Dissertation submitted in partial satisfaction of the requirements
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in

Contemporary Music Performance

by

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The Dissertation of Alexander Alexandrovich Ishov is approved, and it is acceptable in quality and form for publication on microfilm and electronically.

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DEDICATION

To my parents Marina and Alexander, whose unwavering support and encouragement to pursue my dreams have been the foundation of my journey. To my mentors and teachers, who have guided me with wisdom and patience. To all my colleagues, friends, and collaborators who challenge me to expand my musical and artistic horizons. And to Ellen, my life partner and best friend, who inspires me to be the best version of myself through her brilliance, kindness, and resilience.

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ABSTRACT OF THE DISSERTATION

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by

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Doctor of Musical Arts in Contemporary Music Performance

University of California San Diego, 2024

Professor Wilfrido Terrazas, Chair

In the dissertation “PrismaSonus: Bridging Acoustic and Digital Worlds in Flute Practice and Performer-Composer Collaboration,” I examined how technology influences my flute practice, particularly how microphone placement affects technique, perception, and listening in electroacoustic collaborations, and how context and framing shape performer-instrument-composer communication. This research deepened my engagement with my instrument, broadened my practice, introduced new listening perspectives, and enriched my understanding of instrumental habits, affordances, and feedback.

The motivation stemmed from a desire to deepen my role in the musical creation process and to investigate how technological interventions could alter the dynamics between performers

and composers. “PrismaSonus,” an artistic research project developed with composer Theocharis Papatrechas, utilized microphones placed inside the flute to reveal hidden sonic landscapes. This led to the creation of a sample library of techniques and textures used in the co-creation of several electroacoustic works, including “Morphés.” We explored the dialogue between internal and external perspectives of the flute, expanding its range of sonic and expressive capabilities.

My approach combined practical experimentation with theoretical frameworks from human-computer interaction, cognitive science, and phenomenology, alongside case studies of artist-technologists. In our work, an iterative process of recording, listening, and processing not only guided the project’s artistic trajectory but also collected robust documentation on the integration of technology into musical practice.

The findings illustrate how technological interventions can broaden, blur, and redefine the creative roles of performers and composers, fostering a co-creative environment where traditional roles are reimagined. This shift in listening perspectives and disruption of habitual feedback pathways highlight technology’s role in fostering new collaborative exploration, empowering me to engage more actively in the compositional process.

Ultimately, this dissertation contributes to the discourse on music technology, performance, and composition, by showcasing how deliberate technological interventions can enrich musical collaboration and creativity. It proposes a model for future explorations where technology is not merely a tool but a central component of artistic expression, suggesting new possibilities for performer-composer collaborations and the evolution of musical practices. This narrative provides practical insights, inspiring performers and composers to explore new creative dimensions.

Introduction

This work, told from my perspective as a flutist, chronicles my journey through the landscape of contemporary music and music technology, exploring the intersections of co-composition, recording techniques, interface design, and cognition. Analyzing spaces co-inhabited by performers and composers and exploring mediators of performer-instrument interaction has empowered me to develop my own method for shaping the artistic production process. This approach positions me as an active participant in all stages of the artistic development process, synthesizing my performance experience as a flutist with my interest in experimenting with music technology.

I explore methodologies beyond traditional music contexts, using insights from human-computer interaction, cognitive theory, and phenomenology to examine how technology shapes interactions between performers and composers. This dissertation reveals the active steps I took to shape and reshape the diverse, overlapping roles I seek to adopt within contemporary music performance, composition, pedagogy, and scholarship.

This writing accompanies major works I co-created with composer Theocharis Papatrechas at UC San Diego, including *PrismaSonus*, an artistic research project exploring microphone placement, flute technique, and auditory perception; *Morphés I*, a fixed-media installation presented at the Qualcomm Institute in February 2023; and *Morphés II*, a live performance version of the work performed in June 2023. Our project is at the intersection of artistic expression and research, balancing a self-inquiry into my performance practice with technological integration. My role extended beyond performing, venturing into realms of experimental recording techniques, and acoustic research, while Theocharis brought his deep knowledge of composition, acoustical analysis, audio spatialization. This collaboration not

merely merged our expertise but also blurred the boundaries between our roles as performer and composer.

In this project, we critically examined the role of recording technology in shaping our collaboration. A key concept that fascinated us is the way technology can transform listening perspective by uncovering the internal sonic world of the flute. By placing microphones inside the instrument, we accessed unexplored landscapes, revealing hidden timbres and techniques. The contrast between the flute's interior with its external sound projection challenged my listening and performance practice, expanding my understanding of the flute's sonic capabilities. Altering the action-sound mapping of the flute disrupted the feedback pathways I used to explore my instrument. This intentional alteration of the instrumental space fostered innovation and experimentation in my own practice, enriching the collaborative environment in which we worked.

I believe the narrative told by the music demonstrates the coequality of our artistic, technical, and conceptual contributions to this project, in which we merged our individual skillsets and artistic affinities into a unified whole. This exploration has been guided by key questions: How do technological interventions influence the creative roles of performers and composers? What methodologies can be developed to better understand collaborations? This dissertation seeks to answer these questions by documenting and analyzing the detailed processes of our collaborative experiments. The sounds of *PrismaSonus*/*Morphés* were created through an iterative process of recording, listening, and processing over many months. I will provide some technical documentation for the projects, my analysis of the artistic development process, and the goals for the project post-June 2024 (Chapter 4).

As I stepped outside of my comfort zone as an interpreter of notated music, I have been inspired and influenced by theorists, artists, and technologists, all of whom influenced the design of this collaboration. I will detail the concepts that helped me understand the role of technology, perspective, and communication in shaping artistic practice. Jonathan De Souza's *Music at Hand: Instruments, Bodies, and Cognition* established my understanding of how instruments shape the way we interact with music (Chapter 1), inspiring me to connect more deeply with how my instrumental habits shape my creativity, and providing examples of artists who intentionally modify their instruments for expressive purposes (Chapter 2). Paul Dourish's *Where the Action Is: The Foundations of Embodied Interaction* situated my exploration of technology within a social framework that includes designers, users, and their communities, providing me with tools for analyzing how design decisions influence the way we interact with technology (Chapters 1-3. Stefan Östersjö's *Listening to the Other* influenced my approach to documenting project development, analyze the composer-performer dialogue, and navigate the day-to-day logistics of co-composition (Chapter 2). Ge Wang's *Artful Design: Technology in Search of the Sublime* reminded me to always seek out the fun and humanity in everything I design, presenting a practical approach to the decision-making processes involved in working with technology (Chapter 3). Finally, analyzing the work of Khyam Allami and Jace Clayton, two musicians who use technology to engage with their collaborators and communities, provided me with case studies to analyze how the concepts I explored in De Souza, Dourish, Österjsö and Wang apply to the real world (Chapter 3).

Ultimately, this dissertation is about empowerment and agency. By highlighting the material conditions and decision-making processes that mediate my collaborations with composers, I seek to understand how my everyday interactions continually shape and reshape my

artistic identity. By providing insights into the dynamics of co-composition and the mediating role of technology, I seek to challenge the assumed norms of how to structure my artistic projects. I aim to provide other performers and composers one potential model for understanding their creative potentials and constraints. This narrative not only contributes to the rich academic discussion surrounding co-composition and performer-composer hybrid practices but also encourages practitioners at any stage of their artistic development to reflect on and innovate their collaborative practices.

I believe that by defining the filters mediating the performer-composer work process, individuals within that collaboration can exercise more agency over the shape of their collaboration. Exploring the relationship between people and systems allows for a more mindful decision-making process. This work is a personal testimony advocating for a mindful, informed, and innovative approach to musical collaboration and exploration, where technology, technique, design, and communication converge to create new artistic possibilities.

My Creative Origins

I seek to better understand how the material conditions and settings in which I work influence my perception and creative process. My journey in new music has been shaped by institutional structures, academic priorities, and the aesthetics of my mentors. As my own performance experiences have broadened, so too has my definition of music. Engaging with various methodologies outside of music has sharpened my ability to articulate how the music I encounter affects me and guides my decisions about future projects. Through it all, my constant and evolving relationship with the flute has anchored me. Even as my tastes change and I navigate new performance settings and collaborative environments, my dialogue with the flute and its affordances continues to guide and inspire my creative process.

My journey with new music began somewhat serendipitously as a student at the Eastman School of Music, where a chance opportunity led me to participate in a performance of George Benjamin's *Octet* with the student-led new music group.[1] This pivotal experience opened the doors to the technical and conceptual challenges of contemporary chamber music and deeply influenced my artistic trajectory. A graduate student in my studio was out of town for a concert week and knew of my curiosity in new music and recommended me as a substitute flutist. Surrounded by graduate students, I found myself in a group of kind, supportive, and fiercely dedicated musicians, all volunteering their skills for the love of challenging music and community performance. This experience inspired me to seek out every possible opportunity to engage with contemporary chamber music alongside my classical studies. My deepening engagement with new music led me to transition from solely performing pre-existing works to actively co-creating new acoustic and electroacoustic compositions.

Initially, my exposure to contemporary music followed a model common within American music institutions, where students are often "rotated" into new music ensembles to perform works selected by their ensemble directors. This director-led approach significantly shapes many students' perceptions of "new music." My engagement with new music in an extracurricular, student-led setting (and not as a requirement) was very fortuitous, underscoring how within the rigid schedules of conservatory life, sometimes simple curiosity is enough to open unexpected doors. I recognize how this period in my education underscored a traditional narrative of performer-composer-conductor dynamics, often lacking a direct interaction with composers. This highlights a gap in my early music education—a direct connection to the creative process of music composition.

1 OSSIA New Music https://www.ossianewmusic.org

Navigating the varied landscapes of contemporary music across different institutions and localized communities influenced my development. At Eastman, and later in New York City, I was exposed to a wide spectrum of new music aesthetics that challenged and expanded my understanding of what could be expected from a performer, how performers can challenge the spaces in which they work, and what my instrument could produce. Continuing my exploration of contemporary music at a highly academic environment like UC San Diego has continued to challenge me to unpack how environment shapes my perception of music.

Musical affinities are influenced by the specific academic settings and curricular focus of institutions. Different schools and music communities, each with their own priorities and leaders, could have led me down entirely different paths in the realm of new music. I believe this underscores a need within our field to engage with the assumptions shaping educational frameworks. The distinctions between stylistic and demographic diversity, the structure of undergraduate curricula, and the influences of a conductor's taste, are all difficult to question when debated internally within pedagogical and musicological frameworks.

Stepping outside the traditional confines of music to explore interdisciplinary methodologies has been transformative in the development of my practice. It has not only broadened my perspective but has also equipped me with the tools to critically engage with and question how educational environments shape and are shaped by our artistic practices. I have also found that by borrowing the language of non-music fields to analyze my work, I can more effectively challenge myself and others to reconsider frameworks that shape our performance, education, and research spaces.

Mediated by Technology

The trajectory of my doctoral studies at the University of California San Diego was significantly shaped by the COVID-19 pandemic. This period necessitated a pivotal shift in how I engaged with music technology across performance, pedagogy, and scholarship. I delved into the roles of telecommunications and interactive technology in education and performance, which led me to reevaluate my existing relationship with recording technology—from a documentation tool to a medium for musical exploration and collaboration.

I have always been interested in technology, which I explored independently of my flute playing for many years. Throughout my music education, I treated technology as a separate element distinct from my practice. My collaborations with composers typically occurred in conventional settings where technology played a predefined, supportive role.[2] Time away from performing gave me the time and encouragement to fully commit to exploring the intersection of technology and music. During this period, I first focused on identifying tools and platforms for remote teaching in both music theory and flute. I experimented with low-latency audio streaming tools, collaborative digital audio workstations (DAWs), and interactive music theory resources.[3] My goal was not to replicate the in-person teaching and collaboration experience but to explore the unique possibilities offered by remote instruction. These practical explorations were supported by the theoretical frameworks I was exploring, making me realize that each decision made by a designer influences the way I communicated through the software. Working remotely, communication pathways are more limited than in in-person interactions, so each decision made by a designer has a greater effect on perception. As I read Jonathan De Souza's work on

[2] For example, conducted works with fixed-media electronics and/or projections; composers recording meetings for documentation purposes; MIDI playback used as a practice tool.

[3] I applied this technology to courses I taught both as a Teaching Assistant and as an Associate Instructor of Music Theory and Musicianship, spanning a wide range of experience levels (MUS 1A-C, MUS 2A-C, MUS 101A-C).

instrumental affordances and Paul Dourish's work on how designers influence a user's perception of space, I gained insights that would later influence my work with Theocharis.

In addition to exploring various platforms for remote teaching and collaboration, I explored the fundamentals of electronic music, learning the basics of audio synthesis, production, and coding. The electroacoustic flute music I had performed up to that point involved operating programs already fully completed by just pressing "play." I wanted to understand how these electronic tools were built, so I devoted time to exploring the basics of several audio programs, including Max/MSP and Pure Data (Pd). At the time, I was learning some microtonal music and wanted to create a tool for practicing microtonal intervals. This exploration of technology, separate from my flute playing, reminded me of an important lesson from my Alexander Technique (AT) training, where I learned that our strongest habitual relationships with practices present very intense stimuli.[4] To change a habit, it is important to displace it with something else, shifting attention elsewhere. I will discuss this concept further through De Souza's analysis of guitarist Kurt Rosenwinkel, who altered his instrument to shift focus, which is also related to my explorations of *flow states*.[5]

During this period, the microphone emerged as the primary tool through which I connected with my collaborators, my own playing, and my students. I noticed how my perception of playing was shifting, influenced by the close, prolonged interaction with my computer, office space, and recording technology. This new environment prompted me to critically assess how the software and hardware I was using was reshaping my experiences with

[4] Alexander Technique is a method for raising awareness of habits to bring more ease and efficiency into our practices. Like other mind-body integration practices, it is popular among performing artists who use their bodies as part of their craft. For more, see *The Alexander Technique for Musicians* by Judith Kleinman.
[5] Throughout this text, I will refer to *flow states* as a state of absorption in current experience, as described by Mihaly Csikszentmihalyi in *Flow: The Psychology of Optimal Experience* (1990).

my flute technique, with listening, and communication. During this time, I experimented with binaural microphones to capture my flute playing from the perspective of my own ears, contrasting these recordings with traditional, external microphone placements. I considered how recording from my ears could change the way I captured the memory of performing, and how I could communicate the sensation of playing to a student. I learned about the way listening involves not only air conduction through the ears but also bone conduction, and is a highly subjective processes mediated by physiology, psychology, and cultural conditioning. While it is impossible to experience your own playing from someone else's listening perspective, I thought about how technology can create a "neutral," third perspective, external to everyone's own perception.[6] These ideas led to the idea of placing microphones in different locations to record the flute, a key element in my project with Theocharis.

Working remotely necessitated a shift from performing for a live audience in concert halls and engaging with composers in a rehearsal room to engaging with cameras, microphones, and controls in a home studio setting. My training in the Alexander Technique influenced how I integrated technology into my environment, exploring ways to ergonomically invite technology *into my space*, instead of going *into the technology*. This idea of being inside/outside technology would influence another key element of my collaboration with Theocharis, where we explored how placing microphones inside of the instrument transforms the instrumental landscape. This early period of exploration was crucial, as it opened up new avenues for my musical practice. By embracing the affordances of remote work, I began to bridge my existing acoustic practice with technology-mediated spaces. This inspired me to seek out theorists offering methodologies for

[6] Throughout this dissertation, I will challenge the existence of a "neutral" perspective, suggesting how all perspectives are shaped by prior experience, technology, and the context in which the activity is framed.

how to approach technology, laying the foundation for discussions I will present in this dissertation.

Collaborative Beginnings

My collaboration with Theocharis Papatrechas developed over the course of several collaborative projects created in 2019-2023, each building upon the last in complexity and interactivity. This progression developed the creative process that would culminate in our research project *PrismaSonus*, and *Morphés I and II*.

Pythmenas

Pythmenas (2019) is a fixed media immersive sound installation composed and produced by Theocharis Papatrechas.[7] It combines instrumental improvisations[8] with hydrophone recordings of undersea mammals and sea ice formations. This project was produced as part of Professor Lei Liang's seminar at UC San Diego titled "Hearing Seascapes," an interdisciplinary space for artists and scientists. The seminar aimed to explore and reimagine the creation and experience of music at the intersection of science and art, using resources from the Scripps Institute of Oceanography to develop projects centering around sounds of the ocean. This was the first project in which my role began to expand from being purely a performer towards being involved in all stages of the artistic production process.

Pythmenas laid the groundwork for our collaborative dynamics. In contrast to our later projects, it presented a clear division between stages of pre-production, performance, and electronic processing, as well as distinct roles for the performers and Theocharis as the producer and composer. In this early collaboration, our interaction with the source material was separate

[7]https://soundcloud.com/theocharis-papatrechas/pythmenas
[8] Recorded by me; Dimitris Paganos Koukakis, piano; Ilana Waniuk, violin; and Rebecca Lloyd-Jones, percussion.

from the recording sessions; we drew inspiration from a curated collection of sound materials but did not listen to these samples during the recording sessions. Furthermore, the post-recording processing—handled exclusively by Theocharis—meant my direct involvement in the artistic process ended after the improvisation phase. This separation of roles led to a final composition that was surprisingly transformative, revealing the potential of electronic processing to reshape my acoustic improvisations, though without my direct involvement in the artistic or technical development beyond performance.

The program notes for *Pythmenas*, written by Theocharis, elaborate on the formal construction of the work, the interplay between sound material and performer, and the philosophical distinction between human and non-human elements of the composition:

> Three distinct worlds interact to create a musical experience. The ocean sets the primary component of the triadic entity, inspiring the entirety of the artistic work. The sonic profiles from recordings of several of its living organisms (i.e., whales, dolphins, seals) made by scientists of the Scripps Institution of Oceanography are being interpreted by members (instrumentalists) of the overwater universe, who carry out a discussion following a line of instructions for improvisatory action. Technology, the last constituent, intervenes, capturing and processing the activity of the performers as well as manipulating the original recorded media. (Papatrechas, 2019)

Although *Pythmenas* was a highly experimental collaboration, it still had a clearly defined distinction between instrumentalist-performer and producer-composer roles. This project demonstrated Theocharis's interest in crafting sonic environments where performers (and listeners) are immersed within an imaginary landscape, a theme that would be further developed in our subsequent collaborations. It inspired me to consider how technology can be used to create new listening perspectives. Hearing *Pythmenas* at the Spatialization Lab[9] was a revelatory

[9] Audio Spatialization Lab of the Qualcomm Institute at the University of California San Diego

experience. Unaware of what the final product would sound like, I was overwhelmed by awe and surprise as the sonic narrative unfolded through the 28 spherically arranged loudspeakers, blending my improvisations with the layers Theocharis described in his program notes. This fusion rendered parts of my playing indistinguishable from the whale sounds and environmental noises, challenging my perceptions of sound and ownership. Unlike previous fixed media projects where I had previewed the final product, logistical constrains prevented any early listening, positioning me alongside the audience in discovering the piece's final form. Experiencing the composition's premiere in real-time as a listener alongside the audience was unexpectedly liberating. It underscored a pivotal moment of trust, where I heard my musical voice delicately intertwined with the composition. The overwhelmingly positive experience creating *Pythmenas* was a key factor that clarified our collaborative values, which shaped our subsequent projects.

Hearing Earth: Refining Collaboration

Building on our experiences in *Pythmenas*, our next project was conceived, recorded, and presented in a fully remote environment. During this period, I deepened my involvement with recording technology, music software, and low-latency audio streaming solutions. This project was part of another seminar led by Lei Liang, titled "Hearing Earth," which expanded our thematic exploration to include sounds of the Earth.

This collaboration utilized a sample library of bowed metals and rock sounds created by field recordist Thomas Rex Bevery.[10] We set up a two-way stream that allowed me to send my playing to Theocharis and have him send back sampled and processed materials.[11] Similar to

[10] https://thomasrexbeverly.com

[11] We tested several software solutions for this, including: *ListenTo*, *JackTrip*, eventually settling on SonoBus.

Pythmenas, I identified sounds that sparked interest, perhaps a texture or timbre that I felt I could emulate or play with on the flute. This real-time interplay created a more dynamic and immediate interaction loop, contrasting with our previous work where recording and processing were temporally separate phases. Theocharis experienced how the original sample was filtered by my listening and my playing, and I could experience how my playing was filtered by Theocharis's listening and processing.

Working remotely and collaborating entirely through headphones and microphones emphasized the mediating role of technology. It highlighted how the essence of our collaborative experience was inseparable from the technological mediums we employed. The project featured real-time looping and playback, allowing us to experiment with altering my flute playing in real-time and engaging with *latency* as a mediator of our creative expression rather than a limitation.[12]

The evolution in our collaborative approach—from the distinct roles in *Pythmenas* to an integrated, technologically-mediated interaction in this project—demonstrated a shift in our work process. Technology became a fundamental component shaping our artistic dialogue and output. This phase was crucial in providing me with real-world experience in navigating and adapting to the affordances and constraints of technology within a remote collaborative environment.

Deepening Collaboration and Expanding Roles

Our collaboration began with a shared interest in exploring how technology can transform our auditory experiences, prioritizing sonic exploration over notation or fixed

[12] Even specialized tools for audio streaming introduce latency, which is the delay in the signal caused by the computer hardware and software used to record sound, distance between the computer and internet server, and the distance between collaborators. Even using a hard-wired fiber-optic internet connection, as well as a relatively fast computer, results in a perceptible delay.

compositional structures. Exploring sound and technique in tandem and listening intently to each other without rigidly-defined roles marked a significant departure from my previous collaborations with other composers.

During the early projects like *Pythmenas* and our experiments working remotely, Theocharis took the lead in manipulating and processing the sounds we created together, while I focused on selecting the sounds and textures to record. As our collaborative method and trust deepened, so too did our shared understanding of the material we were creating. This evolving relationship led to a more equitable distribution of roles: I began to take a more active part in the compositional decisions, while Theocharis extended his influence on the specific techniques I was exploring. This contrasts with other collaborations in where the composer typically provides the performer with detailed instructions through notation, initiating the communication process. At this stage in our collaborative history, having completed two projects and spent considerable time exploring technology together, I recognized Theocharis's appreciation of my insights as a performer, reflecting a truly co-creative process.

I believe that our initial exploration of technology and source material established a shared history that facilitated the equitable co-creation described. While it is common (and expected) for composers to dictate performance techniques and formal structures, and for performers to comment on the notation, what distinguishes our collaboration is the development of a communication method and documentation system that transcended our defined roles as performer and composer. This approach was shaped by my research on performer-instrument interactions and human-computer interaction (HCI) and exposure to interdisciplinary modes of

thinking, as well as Theocharis's experience working with scientists and technologists before our collaboration.[13]

Our collaboration represents a successful synthesis of complementary areas of expertise. Theocharis brought robust knowledge of audio recording, processing, spatialization, and experience notating a wide range of flute techniques in contemporary and experimental music settings. My expertise in flute performance and recording, combined with the methodologies I will unpack in subsequent chapters, developed our symbiotic partnership. Recognizing when to expand my knowledge and when to rely on Theocharis's expertise was crucial in navigating the complexities of our work together.

Morphés I and II (2023) is the next stage of our artistic journey, embodying the essence of our collaboration through its integration of sounds, performance, and processing. This piece, existing in two versions as both a fixed-media multichannel installation and live-performance concert work marks a significant departure from our previous projects in both scope and methodology. One of the fundamental aims with *Morphés* was to delineate the creative and research process from the musical output itself. PrismaSonus served as the overarching research endeavor underpinning our collaboration, while *Morphés* emerged as the specific musical expression born from this project. This distinction allowed us to focus on documenting our exploratory techniques and the evolution of our creative methods distinctly from the compositional and performance outcomes.

The following chapters will delve deeper into the specific methodologies I explored that informed my contribution to PrismaSonus and *Morphés*. These include human-computer

[13] While I have no formal training in fields outside of music, I was raised by a filmmaker and a scientist. This exposure to navigating technical fields and working in teams with structured division of labor influenced my approach to this collaboration. Prior to my work with Theocharis, I had not found the opportunity to incorporate these modes of working into my music-making.

interaction, cognitive theory, phenomenology, interface design, and other interdisciplinary approaches that influenced the development of this project. By examining these theoretical frameworks, I aim to provide a comprehensive overview of how the work I did away from the flute influenced my contribution to this project. I will also highlight the broader implications of this work for the fields of music performance, composition, and digital interaction. Then, in Chapter 4, I will return to my collaboration with Theocharis, discussing the major project we created in 2022-2023 and how it was influenced by the methodologies I share in Chapters 1-3.

Chapter 1: Object Interaction

As a performer, my primary mode of interaction with music is via my instruments: the piccolo, the concert flute, the alto flute, and the bass flute. As an interpreter of contemporary music, the music I perform demands a wide range of playing techniques, mediated by notation. My practice time is structured by the pieces on my music stand. I am shaped by the music I perform, what it demands from my technique, and how it focuses my awareness. It is impossible for me to keep all elements of my technique equally accessible, so practicing involves cycling various skills, keeping them ready for whatever challenges the music presents me with. As my stylistic interests evolve over the years, so does my technique. I enjoy the process of revisiting styles of music I spend time away from, noticing how my body, technique, and awareness has evolved. For me, practicing music fundamentals (tone exercises, technique, etudes) is space that is truly mine, in which I get to decide what to focus my attention on. Holding that space is sometimes difficult amidst a busy performance schedule, but this centering time is what grounds my approach to repertoire. I am interested in defining the space of entanglement between me, my instrument, the music, and my collaborators. In doing so, I hope to better understand the processes mediating the relationships I am involved in, making me a more mindful flutist and collaborator.

Electroacoustic music introduces technology as an additional element I engage with through my listening and performance practice.[14] *PrismaSonus* and *Morphés* unify my explorations of instrumental technique and technology. As discussed in the Introduction, my initial explorations music technology focused on hardware and software, applied directly to my existing performance and teaching practice. In this initial phase of experimentation, there was a

[14] Electroacoustic music is a genre of contemporary music that uses technology to manipulate acoustic sounds (The Oxford Companion of Music).

gap between my ideas for applying technology to my practice and my technical know-how (both in terms of hardware, and software).[15] As a performer working within highly professionalized spaces, having this time for open-ended and creative exploration was extremely generative for me. I created space to explore new ideas with a *beginner's mind*, away from the strong habits associated with my flute playing.[16] In this hyper-online period, I got oversaturated with the newness of all the hardware and software I was experimenting with.[17] I intentionally stepped away from these explorations to develop a theoretical and conceptual framework for approaching technology, which would go on to inform my collaborative method with Theocharis Papatrechas.

This chapter will introduce some of the theoretical texts I explored during this time, which will be expanded on in Chapters 2 and 3. This includes *Music at Hand: Instruments, Bodies, and Cognition* by Jonathan De Souza, which explores human-object and human-instrument interactions. I unpack De Souza's discussion of instrumental affordances, instrumental topography, technical and motor agency, instrumental idioms, and instruments as compositional tools. I use the terminology and concepts presented by De Souza to guide my exploration of recording technology's effect on my perception of flute technique and performance, as well as the intentional modification of the perception of instrumental affordances for creative, musical, and artistic purposes. In the next chapter, I will unpack De Souza's analysis of guitarist Kurt Rosenwinkel's use of instrumental alteration as a way to break

[15] For example, experimenting with the use of binaural microphones for flute recording, trying to create apps for microtonal tuning in Pd, exploring VSTs for practicing polyrhythms in Ableton Live.
[16] See Section 2.1.1 for discussion of *beginner's mind*.
[17] It was also during this time that I discovered the joy of buying used synthesizers (which I knew nothing about), trying them out, and then re-selling them. As a flutist, the instruments I have a life-long investments, and it is rare event to go through an equipment change. I enjoyed how with electronic music equipment, I could things with a lower barrier of entry. It was almost as if I was back in 4th grade, choosing the flute as my instrument (while also being able to experiment with other instruments).

playing habits and generate creativity, which informed my approach of using microphones to alter my perception of the flute.[18]

The actions I take in my collaborations, and the perception of them, are influenced by social structures. Paul Dourish's *Where the Action is: The Foundations of Embodied Interaction* explores the relationship between people and systems, providing a phenomenologically-informed overview of human-computer interaction. As I read this text, I thought about the uniqueness of each space in which I make music, and how interpersonal dynamics, behavioral expectations, and material conditions contribute to the overall experience. Inspired by models offered by Dourish, I use the terms s*pace* and *place* to situate performer-composer collaboration within the specific contexts in which we developed and presented our work: the recording studio, the listening room, the academic music conference, the interdisciplinary arts festival, and the concert hall.[19]

Performing contemporary music requires me to switch between different instruments that are all part of one instrumental family but are clearly defined as distinct musical objects. My habits map differently onto each of my flutes. The instrument is a mediator of my technique—its unique characteristics alter my playing, the way I perceive of my playing, and the connection between action and goals. I will use the term *affordances* to refer to the link between action and perception, between individual and technology. James J. Gibson, the founder of ecological psychology, uses the term *resonance*, or *tuning* to describe this coupling. Objects are seen in terms of their *affordances*, perceived as things that can be used (1979, 134). Gibson believes that "the object offers what it does because it is what it is" (Gibson, 1979, 139, as cited in De Souza,

[18] De Souza analyzes how Rosenwinkel's practice of instrumental detuning (changing the pitches of the strings) was used as a creative tool by altering instrumental habits.
[19] See Section 1.6.3 for a discussion of *space* and *place*.

52). Different people have a different understanding of what an instrument's affordances are, which can lead to rich dialogues as collaborators explore an instrument together. It can also lead to frustration in instances where two people have a mismatched understanding of an instrument's affordances (e.g., when a composer's idea affordances rely on a very specific performer or piece of music, which the performer might not be familiar with.) Teaching also involves engaging with affordances, where environments are structured for a student to discover affordances and create playing habits. I brought this perspective on affordances and habits to my collaboration with Theocharis, where we used microphones to explore, alter, and document the landscape of the flute.

My habits are intertwined with my instruments. Each instrument has a unique feedback signature. Altered feedback guides technique in a new way, creating new habits and remapping technique in a way that alters my experience performing. Therefore, instruments mediate the way I interact with music. The choice of instrument determines the sort of feedback I get while performing, altering my sense of ownership and/or agency over the musical landscape. Electroacoustic music complicates this relationship, introducing technology as an additional modifier of instrumental feedback. The look/feel of that technology greatly affects how it affects me. Identifying the way technology alters instrumental feedback allows me to be more intentional in the collaborative process. I seek to better understand how technology impacts technique, listening, and creativity.

This process of examining technology's role within electroacoustic collaborations critically engages with creative and technical choices. This mindful approach enables more opportunities for sharing with my collaborator how the music written for me can take advantage of my unique balance between action, perception, and habit. By going through this process, I

ultimately make my performance practice more integrated into the sum of my life experience, increasing feelings of ownership and agency within the performer-composer interactions that I am involved in. By understanding the processes involved in human-instrument interaction, I am more prepared for the additional factors introduced by technology.

1.1 Objects Create Interaction

In my exploration of musical habits, I first stepped away from the specifics of my instrument to explore the general topic of how objects affect the way we interact with the world, and how the qualities of objects mediate my interactions with them. I am interested in understanding how the contexts in which I interact with my instruments reveal certain goals, and how those goals affect the way I perceive of my instruments.

The use of objects requires technique. Interaction involves an interplay of techniques and technologies (De Souza, 2). Technique can highlight or obfuscate the qualities of technology, while the use of technology can emphasize, modify, or create entirely new techniques or modes of interaction. As De Souza puts it, "the instrument, together with my action, reveals a world" (24). What is the limit to how far I can push my instrument to accomplish musical goals that are not built-into its design? I distinguish between the acoustic technology I use (the flute) and electronic technology (microphones, computers, software). How does adding electronics to an existing acoustic instrumental practice alter the way I can accomplish musical goals?

An idea that has greatly influenced me is that our experiences with technology are shaped by the decision-making process of the designers of those technologies. Each element of technology introduced to my performer-composer collaborations implicates the designer within the creative dialogue. We used recording technology to explore the sonic world of the flute and document the development of our project. We used digital interfaces to listen, categorize, and

analyze the recordings we created. I am interested in the ways communication is enabled through the interaction with design. Understanding the processes influencing the design of technology helps understand my perception of my work, myself, and my collaborators.

Embodied Interaction is a set of principles that a designer can utilize in their design process, outlined in *Where the Action Is: The Foundations of Embodied Interaction* by Paul Dourish. These principles emphasize that it is the user who creates meaning in design by interacting with it, and not the design itself. Dourish outlines how designers can get out of the way of users, empowering communities to appropriate technologies for their needs. He outlines the ways that designers often make decision for users that negatively impact the level of freedom and connection the user feels to the design. I use Dourish's framework to analyze the role of design within performer-composer collaborations.

1.1.1 Objects and Goals

My interactions with music require tools, and the qualities of those tools affect the way I interact with them. The instruments I play affect the way I engage with music, and therefore affects the way I perceive it. There are different modes of interaction I can adopt with objects, and different ways I can orient myself towards them. "How to interact with the flute" is a very loaded and subjective concept, so I found it useful to consider human-object interactions more broadly.

For Martin Heidegger, we interact with objects in two distinct ways. *Zuhanden*, or "ready-to-hand" is when we act *through* an object, and when the focus is on the action we wish to complete using the object. *Vorhanden*, or "present-at-hand" is when we act *on* the object, and when action is directed towards the object. (Dourish, 108-09). Dourish uses the example of the computer mouse to demonstrate the distinction between present-at-hand and ready-to-hand

interactions. Picture yourself using a mouse connected to a computer. Your focus is on manipulating the screen, not on the motion of the mouse. The action of moving your arm to move the mouse to then move the cursor is all compressed into a unified focus on manipulating the GUI [Graphical User Interface]. In this moment, you are acting *through* the mouse, and therefore the mouse is *ready-to-hand*. Suddenly you reach the end of the mousepad, and you need to pick up and move the mouse. The focus is now on the mouse as the object of activity, and it is therefore *present-at-hand* (Dourish, 109).

Dourish applies Heidegger's distinction between these two modes of interaction to the way we perceive technology: "…as we act through technology that has become ready-to-hand, the technology itself disappears from our immediate concerns. We are caught up in the performance of the work" (109). In my playing, I am constantly shifting between these two modes of interaction, and it is difficult to pinpoint exactly at what point my interactions with the flute shifts from ready-to-hand to present-at-hand. For example, when a piece of music asks me to play *pianissimo* (very softly) in the upper register, it requires me to act *on* my body to align it with what the music requires. Once my technique is aligned, I can then play *through* the flute. Many years of practicing enables habits, which shorten the time required to switch between these two modes of playing. Eventually, this distinction fades from the performer's perception entirely. Perhaps performing is a matter of choosing which musical elements to intentionally control, and which ones to allow habits (which re developed through practice) to guide. Electroacoustic music complicates this distinction by introducing the element of technology, modifying a performer's perception, creating scenarios that do not follow habitual action-sound mapping.[20]

[20] I will discuss the concept of action-sound mapping further in the text.

Sometimes a composer intentionally asks a performer to adopt a present-at-hand mode of interaction. For example, a few years ago I performed a piece asking me to shift between different finger positions very gradually in a way that emphasized movement of fingers, as opposed to movement between pitches. Woodwind playing involves navigating a series of *fingerings*, where each note requires a combination of fingers to produce. Deconstructing fingerings into a set of individual finger motions involves making conscious something that is otherwise an unconscious process.[21] The composer was specifically interested in me exploring how the shifts between finger positions revealed moments of instability, and how staying in this space of instability generated curiosity to keep exploring. I was not playing *through* the flute to access the music. Instead, the notation invited me how to act *on* my flute. In this example, acting *on* my technique was the vector through which I generated feedback from my instrument.[22]

1.1.2 Framing and Reframing

The objects I choose to interact with the world with are always framed in relation to other objects. Martin Heidegger's concept of *geworfenheit* or "thrownness" explains how we are "thrown" into a world that already has its own culture and history (Heidegger, 1927/2010, 127-28). My instrumental practice is informed by my own experience and is also influenced by the collective history of my instrument. The knowledge of this history informs my perception of the instrument. Therefore, my flute technique does not exist in a vacuum, and is informed by the sum of my experiences, my knowledge, my habits, and my perception of them. I am able to

[21] Later I will talk about the software design concepts of *abstraction* and *implementation*, which I think have parallels with the idea of finger combinations representing discreet pitches on a woodwind instrument.

[22] As I reflect on this, I could see how one could argue the opposite. Rather than having a definitive understanding of what it means to play through the flute versus on the flute, I am interested in finding the middle ground between these two concepts, emphasizing how performance involves constantly switching between different modes of interaction.

access the past experiences of objects that I have not experienced myself (Steigler, 1998, as cited in De Souza, 2017, 26-27). I connect to this idea deeply, because it means that through my instruments I can access the knowledge of others. Musical notation is example of a technology enabling me to connect with musicians of previous centuries. My work with Theocharis uses technology to create additional vectors through which we access each other's knowledge.

Instruments are framed in relation to other instruments (De Souza, 119). My choice of musical object has a framing effect on my experiences. The actions I associate with objects conditions the way I hear. Changing or modifying the musical object reframes the experience and creates new potential actions. I learn about music through the process of interacting with it. Altering instruments alters action, therefore revealing an altered world.

> We learn how to play an instrument by doing it, not be merely reading a book or watching others. Leonard Meyer compares this to riding a bike (1973, 15-16). This bike cannot ride itself without the person. The world is felt *through* the bike - the feet never touch the ground. The human is the bicycle's engine. Riding a bike is a way of being in the world, for it transforms the experience of space, of speed, and of body. A bike converts action into momentum, a musical instrument converts action into sound. (De Souza, 28)

It is impossible for me to perceive something without first choosing the tool through which it is perceived. The choice of tool alters my perception of the world. Introducing new tools to collaborations creates new possibilities for interaction.

1.1.3 Priming Action

What exactly forms musical interpretation and creative decision-making: my actions, my grip of the flute, the flute's grip on me, or some other process? How does changing the object I use to reach music affect our interpretation? How does technology mediate my perception of instruments? In what ways does music reach back out to me?

Every time I play the flute, my past experiences, current awareness, and projected intentions synthesize into a single action. The memory of objects affects the way our minds process information, alters our perception, and affects performance.[23] Maurice Merleau-Ponty states in *The Phenomenology of Perception* that "the gesture of reaching one's hand out toward an object contains a reference to the object, not as a representation, but as this highly determinate thing toward which we are thrown, next to which we are through anticipation, and which we haunt" (Merleau-Ponty 2012, 140, as cited in De Souza, 2017, 79). What is the effect of technology (which includes instruments) on the process of me reaching towards my instrument?

I associate different memories with different musical objects, which affect the way I reach them. I perform on the bass flute in a very specific context (contemporary music), while the piccolo has a wider range of memories associated with it (orchestral music, as well as contemporary music). This carries over to the way I approach technology. My embodied habits and memories associated with the flute are much stronger than my memories of specific audio hardware or software, which I have comparably little professional training and experience with. Instead of stepping outside of my instrumental practice and into technology, my approach is to bring technology into my instrumental practice. What I propose is an instrumentally-informed

[23] Scientific studies that show that even when imagining an object, it already alters our perception (Mike Tucker and Rob Ellis, 1998, 2001, 2004, as cited in De Souza).

exploration of digital technology, which uses my acoustic instrumental technique as the central reference point of my explorations.

Objects prime the actions they afford and alter perception. Merleau-Ponty describes process as gripping, in that each object affords a unique grip. What I reach affects the quality of how I reach it. In other words, how and what we reach are inherently tied to our perception of the overall experience. Instruments have unique ways of gripping sound, which means that the way I reach music will be affected by the instrument that I use. Merleau-Ponty describes this as "being-toward-the-thing," which means that the body is aimed at a particular object (De Souza, 79). Introducing technology into this equation alters my sensation of *gripping* and *reaching*, revealing a transformed object. This concept informed my approach of placing microphones inside of the flute, which created a new pathway towards reaching my instrument. The way I *grip* and *reach* a flute that has a microphone placed inside of it (the input of which I monitor via headphones) is very different from a flute in a purely acoustic environment.

Something I considered in my exploration of instruments and technology is how decision-making is affected by a sense of *ownership* and a sense of *agency*. Ownership is: "my body is mine," while agency is: "I am causing or controlling action" (De Souza, 79). To me, these two ideas are interconnected, one affecting the perception of the other. Introducing an unfamiliar technology into instrumental practice affects my sense of agency. My early explorations of music technology sometimes led to feelings of frustration because my instrument no longer responded in a predictable way. My habits were not aligned with the altered affordances of the instrument. In my work with Theocharis, I found these to be the most generative moments, in which we discussed how intentionally mismatching my instrumental habits with the way I was gripping and reaching created new spaces for creative exploration.

1.2 Habits Enable Performance

My instrumental practice involves constantly reassessing how my habits (conscious and unconscious) affect my performance. Pedagogy involves showing students how to identify, modify, and develop habits. As I explore how objects shape perception, I am curious about the role of habits in affecting how I interact with my instruments. At what point are my habits not really mine? In other words, how does the concept of *thrownness* affect my individual habit-forming agency? How does electronic technology intervene in these processes?

1.2.1 Habits and Objects

Habits involve objects and support the way we use objects and enable human performance (De Souza, 18). As De Souza puts it, objects "afford particular kinds of motor and perceptual habits; they reveal certain possibilities, while concealing others" (23), and goes on to say:

(1) Habits have limits and apply only within a certain genre of action.

(2) Unlike reflexes, habits are acquired.

(3) Habits can stagnate.

(4) Habits can be unlearned and relearned.

(5) Habits are dynamic.

The years I have spent playing the flute have built up habits that are tied to specific performance contexts. Is there a perceptibly significant difference between a reflex and a habit? Performing concert music requires me to react quickly to things happening around me, which often feels like an unconscious process. Hearing an out of tune note requires me to adjust my own playing to match it. I perceive this as a reflex—stimuli that requires me to respond to it. And yet, I learned

it through years of habit-forming practice. While I accept that there is a scientific or conceptual distinction between habits and reflexes, in practice it is often unclear.

I agree with De Souza's assessment that habits are always in a state of movement. I believe that physical and mental tension is sometimes caused by forcing our habits to become fixed, and/or perceiving them as fixed.[24] What happens when we assume our unconscious habits are still the same, when they have changed outside of our zone of perception?[25] What happens when habit, action, and perception are mis-mapped, and how does that alter my sense of ownership and agency?

Electronics allow me to intentionally re-map my instrumental habits, or bring to my attention habits that are otherwise outside of my zone of perception. For example, placing a microphone inside my instrument will allow me to hear extraneous noises made by my fingers which are otherwise unheard. Placing a motion sensor on my elbows would allow me to observe what my movement habits are, which otherwise do not contribute to the sound of my playing.[26]

Throughout my instrumental training, I have heard teachers and professionals speak of "effortless" performance and "limitless" technique. For me, that does not mean that there is literally no effort and no limits, but that in the moment of performance those limits are not perceptible.[27] If I do not perceive of my technical limits, and no longer perceive challenging music to be difficult, are those limits still there? When preparing a recital of difficult music, at a certain point there is a switch that occurs when I feel that my mind *trusts* what my body can do.

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[24] For example, when learning classical repertoire (especially orchestral excerpts), performers strive to be able to very closely replicate an "ideal" way of performing, even though our technique is constantly shifting and changing.
[25] Alexander Technique, as well as many other mind-body integration practices, seeks to connect what we think we are doing with our bodies, with what our bodies are actually doing.
[26] Using that motion to generate sound would extend my instrumental technique. I will discuss how instruments map habits onto technique in Section 1.5 on Instrumental Topography, and throughout Chapter 2.
[27] In other words, there is an optimal balance between ability and perceived challenge, which is how Mihaly Csikszentmihalyi would describe *flow state*.

Or perhaps there is no longer a distinction between what I can do and what I can perceive. In the *Phenomenology of Perception*, Maurice Merleau-Ponty uses the example of walking with a cane to demonstrate the effect of habit on the perception of technique. Once the cane becomes familiar, it withdraws from the attention of the user. The person feels the world *through* the cane's tip. One isn't necessarily thinking about all the data the cane is giving (pressure, position of tip, position of environment).[28] Habit relieves the person from doing this work. Once we become habituated to using a tool, it becomes *in-hand*. De Souza believes this is why musicians claim instruments sometimes feel like they are a part of their body (48).

Changing something about my technique or learning an unfamiliar piece of music makes me much more aware of the data the flute is giving me, preventing me from feeling limitless or effortless in my playing. Learning new music requires that I switch in and out of these distinct modes of interaction. Remaining entirely within a habitual, unconscious space leads to technical and artistic stagnation.[29] By incorporating technology into my practice, I create an altered instrument with which I have less associated habits. I intentionally prevent the flute from fully withdrawing from my attention. I act *on* the electroacoustic flute, while playing *through* the acoustic flute, even if I am playing the exact same technique.[30] The goal of practicing is to build habits that will allow this new instrument to become a part of my body.

Related to the concept of *thrownness*, the collective habits of a community form an *external memory* for objects. This means that my understanding of the flute references all the

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[28] "The pressures on the hand and the cane are no longer given, the cane is no longer an object that the blind man would perceive, it has become an instrument with which he perceives" (1945/2012, 154).

[29] In Chapter 2, I will use De Souza's analysis of guitarist Kurt Rosenwinkel's playing to illustrate this point.

[30] When I imagine a sound I want to play on the flute, my habits guide my body to position itself to play that sound. Feeling primes action, which I then confirm once I hear my playing. In my recording sessions with Theocharis, I would wear in-ear headphones that blocked out external sound. I created scenarios in which the aural feedback I received from my playing was drastically different from what my ears would hear without headphones. I will discuss the role of feedback in guiding performance later in the chapter.

interactions I have had with other people about it. The following points, synthesizing De Souza (77-78, referencing Stiegler, 67) and my own observations have helped guide my thoughts on where my own contribution to the flute ends, and where I tap into the contributions of others:

(1) Instruments do not exist in a vacuum and cannot be neutral.

(2) External memory creates *musical idioms*, used by performers to draw on larger, ready-made sequences to perform.

(3) Idioms allow performers to offload the processing required to navigate musical gestures.

(4) Idioms are not universal, and are unique to specific genres, composers, performers, and communities.

(5) Performers and composers do not always share the same concept of instrumental idioms.[31]

(6) The development of idioms is a social process.

(7) Idioms are produced, maintained, and negotiated in communities.

(8) Idioms are rooted in social groups.

(9) Idioms can overlap between communities, but always have a degree of untranslatability between them.

Over the course of my collaboration with Theocharis Papatrechas, we developed shared idioms that increased our sense of co-ownership over musical materials, which I will discuss in Chapter 4 as related to the idea of a *self-referential collaboration.*[32]

Perhaps the interplay between an instrument's external memory and an individual performer's technique and habit creates an *internal memory*. Instrumental music education

[31] I am interested in the process by which I created a shared understanding of my instrument with my collaborators. Chapter 2 will expand on this.

[32] I use this term to describe the feeling of having enough shared history with a composer, enabling collaborators to access memories of earlier stages in the project development process.

focuses on learning an instrument's external memory first, introducing a student to technical exercises, recordings, and technique. Gaining the ability to perceive your own playing *independently of* how the instrument is guiding you is an important step towards taking ownership over your own technique. Once a student reaches this point, the increased feeling of agency incentivizes further practice, forming habits, which guides technique. Learning new music materials re-starts the process by re-focusing attention on the individual physical actions required in performing. This pedagogical approach to learning influenced the way I have invited technology into my existing instrumental practice. Technology becomes a vector through which I engage with my perception of the flute, challenging and modifying it. Articulating and documenting the specific steps I took in the decision-making process was one of the ways I exercised creative agency throughout this process.

1.2.2 Unconscious Navigation

Not all decision-making involves a conscious process. Professional musicians rely on habits and idioms to navigate musical gestures without controlling each individual aspect of technique. Merleau-Ponty uses "motor intentionality" to describe automatic movements (2012, 113).[33] In highly regulated performance environments, sometimes it can feel as though the body is improvising on its own, or that the body is being played by your instrument (De Souza, 78). Unconscious decision-making plays a role in the development of musical interpretation. When I introduce technology into my performance practice, aspects of my technique that are unconsciously performed need to be consciously managed, until I form enough habits with this altered instrument.

[33] Studies have shown that quick responses can outpace conscious thought, leading to a dissociation between action and awareness (Jeannerod 2006, 46-49). For example, a driver responding to something in the road before realizing what it is. Therefore, actions aren't always caused by self-conscious decision-making (De Souza, 79).

Habits allow performers to require less conscious management of their technique. Becoming fluent with fingering systems is an example of this. "In performance, the fingering feels automatic. After all, how could they perform the piece fluently if they needed to consciously initiate every finger movement? The action must become habitual, so playing the scale feels like a single flowing gesture" (De Souza, 19). Over the course of the development of PrismaSonus, this relationship between technology and conscious management of technique evolved. In the early experimental phase of the project, I was very aware of the impact of technology on my technique. As I learned more about the action-sound mapping of this new instrumental space, I gradually moved towards being able to play in a "single flowing gesture."[34]

When something is difficult or unusual, I act *on* my instrument, as opposed to acting *through* the instrument. Difficult music requires conscious attention. When something is difficult or unusual, we act *on* the fingerings, as opposed to acting *through* them (De Souza, 18-19). The more experienced a performer is, the quicker they can respond to unfamiliar music and new instruments. Earlier, I shared the example of the piece of music where I was asked to individually move my fingers, decontextualized from their specific fingerings. Perhaps if I continued exploring this technique, at a certain point this way of moving my fingers will become an unconscious process, at which point I can distance myself from the actual technique and

[34] Throughout this time, most of my flute playing continued to be (and continues today) primarily acoustic. Switching back and forth between the electroacoustic environment in which everything was intentional and conscious, and more automatic/unconscious performance settings has been very useful.

instead engage with these unexpected sounds.[35,36] The music of Brian Ferneyhough represents an opposite experience: everything is very clearly outlined, but there is such a vast amount of information to process that a performer must choose which aspects are processed consciously, and which are left to unconscious habit.[37] In Ferneyhough's case, I find his music to be written very idiomatically for the flute, partly due to his personal experiences as a flutist. The more encounters I have with his music, the more memories I have associated with the actions required to perform it. Perhaps successfully performance is a matter of identifying where the meeting point of a composer's and performer's understanding of instrumental idioms lies, and then analyzing how conscious and unconscious processes can be effectively enacted to enable fluent performance. This extends to technology as well. A performer's familiarity with music hardware and software affects the degree to which they can achieve unconscious navigation.

De Souza shares an interesting example from Merleau-Ponty's *Phenomenology of Perception* that highlights the way an experienced performer navigates instrumental space:

> An experienced organist is capable of playing an unfamiliar organ, whose keyboards are more or less numerous, whose stops are differently arranged than those on his customary instrument. He needs but an hour of practice to be ready to perform his program…. He sits on the bench, engages the pedals, and pulls out the stops, he sizes up the instrument with his body, he incorporates its directions and dimensions, and he settles into the organ as one settles into a house. He does not learn positions in objective space for each stop and each pedal, nor does he entrust such positions to "memory." During the rehearsal—just as during the

[35] An experiment by Caroline Palmer and Rosalee Meyer (2000) showed that professionals focus more on sound, and beginners focus more on hand movements. It demonstrates that professionals develop instrumental skills to the point that they require minimal attention when playing patterns. Therefore, technique becomes in-hand because it withdraws from awareness. The performer's focus is on the work, not the tools. This is only possible when a tool can be trusted. An example of this is of hammer that you're not focusing on but using it as a means to an end. (De Souza, 20-21).

[36] Manipulating the air column as part of sound production is another layer of technique that exists beyond and parallel to fingering technique. Deciding on fingerings is part of the process of mediating sound, which interacts with other elements of technique.

[37] Brian Ferneyhough (born 1943) is associated with the New Complexity movement, a style of composition that creates highly complex, densely-notated scores that require a very high time investment for the performer to process and internalize.

> performance—the stops, the pedals, and the keyboards are only presented to him as powers of such and such an emotional or musical value, and their position as those places through which this value appears in the world. Between the musical essence of the piece such as it is indicated in the score and the music that actually resonates around the organ, such a direct relationship is established that the body of the organist and the instrument are nothing other than the place of passage of this relation." (1945/2012, 146–47, translation altered, as cited in De Souza, 22)

This example demonstrates how experience, strengthened by habit, allows a performer to navigate an unfamiliar instrument with relative ease. The establishment of the "direct relationship" between body and instrument is the key phrase here. What I like about this example is how experience allows a performer to make decisions about what they will consciously control, and what they will leave up to habit. I relate to this description strongly, because it is similar to the process I have adopted to learn Ferneyhough's music.

The way we unconsciously navigate our first language, or our first instrument means that perhaps there is a more direct connection to the essence of what we are saying. When those thoughts are translated to another instrument or language, there are more conscious steps involved in deciding how exactly we wish to express that idea. In my own experience, having an embodied experience with translating my thoughts into different languages occasionally gives me the sensation of having a thought or emotion before they are associated with a specific language. This, combined with my multi-instrumental training, gives me the feeling of having more space to consciously decide what to do when using a musical object, instead of just "saying" the thing.

1.3 Instrumental and Technological Affordances

I engage with music by objects. Habits, combined with technique, support the way I interact with those objects. The qualities of musical objects mediate my perception of the

musical landscape I am situated in. Affordances are the possibilities for an object's action, which mediate my experience with the world (Östersjö, 18).

What are the processes by which I learn about the flute's affordances, and how does social conditioning affect what I consider to be its perceived uses? How can this terminology inform my approach to music technology? How do habits strengthen or obfuscate the perception of affordances, and how does technology mediate these processes?

1.3.1 Tuning to Objects

Affordances are the link between action and perception, between organism and environment. James J. Gibson, the founder of ecological psychology, uses the term *resonance,* or *tuning* to describe this coupling. Objects are seen in terms of their *affordances*, perceived as things that can be used (1979, 134). Gibson believes that "the object offers what it does because it is what it is" (Gibson, 1979, 139, as cited in De Souza, 52). Using Heideggerian language, this perspective is oriented towards an object's *handiness,* as well as its possibilities of action (De Souza, 12-13).

While an object's affordances are potentially endless, memory and social conditioning create an expectation of how objects are used. Certain interpretations of an object's potential uses will come more naturally than others (De Souza, 52). External memory and social conditioning create expectations of how instruments are used. Most of my prior collaborations with composers used musical notation as the primary method of communicating ideas. When working with notated music, performers and composers rely on their background knowledge, along with a set of memories and associations, to connect markings to a set of expectations. Effective notational practices consider this complex web of interaction. My collaboration with

Theocharis Papatrechas instead used recording technology and a shared listening practice to develop the foundation of our interaction.

At the beginning of this chapter, I discussed how interaction involves an interplay of techniques and technologies (De Souza, 2). David Kirsh's idea of the *enactive landscape* is the space in which this interplay occurs. Musical instruments "provide musicians the physical landscape necessary to change their possibilities—to create a perfect niche for making music" (Kirsh, 2013, §2.6). Different musical contexts enable different musical landscapes. Instruments can support multiple landscapes (De Souza, 53). This allows me to apply my flute practice to a wide range of musical contexts and aesthetics, each activating a distinct combination of affordances and associated habits and memories. Technology expands the scope of landscapes I can access. Technology can highlight or obfuscate various aspects of my instrument. Technology combined with technique can uncover landscapes that are otherwise hidden.[38]

I became interested in contemporary music because I felt as though it provided me with the widest landscape possible for engaging with my instrument. I gravitate towards performance environments in which I am expected to jump between different modes of engaging with my technique and listening. This desire for variety informs the way I practice: while I have a core of techniques that support all of my music-making, I pick and choose what to practice based on the landscape I have ahead of me.[39] I became interested in music technology and electroacoustic

[38] From the project description: "This project focuses on transforming the listener's perspective to uncover the flute's internal sonic world. *PrismaSonus* aims to capture and document the unique acoustics of the flute's interior, contrasting it with its external sonic projection. This exploration challenges conventional listening practices by providing access to the flute's nuanced, internal soundscapes, thus offering fresh musical insights and expanding our understanding of the instrument's capabilities. By placing microphones inside the instrument, we reveal the unexplored landscapes within the body of the flute, uncovering timbres and techniques usually hidden from both performers and listeners."

[39] I believe this is one of the potential benefits of a classical education, because it offers a wide yet sturdy technical foundation upon which a performer can then build their personal performance practice. Unfortunately, this method of education also often leads to a high degree of social conditioning that creates a fixed understanding of an instrument's potential roles, but this issue goes beyond the scope of my discussion.

music not out of a desire to step away from my acoustic instrumental practice, but to invite technology into my practice in a multimodal dialogue centered on perception, memory, and expectation.

1.3.2 Constraints

The technologies I choose to utilize in my practice have constraints, which influence the way I accomplish musical tasks. As I considered the ways I wanted to engage with technology in my music-making, I was influenced by Jonathan De Souza's analysis of Edwin Hutchins's book *Cognition in the Wild* (1995), a case study of the way that navigational tools are used on the US Navy amphibious helicopter transport ship U.S.S. Palau. The tools used not only affect the way that the individuals process raw data, but sometimes change the task at hand.

> For example, sailors must often calculate interrelated quantities of distance, rate, and time (147–55). A pencil and paper may be used to record the numbers, holding them in a kind of external memory while the navigator focuses on algebraic and arithmetic operations. Alternatively, the calculations can be done with a three-scale nomogram, a kind of nautical slide rule. Since the appropriate mathematical relations are encoded in the slide rule, the navigator's task then involves lining up indices with numbers on scales. Computational constraints are built into the physical structure of the tool (96). It embodies cultural knowledge and strategies, and precludes certain kinds of mistakes. In this sense, instruments may know things for their users (De Souza, 24).

Constraints are built into the tools I use to accomplish tasks. They are either built into their design, or established through the social setting in which they are used. I like the idea of wondering what kinds of things my flute *knows* when I work on music. Inviting technology into an acoustic music-making practice involves a conversation with your instrument in which you balance the knowledge built-into an object (its affordances), your own knowledge of the object (your memory), the knowledge of your collaborator (and their perception) and the method for documenting and communicating the work (in our case, a sample library).

Technology requires designers. Even when working in a purely acoustic setting, designers are part of the dialogue (e.g., instrument builders), who contribute to the flute's external memory. Introducing electronics into my practice invites many more types of designers into the dialogue (interface designers, microphone builders, etc.). Dourish outlines his vision of a design philosophy influenced by what he refers to as "Embodied Interaction," a set of principles designers can utilize in their design process. The designer communicates a set of constraints and expectations about using the design. These intentions are communicated through the form of the interactive system itself, and its *usability*. Usability is defined as the way that a system reveals its purpose to the user. The user then develops an understanding of the meaning of objects and the consequences of actions within the system (132-133).[40] Once technology is added as a mediator of performer-composer interaction, the designer now inhabits that creative space. Technology gains meaning once the users (performer and composer) work within the design together.

This idea from Dourish that users create meaning by communicating *between* each other, *through* the system influenced my thoughts about music technology. By centering on what decisions people make and what expectations they have when using an interactive system, the focus is not just on what a system *can* do, but what it *really does do* for the people who actually use it (133).[41] Using Dourish's term, what does it mean to *appropriate* a system (or technology)

[40] Some instruments reveal their purpose to the user in obvious ways. One of the formative musical experiences I had while growing up was switching between flute, piano, saxophone, drums, and guitar, all instruments that at one point I was taking private lessons in. Each instrument communicates usability differently. Piano, with its black-and-white keys, reveals its range differently from the flute, which relies on a combination of fingerings and airflow to create pitches.

[41] The principle focusing on the act of using an interface will guide my analysis of my collaboration with Theocharis Papatrechas in Chapter 4.

to fit a community's needs?[42] How does this principle apply to performer-composer collaborations?

1.3.3 Technology's Artifacts

In addition to defining constraints for its users, technology leaves *artifacts.* Dourish points out that designers sometimes intentionally create artifacts within their designs that lead users through the process of working with the interface.

> …designers can create artifacts that lead users through the process of using them, with each stage leading naturally to the next through the ways in which the physical configuration at each moment suggests the appropriate action to take. The relationship between physical form and possible action can give designers some purchase on the problems of unbounded parallel action." (Pg.52)

A way to think about notated music is that it exists to guide me through an instrumental landscape, defining a set of moves, inviting me to access areas of the flute. Incorporating technology into the collaborative process also introduces *unintentional artifacts*.[43] While it is possible to anticipate and account for the technical specifications of microphones, digital signal processing (DSP), and particularities of the spaces in which the music is presented, technology will always leave unintentional artifacts.[44] When building a collaborative dialogue, deciding what gets filtered out is just as much a technical process as it is a social one.

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[42] In Chapter 3, I examine two case-studies of artist-technologists who create interfaces to engage in a dialogue with their musical communities.

[43] In addition to being model-specific, each individual microphone will have micro-variations that imprint themselves into the recording.

[44] For example, audio production software sometimes with presets for a particular type of microphone or apply an equalization (EQ) to compensate for a particular headphone's characteristics. While I have never worked as a professional audio producer, seeing how they listen to the same sounds through many types of speakers influenced my idea of recording the flute from many different perspectives. There is no way to capture "true" sound, only a variety of perspectives, each mediated by specific technologies. The more perspectives I can access, the I understand the essence of my musical actions.

1.3.4 Discovering Affordances

Objects have affordances which shape my experience interacting with them. Affordances are discovered via an instrument's *effectivities*. This term was coined by von Neumann (1966, 78), and represents "the potentiality to do things." It is connected to the idea of affordances, but specifically focuses on how learning "is to discover (sometimes with the guidance of others) and become attuned to, more and more subtle affordances" (Windsor and de Bézenac 2012, 109, as cited in Östersjo, 18). When I practice, technical exercises create scenarios which focus my attention on particular affordances. A microphone placed inside of my instrument changes what I can hear, thereby creating new effectivities for discovering the flute's affordances. In our project, quiet, subtle sounds that would otherwise remain undiscovered are augmented by technology. Recording technology is the method by which we modify our perception of the flute's effectivities.

In *Listening to the Other,* guitarist Stefan Östersjö analyzes his collaboration with composer Richard Karpen on *Strandlines*. Their dialogue is centered around creating a shared language for analyzing the guitar's effectivities. In their collaboration, retuning the guitar became an important structural of the piece. Östersjö and Karpen established a shared creative practice by unpacking the differences in perception of the guitar's affordances. In this example, the alteration of musical instruments became a space of dialogue. In other words, the instrument allows for communication, and alteration (as well as the perception of it) is the communicative process. When instrumental alteration is built-into the collaborative process, alteration itself becomes the mediator of communication. In my collaboration with Theocharis Papatrechas, we used microphone placement as the method of instrumental alteration.

For me, the purpose of technology is not as much about adding something new to my playing that does not exist in it, as much as it is there to create new pathways for engaging with the flute. Our shared exploration of the flute via microphone placement generated creative energy, by creating scenarios in which we were both surprised by the sounds we were hearing. An example of this is when we were recording from inside of the alto flute, the end of which was plugged with a rubber flask stopper with an embedded microphone.[45] Plugging the flute and playing the lowest pitch (fingered C4, sounding G3) creates a very soft note that is impossible to play without plugging the end of the flute. Amplifying this pitch by listening to what was happening inside of the flute hugely contrasted with how that same pitch sounded externally from my habitual listening perspective. Another example of this is whistle tones, which are a very delicate and quiet technique on the flute. It is also highly directional, meaning that a microphone placed off-center from my embouchure will pick up a very different sound. Hearing it from the inside of the flute created a "wow" moment for both of us!

Altering our habits sometimes uncovers possibilities for action that were not envisioned by the instrument's original designers (Windsor and de Bézenac 2012, 110). This connects with how I interpreted the following passage in Dourish's *Where the Action Is:* "Users are less predictable than planned-out systems. Users have different goals, and different ways of using the system" (Pg.83). The unpredictability of live electronics contrasted with my prior experiences working with composers in notated, acoustic music settings. While composers can use their knowledge of an instrument's external memory and idioms to predict certain aspects of how a performer will interact with their score, even in fully-notated music they cannot foresee all

[45] See Section 4.1 for further discussion, as well as a picture of this setup.

potential outcomes. Introducing electronics into this dialogue is one way that users (performers) demonstrate their unpredictability when working with an interface (a musical instrument).

PrismaSonus explores how microphone placement alters the perception of flute technique. The method by which we explored this was informed by my experience exploring my flute technique. Östersjö shares an example of Swedish folk-music flutist Markus Tullberg discusses *alternative fingerings*[46], and how the effectivities (intentions and abilities) define the affordances of a fingering:

> The alternative fingerings require more from the player far beyond a particular finger combination….However, *a musician may also discover new fingerings through exploration*. These fingerings each have their own potentials of timbre, volume and intonation. Thus it is possible to talk about the affordances of each fingering combination as well as its character, which depends on both the flute and the player (Tullberg 2018, 97, as cited in Östersjö, 20).

In this example, notice how Tullberg emphasizes a musician's personal exploration of their instrument. On the flute, a performer needs prior knowledge of the instrument to know *how* to explore the instrument to find their own fingerings.[47] One very interesting technique I recorded was what I call the *stopped piccolo*, where a small-diameter rubber flask stopper with an embedded microphone is used to plug the end of the piccolo. By exhaling and inhaling through a closed embouchure hole and venting one key at a time, I was able to isolate and record the sound of air moving through a specific area, from both inside and outside of the instrument. This degree of specificity greatly expanded the range of nuance I could bring to the air sounds I recorded as

[46] Woodwind instruments require a combination of fingers placed on keys to play a particular pitch. While there are certain standard fingerings, alternative fingerings are other combinations of fingers that create the same pitch, often with slightly different tuning or tone color (timbre).

[47] Every teacher who has worked with beginner woodwind students (and remembers when they were themselves a beginner) has experienced the classic "scramble" to remember a fingering, where a student might go through a few different finger combinations to try to find their way back to the proper fingering. This is very different from a professional who knows what the "standard" fingering is and can methodically experiment with what happens when they intentionally alter a fingering.

part of our sample library. I applied a similar method of altering one variable at a time while keeping others constant to recording other flute techniques, which included singing and playing, whistle tones, timbral trills, etc.

The affordances of an instrument and a player's intention affect each other. The "very detail of the performer's embodiment is decisive in choosing individual solutions to such issues, which arise from a combination of musical conventions and their physical realization on a particular instrument" (Östersjö, 22). This interaction also creates a space of resistance between a "musician's acts and the cultural space with which he or she interacts." My understanding of flute techniques was created not only through my technical exploration of the flute, but also by the music I have performed, and the spaces I have performed them in, creating *resistance*, "…experienced in the interactions between musician and cultural tools, [which manages] the development of voice" (22). Instruments have affordances, but players do not always go down the path of "least resistance." Players "often go to great lengths to overcome bodily and instrumental constraints in order to achieve particular aesthetic or functional goals" (Windsor and de Bézenac 2012, 110, as cited in Östersjö, 18). I see a parallel between resistances and the "sweet spot" of an instrument, where an object's affordances converge with the agent's abilities, enabling more expressive possibilities (De Souza, 74).[48] Technology can empower an instrumentalist's ability to push against the resistances of their instrument by introducing additional mediators and modifiers of it.

1.4 Feedback

Habits are guided by conscious and unconscious processes that highlight and obfuscate instrumental affordances. Technique and technology coexist within an enactive landscape that

[48] This convergence also enables accessing *flow*.

can be transformed and re-contextualized. An instrument's effectivities, or its possibilities for action, are mediated by the context in which performance occurs.

My playing relies on feedback, which is the mechanism enabling the formation of habits, and the vector through which I learn information about my instrument's affordances. The instrument I play defines the form(s) of feedback I receive from it. Introducing technology into the performer-instrument dialogue can alter the relationship between action and perceived feedback. Intentionally re-mapping the way I perceive instrumental technique creates new space for creative exploration.

I apply the role of feedback in my acoustic playing to the way I approach electronics. I am interested in the way technology alters, resists, or augments the feedback I get from my instrument. I use technology to see a new perspective of the habitual action-sound mapping I have learned through years of acoustic playing. Technologically-mediated listening engages with my conscious and unconscious habits. What happens when I intentionally disconnect my body's feedback and the instrument's feedback? What does it feel like to perform without expected feedback, redirected feedback, or newly-created feedback? How conscious am I of my instrument's feedback when I perform?

1.4.1 Feedback is a Two-Way Street

Sound production on an instrument is a two-way process because it provides feedback, which can manifest in several forms. *Intonation* is an example of a continuous parameter in music technique that requires constant feedback.[49] Without feedback, there is less accuracy. For

[49] *Intonation* refers to the accuracy of pitch when performing an instrument. Depending on the instrument, intonation is controlled via a variety of physical inputs. In some instruments, finger position determines intonation (e.g., violin), while in others it is primarily controlled via lip pressure, air direction/volume/speed (e.g., flute). In other instruments, intonation is predetermined via the tuning of the instrument (e.g., piano) and is not directly controlled by the player during the act of performance itself.

example, a study by (Chen et al. 2013) showed that if cellists shift along the fingerboard but do not bow, their left hand shifts away from the correct position. The control pathway cannot function without the activation pathway. Even with years of practice, professionals' motor performance still depends on auditory feedback. (De Souza, 45).

The characteristics of my instrument create a specific feedback signature that I become familiar with. Some of these characteristics remain constant (e.g., the brand of flute I play on, the shape of the headjoint cut, the thickness of the metal, the specific scale used to determine the placement of toneholes[50]), others are affected by the wear and tear of the instrument (e.g., the seal of the headjoint cork, the adjustment of the pads and mechanism), while others yet are external to the instrument (e.g., the ambient temperature of the room, the shape of my embouchure, muscular tension in by body, the acoustic characteristics of the room I am playing in). Being a professional musician requires using my perception of feedback and knowledge of my instrument to determine the line between my abilities, and the resistances of my instrument.

Technology introduces additional ways of experiencing feedback. When performing with live electronics or amplification, performers often monitor the audio processing that occurs in real-time. The affordances of the technology used to do this impacts the quality of feedback. Deciding the control and activation pathways of electroacoustic performance settings is a critical stage of development.[51] In the recording sessions where Theocharis and I created the sample library used for *Morphés I/II*, choosing how I was monitoring my playing greatly influenced how I created sound. One of the most interesting interactions was when Theocharis would actively

[50] On woodwind instruments, the size and placement of holes in the instrument's bore determines the relative tuning of various pitches.

[51] In this example, what kind of feedback I get to monitor my playing is a control pathway. My playing (action pathway) then feeds into the loop, which then guides my continued playing. Some musical styles intentionally create *feedback loops*, where sonic input in a system directly feeds back into itself.

change what kind of feedback I was getting (via headphones) as I was playing.[52] In my subsequent analysis of the monitoring, feedback, and processing methods used by PrismaSonus, I will use the term *raw* to refer to unprocessed sound, and *processed* to refer to sound that has undergone some kind of intentional electronic manipulation.[53]

One of the challenges of introducing live electronics into my existing acoustic practice is its unpredictability. I have far less experience with electroacoustic music than I do with acoustic flute playing. Developing these new techniques required consistency in the feedback I was getting, otherwise it would be impossible for me to form habits within this new environment. I wanted to create scenarios in which I could tap into my existing skillset as much as possible, retaining the high degree of nuance and control I have in my technique. This meant that in each of our sessions, we did our best to recreate the exact set-up of the previous recording session, noting the microphone placement, distance to speakers, etc.[54] De Souza refers to consistency as *invariance*, which allows performers to create specific mappings between actions and musical materials (15).

In a collaboration so heavily reliant on microphones, the invariance of their placement was crucial to creating invariance in my technique, particularly when recording from the inside of the flute. Learning any technique, whether it involves electronic technology or not, requires

[52] For example, while I played a sustained pitch, Theocharis could turn down the external microphone (aimed at my embouchure) and turn up the microphone inside of my flute. Alternatively, I could take the headphones off and just hear how I sounded in the recording room, while Theocharis listened only to the microphone inside of the flute. Isolating these variables created a lot of interactive scenarios. Exploring these different combinations fueled the decisions we were making.

[53] No recorded sound can truly be *unprocessed*, and all documentation technology leaves an imprint on the source material. This is related to the concept of *artifacts* which I discussed earlier—artists often choose their technology based on the artifacts (intentional or not) they imprint on their materials. Artifacts are therefore not necessarily a negative attribute of technology, even though they are often seen as such when working in purely acoustic settings, in which the goal is sometimes to use technology to capture the live experience as closely (neutrally) as possible. In other cases, technology (microphones, recording techniques, processing) is selected because of the specific ways it "colors" the original sonic material.

[54] Over the course of several months of recording sessions, we did not have access to a room where we could permanently keep our gear and had to set-up/tear-down before/after each session.

the development of routines, as well as the incorporation of feedback.[55] Doing our best to establish invariance (while accepting a degree of variability) helped us create consistent feedback, supporting the development of habits, forming the techniques I used in these musical works.[56] When technology is introduced as a mediator of feedback, it alters performance. Over time, altered feedback leads performers to develop a different connection between action and perception, creating new effectivities that uncover new instrumental affordances.

1.4.2 Feedback and the Senses

Different instruments provide different kinds of feedback and are controlled in different ways. A musical gesture on one instrument that provides tactile feedback might primarily provide auditory feedback on another. Incorporating technology creates feedback systems that might not be as apparent in purely acoustic settings. For example, placing a microphone inside of the body of the flute will pick up sounds made by striking the keys of the instrument that are otherwise not as apparent from an external listening perspective.[57] In an un-amplified setting, key-clicks need to be a very intentional act for an audience to hear them. Amplifying the flute allows me to do certain musical actions in a wider dynamic range than is possible un-amplified, disconnecting *perceived loudness* from the *energy level* I use to perform the action.[58] This also

[55] De Souza cites a neuroimaging study by Marc Bangert and Eckart Altenmüller (2003) which tested pianists' development of auditory-motor coactivation. One group practiced on a keyboard where mapping between pitch and key changed randomly after every piece. The other group practiced on a regular keyboard. Their brain activity was measured by EEG during this five-week process. The first group never developed this coactivation. Therefore, with highly variable instruments, the links between hand and ear did not appear (De Souza, 16).

[56] At this point, we already knew that we would have a fixed-media and live performance version of the piece, so we had to ensure that I could recreate similar textures over the course of several sessions. Being able to do it live informed the technology we chose for our sessions.

[57] In certain works of contemporary classical music, composers ask wind players to exaggerate the sound of striking the key for musical effect. These percussive sounds are called "key clicks," or "key slaps," depending on the instrument.

[58] In notated music, dynamic markings are used to denote the relative loudness/intensity of performance. Composers sometimes distinguish between *perceived* loudness, and *energy levels* (i.e., asking a performer to play something at a loud level, even if the resulting sound is still quite soft).

allows me to disconnect the "loudness" of extra-musical performative acts (moving on stage, facial expressions, etc.) with the loudness of sound I produce. The sound of the keys was present without the introduction of technology—in this case, technology augments an element of technique by displacing listening perspective. Is there a point where technology alters an instrument to such an extent that it is no longer the same instrument?

Alternatively, the technologically-mediated instrument might remove or obfuscate feedback systems that are apparent in acoustic performance. The effect of this can vary different depending on the instrument that is being altered. For example, string instruments can utilize a microphone pickup that is placed inside the body of the instrument, amplifying sound to the extent that electronic sound might displace the acoustic sound of the instrument (e.g., electric guitar). A flute on the other hand relies on unobstructed air traveling over an embouchure hole to create pitched sound. Therefore, even an electronically-amplified flute will still project a great deal of its acoustic sound. This dilemma influenced *PrismaSonus* to go *inside* of the flute, allowing me to play extremely quiet sounds that would be barely heard in an un-amplified setting, and then using technology to amplify those sounds to an audible level. Microphones altered the *resistances* of my flutes; the nature of sound production on the flute placed musical and technical limitations on the way I could perform on this electronically-augmented flute.[59]

Tactile feedback is also essential to performance and is important for temporal regulation It is distinguished from kinesthetic or proprioceptive feedback, which involves bodily movement but not touch (De Souza, 46). Acoustic flute playing requires more kinesthetic/proprioceptive feedback, since touching the keys does not give me that much feedback, nor does striking harder

[59] I eventually settled on a DPA 4061 miniature condenser microphone for recording inside of the flute. The inside of the flute is a surprisingly loud sonic environment, so we needed a microphone that accepts a high maximum sound pressure level (SPL). Even then, there was still a limit to how loudly I could perform techniques (especially playing and singing) with the keys closed, since this would send a very high signal to the microphone.

or softer change the sound (like it does on a piano).[60] In an amplified setting, I must be much more mindful of the extraneous noises I am creating on the flute, since they will be heard much more clearly. When I think about my technique, I do many things that do not directly impact sound. For example, moving together with the beat does not directly impact my sound. However, this motion generates feedback that primes the rest of my technique, altering the overall way I play. I use feedback to communicate with instruments and use their feedback to communicate with music.

Tactile feedback can pass through a mediating implement. A microphone placed inside of the flute can re-map and magnify a tactile action (me pressing keys) to an aural one, which I can then use to guide my playing. This demonstrates how technology can create a new vector through which a performer experiences instrumental feedback, thereby affecting a performer's perception of instrumental technique.

1.5 Instrumental Topography

I use my technique to navigate affordances and am guided by feedback. *Instrumental topography* allows me to perceive the way my instrument organizes its musical dimensions. As De Souza points out, instruments resonate with human physiology—different instruments lead to different ideas of motion and physicality. The unique topography of an instrument enables certain modes of navigation and excludes others (De Souza, 13).[61]

Technology modifies the feedback I get from playing, thereby altering my instrument's topography. I am interested in the way modifying topography via technology affects instrumental

[60] A study (Palmer et al. 2009) showed that clarinetists strike keys more forcefully as the tempo increases, even though their fingers do not affect note onset or volume. (De Souza, 46).
[61] For example, going up in range on the piano goes left to right, but on a clarinet might result in a different motion. Moving across a fingerboard, moving across the strings. Or in a woodwind instrument, hands are in place, while the mouth does work (De Souza, 13).

habits.[62] How is topographical knowledge communicated between performers and composers? When working with a composer interested in incorporating technology into a musical composition, how does instrumental topography mediate communication within the collaborative dialogue?[63]

1.5.1 Knowing the Map

My prior experience with the flute's topography and my knowledge of its affordances affects my perception of the instrument, which is strengthened by habit. The more I embody the topographical map of the flute, the stronger its topography affects my perception. This effect was demonstrated in an experiment by Drost, Rieger, and Prinz (2007), which showed how instruments can affect the perception and reaction of a performer.

In the experiment, guitarists were given visual prompts to play chords with a musical representation of that chord. When a chord was shown on screen, it was paired with an audio cue that sometimes matched the sound, and sometimes did not. When it did not match *and also* had the timbre of a guitar, it slowed the reaction times of the players. If it sounded like a different instrument, it did not affect their performance. When testing pianists, they were influenced by piano *and also* organ sounds. This is evidence that when we can kinesthetically relate to sounds, they have a stronger overall effect on us (De Souza, 51). Not only does the presence of feedback affect the way a performer reacts to it—the degree to which it matches a performer's experience with their instrument determines its impact on performance. Therefore, intentionally altering feedback alters performance.

[62] Each of the flutes I play (piccolo, concert alto, and bass flutes) have subtle topographical differences, leading to altered habits. Playing the same thing on a different flute gives me a new perspective on the music.
[63] What is the difference between knowing topography through personal experience playing that instrument, versus listening? How does instrumental topography mediate listening?

Based on my experience in my recording sessions with Theocharis, I see a link between unexpected feedback and generating creativity. The study I cited above tested how altering feedback affected a performer's speed in responding to a specific musical cue, a quantitative measurement. It centers on performers of invariable instruments who are used to relying on fixed, *invariable* feedback to perform. I would be interested in a follow-up study that examined performers whose practice already incorporates a high degree of feedback modifiers. For example, keyboardists who perform on synthesizers are involved in real-time manipulation of their instrument's feedback. Experimental artists working with generative patches often modify their electronics in real-time. Electronic musicians often work with feedback loops that sometimes are intentionally designed in a way to create unexpected and/or uncontrollable results. What this experimental setting *did not* focus on is how altering feedback affected the performer's musical creativity, something that is highly subjective and context-dependent. Throughout my recording sessions with Theocharis, I found that the more unexpected a sound was, the more it drew me to explore it further.

Throughout the research phase of our project (*PrismaSonus*), we used technology (microphones, headphones, speakers) to alter the feedback I received from the flute, disrupting and recreating its invariance, and creating a new instrumental topography. In this altered space, we explored this new acoustical landscape, guided by curiosity sparked by the new action-sound mapping I was inhabiting. After this initial exploration, we focused in on a specific element of this new topography (e.g., the effect on moving a single finger on the feedback I receive, or changing the microphone placement while playing a single pitch, etc.). The controlled application of technology allowed me to re-create invariance in a changed environment, which allowed me to form new habits with this altered instrument. This approach to electroacoustic

experimentation acknowledges that my practice remains centered on acoustic performance—the connection I have to my flute (an invariable instrument) via my instrumental technique (which can be re-mapped) enabled us to create a library of samples (a library of *processes*) that we replicated in both fixed-media and live performance environments.

1.5.2 Topography Affects Navigation

The topography of my instrument affects the way I navigate instrumental space, and therefore impacts how I interact with the music (and my collaborator). There is a relationship between the physical form of an instrument and possible action, which can be utilized for musical effect.[64] The design of an instrument impacts the way a performer physically interacts with it. There is a connection between the way De Souza describes how pieces can be aware of an instrument's topography with how Dourish describes how designs have built-in artifacts. The artifacts left by designers lead users through the process of working with designs. Each decision in design unlocks a set of possible steps a user can take to navigate the design (Dourish, 52). Therefore, instrumental topography affects navigation. Any alteration of the instrument's configuration or change in its feedback (by introducing electronics) alters the relationship between player and musical object, leading to altered performance.

The connection between artifacts and topography and their effect on navigation, combined with my experience interpreting musical notation, influenced my approach to incorporating electronics into my practice. I found that one of my favorite aspects of working with Theocharis was searching for the artifacts introduced by the electronics, having my

[64] De Souza uses the piano's topography of groups of two and three black keys to demonstrate this concept. Pianist Lang Lang has a parody video of Frédéric Chopin's *Étude Op. 10, No. 5 in Gb Major*, in which he uses an orange to play the right hand notes. It works because so much of the melody is written for the black keys. Therefore, the étude is aware of keyboard's topography (25).

collaborator create new artifacts for me to discover, and noticing how they affected my topographic awareness of the flute.[65] This became a key mediator of our interactions throughout the collaborative process.

1.5.3 Guiding Others and Guided by Technology

I have found it useful to reflect on how my experience as an educator relates to my exploration of music technology. Pedagogy involves helping a student navigate an instrument's topography. As shared earlier, effectivities relate to the process by which a student learns the affordances of their instrument. Habit and technique allow a student to create their own topographical map of their instrument. By this metric, successful teaching can be evaluated by the degree to which it enables opportunities for a student to discover effectivities, empowering them with tools to continue exploring the instrument on their own.

Pedagogy involves creating an experience for a student. Learning how to navigate an instrument's topography is an experience that requires intentional design. Pedagogy requires anticipating the effect of design choices on the learning experience. Learning a new technique or technology requires a framework for how to explore it. Each technology, through its inherent design, implies a certain way of navigating it. For example, notated music provides a map used that outlines a series of steps that navigate an instrument's topography on a linear timeline. The design of music notation implies a series of possible steps. Teaching how to navigate notated music involves guiding a student through this obstacle-course of a landscape. Over time, instrumental technique transforms these obstacles into opportunities for creative exploration.

[65] I shared earlier how in our recording sessions, Theocharis would sometimes change what microphone I was monitoring my playing through. Adding live processing to the performance version of the piece (*Morphés II*) introduced even more possibilities for us to generate musical artifacts for each other to discover.

A musical score is an interface that encodes information that is then translated to physical action. Initially overwhelmed by the amount of new software I was learning, I overcome the intimidation I felt by approaching it as a new set of pieces or composers I was exploring. Framing my exploration of technology within my existing performance practice grounded me, and clarified my approach. In the Introduction to this dissertation, I shared how I went through an initial period of exploring hardware and software in a very fast-paced environment, often having to put something new into practice the same day I learned about it for the very first time.[66] Stepping away from the day-to-day challenges of working with new technology in order to create a philosophical framework empowered me to be more mindful and creative, especially as PrismaSonus/*Morphés* took on new layers of meaning and complexity.

Memory shapes my perception of the flute and guides my experiences with it. The study I shared earlier about feedback and performance was an example of how we are strongly affected by sounds that are unfamiliar. Using technology to disrupt familiar habits in my instrumental practice creates the initial space required for creative exploration. Structuring that exploration with a clear set of goals guides the development of new techniques. Habits can be learned and re-learned and can be forgotten.[67] De Souza points out that the physicality of an instrument influences a player's perception [of music] (50-51). Technology alters the physicality of my playing by altering the instrumental landscape. Technologically-altered instruments transform the relationship between memory, habit, and technique.

[66] For example, finding a new piece of software for streaming low-latency audio to my students the night before a lecture, because the other solution I was using no longer worked because of a server issue.

[67] When I was younger, I had a very strong connection to both piano and flute technique and could easily translate the feeling of playing things between the two instruments. I no longer play piano, so the strong habits formed with piano technique have faded. And yet, I can still access the memories. Therefore, when listening to piano recordings, my body has a memory of how it played those pieces. I can hear the physicality of playing it much more clearly than instruments that I have not played at all.

1.6 Situating Instruments and Technology

The dialogue between my flute playing, listening, and electronics influenced our collaboration by structuring the compositional process. I have been discussing the ways I use technique to access music via my instruments. Theocharis, my collaborator for this project, is a composer who also requires instruments to access music. Composers use their prior experience with music to become attuned to the affordances of the instruments they are writing for. Our project used technology to disrupt those affordances. In Chapter 2, I will share ways of documenting that process. In this section, I will reflect on De Souza's discussion of instruments as composition tools, connecting it to Dourish's perspective on the relationship between technology and the potential for action.

1.6.1 Instrumentation Enables Composition

A composer's experience with instruments informs the way they compose. A quote from C.P.E. Bach showed that while listening to a fugue, his father J.S. Bach could hear the possibilities or necessities for where it needs to go next.[68] He was thereby tuned to *contrapuntal affordances* of the instruments that he was writing for (De Souza, 126).[69] Therefore, composition and instrumentation are entwined—one informs the other.

J. S. Bach's experience with multiple instruments also affected his fugal writing, evidenced by his ability to write highly idiomatic music for the violin. If transposed to a different key, these idiomatic models are often lost. This shows that his process of composition was directly tied to his knowledge of specific instrumental affordances.

[68] Conscious and unconscious habits guide a composer's perception of an instrument's resistances.
[69] Contrapuntal writing, also called *counterpoint*, refers to the relationship between independent musical lines. Defining the relationship between these lines formed the basis of Western European music theory.

> The composer's instrument-specific habits and auditory-motor connections reveal certain possibilities, shaping the way that musical affordances show up. This goes beyond *instrumental composition*—that is, writing music that is playable or idiomatic. The violin here functions as a conceptual tool and a source of material; it becomes a *compositional instrument.* (De Souza, 133)

Knowledge of an instrument's affordances, its topography, and a personal performance practice develops a composer's ability to generate musical materials. Compositional practice involves drawing on an instrument's external memory. Over time, a composer develops their own memory of an instrument.

Growing up playing different instruments, I have memories of playing the same melody on the flute, piano, and saxophone. The translation between instruments is never literal and draws on the differences between the affordances of each instrument. Accessing the same musical materials on a different instrument highlights different aspects of the music. De Souza shares an example of how J. S. Bach sometimes played his solo violin pieces on keyboard (David and Mendel 1945, 447, as cited in De Souza, 133). He also sometimes made alterations of existing works when changing instrumentation. To me, the experience of re-mapping a melody to a different instrument is like what I shared earlier about recording the same sound from different perspectives. Is there an "authentic" perspective when listening to an instrument?

A special aspect of working with composers is learning about their perception of the flute. A common way to do so is by having a conversation about composers they have been inspired by, or performers whose playing they admire—in other words, finding out what they already know and are curious about. Collaborations are often time-limited, and so this helps kickstart the process of getting to know each other. A special aspect of my collaboration with Theocharis was how much time we had to develop our collaboration. We began with a direct

focus on sound and not instrument-specific discussions.[70] Disengaging with our individual roles as performer and composer and connecting about our experience listening to sound changed the way we ultimately approached the formal elements of the projects we created.

1.6.2 Transform the Instrument, Transform the Compositional Process

Intentionally mapping the affordances of one instrument onto another sometimes results in the invention of brand-new instrument. For example, Bach helped design a "lute harpsichord" (Lautenclavicymbel) which was built by Zacharias Hildebrandt. By combining the harpsichord's interface and basic mechanism with the lute's strings, it links the harpsichord's playing techniques with the sonic textures of the lute (De Souza, 140). This allowed him to write keyboard pieces in lute style. The lute functions as a compositional instrument, even though it is not used to perform the piece.

The affordances of one object can inform interactions with another object. Earlier, I discussed how technology alters the feedback a performer gets from an instrument, or can turn an aspect of technique that was previously unheard into a key component of technique.[71] De Souza cites Lawrence Zbikowski's concept of *cross-domain mapping*, "a process through which we structure our understanding of one domain (which is typically unfamiliar or abstract) in terms of another (which is most often familiar and concrete)" (Zbikowski, 2002, 13, as cited in De Souza, 141). De Souza applies Zbikowski's ideas to "intra-musical" mapping, which allows for mapping to occur between two different instruments (141). Bach's compositions were informed by his experience as a keyboardist, transcriber, violinist, and *instrument designer*. Bach used cross-

[70] In the Introduction, I share how our first collaborations involved reacting to pre-existing sound libraries. In Chapter 4, I discuss how we structured our listening approach for *PrismaSonus*.
[71] Placing microphones inside the instrument augments the sound of key-clicks and uncovers other sounds that are unheard in acoustic environments.

domain mapping as a compositional tool. The relationship between technology and action is affected by the context in which it is situated (Dourish, 183). As Dourish points out, "how technology will be used in working practice cannot be predetermined by the designer, but instead will emerge from the specific, situated activity in which the technology is incorporated" (171).

Technology is fundamental to composition. Instrumentation coordinates "tonal and performative patterns" (De Souza, 118). Instruments inform theoretical understanding. Acknowledging and defining the specific impact of technology on instrumental technique strengthens compositional potential of technologically-augmented instruments.

1.6.3 Space, Place, and Embedded Action

My engagement with musical instruments and technology is influenced by the specific contexts in which they are used. The framing of technology can significantly alter the nature of interaction. Previously, I discussed how different musical environments allow for diverse explorations of an instrument's capabilities, each environment accentuating certain ways of interaction over others. Context not only defines the extent of agency and ownership I feel over my actions but also impacts my decision-making process. Examining how technology is embedded within my collaborations with composers helps me understand its role in shaping the artistic development process.

My flute playing is embedded in a complex web of interactions forming a system, mediating my relationship with technology and my collaborator. *Space* and *place* are two terms Dourish uses to describe how technology is situated within specific contexts. I apply them to my discussion of how I interact with instruments and technology.

Space refers to the physical properties and configurations of objects (Dourish, 89) —such as the instrument being played, any electronic hardware added to it, and the interactions between

the performer and the instrument. It also includes how the original affordances of the instrument map onto the altered instrument's affordances.

Place, on the other hand, relates to the social understandings that dictate "appropriate behavioral framing for an environment" (Dourish, 89). Place illuminates how context shapes our behavior within these spaces. For instance, the use of a microphone and a flute in a studio recording a piece of standard classical repertoire versus their use in my electroacoustic experiments with Theocharis dramatically alters the meaning of my interactions with technology. How technology is situated within a social environment impacts its perception, influencing the decision-making processes involved in their application.

The *embedded action* within these spaces and places shows that systems are deeply entrenched in social and cultural practices, which give them meaning while simultaneously constraining and transforming them (Dourish, 97). My relationship with the flute, when integrated with technology, synthesizes the affordances of the instrument, the embedded artifacts of the technology, and the social setting in which action is situated. This synthesis creates meaning within the performer-instrument-technology dialogue.

Practice emerges from the actions of technology's users, not from the designers of the system (91). In many concert settings I have experienced, once a piece of notated music is written, the work enters my domain as a performer. Performance practice emerges from the actions of performers, not from the design of the musical score.[72] Scores also contain references to existing work, which relies on my experience with that musical genre. The multi-year collaboration I have had with Theocharis has built-up a set of shared experiences that allow us to relate to prior actions and decisions we made. Our collaboration used technology to obfuscate at

[72] Composers leave artifacts that guide a performer's actions, activating specific elements of the instrumental landscape.

which point the composition left my domain as the performer and entered the domain of my collaborator.

Listening, a crucial component of my collaboration, is also conditioned by technology. In *PrismaSonus*, we developed a method informed by our social conditioning and prior experiences to collectively interpret the library of flute recordings we created. Our understanding of an instrument's external memory shapes how we listen (De Souza, 146). Altering this dynamic through technology with technology transforms our interpretation of these sounds by creating an instrumental landscape unfamiliar to both me as the performer, and Theocharis as the composer. This approach to listening challenged traditional distinctions between our roles, using technology to integrate my existing performance practice with my collaborator's compositional interests, effectively blurring the lines between our domains.

1.7 Conclusion

My performance practice is situated within a network of interactions intertwining technique, instrument, habit, affordances, and contextual framing. It is difficult to precisely delineate where the flute's influence on me ends and where my influence on it begins. I exist at the intersection of numerous factors—some within my control and others beyond—that contribute to a complex web of memory and expectation.

Integrating electronic technology into my existing acoustic instrumental practice disrupts established mappings between action and habit. This intervention creates a space of unpredictability where I may deviate from the intentions of instrument designers, thereby recontextualizing musical actions and creating new experiences. Habits are not static and are continually reshaped by my experiences and actions. Technology can disrupt affordances of the

flute I perceive to be fixed. This challenges the notion of an “authentic” version of instrumental practice, suggesting that perception of authenticity is constructed and fluid.

This chapter outlined the foundational concepts I explored to understand the transformative potential of technology in my instrumental practice, and how these methodologies influenced my contributions to my collaboration with Theocharis Papatrechas. I highlighted how technology has not only modified my interaction with the flute but also has blurred the traditional roles of composer and performer in our work. Using microphones to displace listening perspective has allowed me to uncover new perspectives of my musical voice.

Chapter 2: Object Modification

As discussed in the previous chapter, instrumentalists develop deep connections between their bodies and their instruments. Habits enable tight motor-neural connections crucial for developing technique. These habits not only prime my actions but also fuel my creative and musical energy. Situating action within specific settings influences my sense of agency and ownership. My perception of the flute's potential uses—its affordances—is influenced by my experience, habits, and memory. Effectivities are the path of discovering these affordances, shaping interaction, and developing my understanding of instrumental topography. Disrupting and reframing this intricate relationship by using technology creates a new lens through which I engage with my instrumental practice and my collaborators. These insights have shaped my approach to music technology and its role in mediating my connection to the instrument.

I am interested in understanding how intentionally disrupting my instrumental habits by altering action-sound coupling can be used for creative purposes. In my collaboration with Theocharis, we used instrumental alteration via microphone placement to alter the feedback I rely on to perform. Through this process, we explored the flute together, developing a shared listening practice, which informed our approach to composition. This chapter aims to delve deeper into the intentional modification of instrumental space, whether by the performer, the composer, or through collaborative efforts. I apply the previously introduced concepts to several case studies where alteration serves as the primary mode of communication.[73] I am interested in how these altered instruments facilitate both intrapersonal communication—between myself, my instrument, my listening, and my technique—and interpersonal communication, which includes

[73] In this chapter, the focus will be on performer-instrument and performer-composer interaction (via instruments). In Chapter 3, I will discuss performer-interface and performer-performer interaction (via interfaces).

interactions with my collaborators, and audience members. I seek to uncover the nuances in these moments of communication to better understand how alteration transforms meaning.

My discussion of instrumental alteration draws from Jonathan De Souza's work, which I used in Chapter 1 as the basis for my discussion of body-instrument interaction. De Souza discusses various methods for instrumental alteration, such as detuning, preparation, and invention. Performers use these techniques not only to serve practical needs—like making a difficult technique more accessible or ergonomic—but also to foster musical innovation. My focus in this chapter focuses on how alteration can disrupt entrenched playing habits to unlock creative potential. An example from De Souza that influenced me is his discussion of jazz guitarist Kurt Rosenwinkel, who found his highly-developed technique and ability to anticipate possibilities for action stifling his creative expression.[74] Rosenwinkel transformed the subjective experience of playing by changing the material conditions of his instrument. This mirrors my own experiences developing my work with Theocharis, where I used technology to redefine my interaction with the instrument and broaden my expressive capabilities. Through these modifications, my instrument and I undergo a transformation. This process of change not only affects how I listen to my instrument but also how I listen through it.

Intentionally generating instability in my practice helps me break free of instrumental habits. I embrace the instability created when technology prevents me from anticipating the results of my actions. Strategically disrupting the *invariance* of my flute playing (and then re-creating it in a new environment) has shifted my perception and ownership over technique.[75] This demonstrates to how instability can be a powerful catalyst for artistic development. A

[74] It is almost as if Rosenwinkel was both the user and designer, feeling limited by the design decisions his unconscious playing habits were creating.
[75] As discussed in the previous chapter, *invariance* is required for the formation of habits, which support technique.

shared practice of instrumental alteration plays a role in performer-composer interactions. Drawing on Alfred Schütz's concept of intersubjectivity, I explore how mutual understanding can be fostered—or inadvertently undermined—in the pursuit of artistic collaboration.

Guitarist Stefan Östersjö's book *Listening to the Other* influenced my understanding of creative, collaborative dialogue. Through his analysis of a collaboration with composer Richard Karpen, where instrumental alteration served a key role in communication, Östersjö explores how a performer's embodied knowledge of their instrument can drive the co-compositional process.[76] This approach, situated within a broader discussion on the philosophy of listening, presents ways performers can engage with themselves, their instruments, their collaborators, and the environments in which they are situated. His insights were useful in shaping my approach to documenting the artistic development process, guiding the structure of the project, and influencing the way I have reflected on the results of the collaboration.[77] This has led me to question the underlying mechanisms and structures defining creative agency within musical collaborations.

This raises several critical questions: How do performers and composers negotiate their creative inputs to create a shared artistic vision? Where does sound truly reside? How do habitual interactions with our instruments shape the music we create? Throughout my collaboration with Theocharis and the process of writing this dissertation, I have been exploring how conscious and subconscious habits contribute to musical decisions. In what way does technology engage with these processes?

[76] Östersjö/Karpen focus on instrumental alteration (via detuning) in their shared exploration of the instrument (guitar), while my collaboration uses microphone placement as its primary vector for collaborative dialogue.
[77] I adapted Östersjö's technique for recording and transcribing meetings I had with Theocharis throughout the artistic development process.

The process of playing an instrument always involves a negotiation with what I want, what I am capable of, the demands of the instrument, the intentions of the composition (and composer), and the expectations shaped by the performance context. This interplay is made more complex when I introduce technology into my practice, which adds the designer's expectation for its potential use, its technical limitations, and my comfort using these tools. Guitarist Derek Bailey captures the often-polarized relationship performers have with their instruments, describing them as either a "best friend, collaborator," or as a "liability, intruder." Challenging this binary, Bailey advocates seeing the instrument not merely as a tool but as an ally—an integral source of material where technique becomes an exploitation of the instrument's natural resources (Bailey, 1992, 99). De Souza extends this idea, viewing the instrument as a "creative partner," framing the body-instrument interaction as a collaborative endeavor (De Souza, 101).

My work has explored technology as a way to alter the relationship between me and my instrument, recombining and recontextualizing habit and technique. This creates a dynamic where the instrument becomes more than a medium for expression; it is an active participant in the musical dialogue. I act on my instrument, creating feedback that in turn influences further musical decisions. This iterative process of action and feedback creates musical meaning. By altering the musical object in any way— by changing the spatial relationship between my instrument and my listening perspective—the feedback cycle is modified, creating a transformed musical experience. As I further explored De Souza and Östersjö in preparation for the next phase of my work with Theocharis, my aim was to learn how to integrate alteration more deliberatively into my practice.

2.1 Habits and Musical Creativity

Memory and experience shape my habits and mediate the way I interact with my instrument. Unconscious habits enable fluid technique by allowing me to manage performance aspects effortlessly. Instrumental idioms further enable performance, enabling me to group action into larger, ready-made gestures. I access musical materials *through* my instrument. Habits, along with unconscious and automatic movements, mediate the degree to which I feel bodily autonomy and ownership while performing. By centering the discussion on my experience and perception, I can better understand how technology augments, obfuscates, and modifies these processes.

My initial interest in music technology stemmed from a combination of necessity, and of a broader interest in how technology could expand on my relationship with the flute.[78] As mentioned in the introduction, my love and commitment to contemporary music emerged from the realization that the stylistic diversity and wide range of performance techniques of the genre expanded the range of interaction I could have with my instrument. Using Dourish's terminology, the *place* in which I situate my work has expanded my awareness of *instrumental space*. My perception of the flute's affordances was already being altered by the contemporary music I was being exposed to. My exploration of music technology is another step as part of the broader timeline of my evolution as an artist.

Artistic development as a process of continually breaking and re-forming habits is a process common to many musicians. De Souza cites jazz guitarist Kurt Rosenwinkel as an example of a performer who believes that habits, when they are too strongly engrained, limit

[78] The shift to remote music education during the pandemic required all of us to engage with music hardware and software in new ways. Workplace requirements and student expectations often directing our exploration of technology.

musical creativity. As he describes it, his instrumental practice is constantly going through a cycle of stability and instability, learning and unlearning. “You start off not knowing what you’re doing,” he says, “then you organize things so they become ordered. When that order becomes static, you have to break it up to create another state of instability, which, in turn, throws you back into *chaos*. That’s what continuing on to the next step is all about” (Rosenwinkel, 2007).

Introducing technology into my practice generated an equivalent of the *chaos* described by Rosenwinkel. When I first read this quote by him (prior to my work with Theocharis), I was not sure what he meant by chaos, because it was not a term I would have used at the time to describe the process of creative exploration. I interpreted chaos as the absence of center, of a grounding element, or something that implies letting go entirely of all habitual practices. After integrating technology into my technique, I have come to understand “chaos” as a phase of creative exploration, a process of re-discovering my instrument from a new perspective. My collaboration with Theocharis has allowed me to experience the flute from new vantage points—a sort of out-of-body experience enabled by technology. First freely exploring, and then documenting and analyzing this experience, has helped me reorient and redefine my relationship with the flute.

The music I perform is constantly reshaping my relationship to the flute. The vast range of sounds and techniques required in contemporary music means I cannot maintain constant access to all elements of my technique. Like selecting tools from a toolbox, I select elements of my technique based on the music at hand. Repeating pieces of the same aesthetic again and again

would gradually narrow my perception of the instrument.[79] The more I practice shifting between repertoire styles, the more quickly I can adapt to these new environments.[80] Amidst all these shifts, a core element of instrumental practice remains, stabilized by something more fundamental. Perhaps it is impossible to fully get rid of invariance when playing an instrument with habits deeply associated with it.[81]

The following discussion explores how Kurt Rosenwinkel went through a process of instrumental alteration while working on his 2001 album, *The Next Step*, in which alternative tunings was the mechanism by which he created new space for creativity. Rosenwinkel describes this album as "the culmination of many life phases for me….It represents the next step in my music and in my life" (Rosenwinkel, 2007). Understanding the process Rosenwinkel went through in *The Next Step* influenced my approach to instrumental modification via technology. Although my collaboration with Theocharis is situated within a very different instrumental space and collaborative place, Rosenwinkel's journey provides me with a valuable case study. It has informed by own exploration of the intentional modification of instrumental technique, inspiring my own approach to opening new spaces for creative exploration.

[79] In 2023, I recorded and performed Morton Feldman's *For Philip Guston* (1984), a four-hour minimalist work for flute, piano, and percussion. This physically demanding work alternated between extremely delicate long-tones with repetitive sections with minor variations, requiring a high degree of focus. In the lead-up to this project, I geared my entire practice to these techniques. The more I explored these sounds, the more detail I could hear in them. I mention this example because having a narrow focus in technique is not necessarily a negative thing.

[80] As I re-engage with repertoire I have not performed in several years, I recognize how quickly old habits come back. And yet, all the musical experiences I have had since I last saw a particular piece leave an imprint on my technique and alter my perception. These moments of re-engaging with music I learned at a prior stage in life are some of the most generative for me. Noticing how my focus narrows when I shift between different musical aesthetics has been a very useful tool in the development of my performance practice.

[81] This makes me think of how it is impossible to pretending to not know something or listen to a language I understand without thinking of the words.

2.1.1 The Comfort Zone

At a certain point in his playing career, Kurt Rosenwinkel began to feel dissatisfied with his playing. He felt his extensive knowledge of the guitar was becoming a limitation. Rosenwinkel described this as knowing too much about what he was doing, and not hearing the music directly enough (Rosenwinkel, 2007).[82] As discussed in my previous chapter, performers develop strong habits to support their technique. These habits allow for a high degree of fluency when navigating musical passages. Eventually, some performers start to feel as though their instrument begins to play itself. Many performers strive for this, and yet this was a negative feeling for Rosenwinkel. What does Rosenwinkel mean by not hearing the music directly? Musicians develop the ability to *audiate*, allowing them to internally simulate the sounds that instruments make.[83] Is Rosenwinkel suggesting that his internal process of audiation distracted him from the actual sounds of the guitar, or is he alluding to a different kind of interference? Instrumental technique involves listening through your instrument.[84] I am curious to understand where the line is drawn between useful habits, which are essential to perform on an instrument, and those habits that limit a composer-performer's creativity, particularly when they inhibit the ability to truly listen to the music, as experienced by Rosenwinkel. Audiation requires familiarity with the predictable characteristics of an invariable instrument. Although in my own practice I do not improvise over tonal patterns within formal structures like a jazz musician, I use audiation

[82] I am personally a fan of Kurt Rosenwinkel's music, who is renowned as one of the leading guitarists and jazz composers of his generation. Recognizing that even the most prolific artists like face creative challenges is humanizing. My interest extends beyond simply acknowledging these challenges; I am to understand how artists like him navigate and overcome them.

[83] Coined by American music researcher and educator Edwin E. Gordon (1927-2015), *audiation* is the comprehension and internal realization of music by an individual in the absence of any physical sound. This contrasts with *aural perception* where one listens to music being performed (Gordon 1976, 7 n.2).

[84] This idea informed *PrismaSonus's* exploration of the inside of the flute. I have discussed how placing microphones inside the body of the instrument allowed me to listen *through* the flute in a literal sense, which I will discuss further in Chapter 4.

to imagine the sounds required by the music, which primes my action. Intentionally disrupting this process with technological modifiers of my aural perception has helped me break free from habits that were limiting my creative exploration of the flute.

Like other performers, Rosenwinkel developed his technique through years of practicing sequences, which over time evolved into musical idioms (De Souza, 77-78). He expressed that these habits started to limit his creative expression. Over the years, Rosenwinkel formed tight auditory-motor connections essential for performing music that draws heavily on a performer's knowledge of instrumental idioms—such as scale patterns and tonal structures—as well as musical references to other performers and composers. However, these same connections also created expectations for potential actions that ultimately became constrictive.[85]

Rosenwinkel's perception of his technique was shaping the way he interacted with his instrument, perceived as a barrier that distanced him from a direct connection with it. De Souza draws a parallel to insights from another guitarist, Christian Rover, who noted that having a predetermined "collection of voicing for every harmony, and a sound you already internally hear before you actually play it, would eventually make it redundant to still play it" (Rover, 2006, as cited in De Souza, 88). I believe this encapsulates Rosenwinkel's creative dilemma, where his technique—though highly refined and efficient— began to undermine his creative agency by making his musical engagement feel predetermined and therefore limiting. Viewed through my perspective as a classically-trained flutist, I find this paradox to be fascinating. My ability to perform very specific sounds and techniques, and to be able to replicate them with consistency, is a prerequisite for success. I balance this requirement for precision with the flexibility to adapt to the spontaneity and unpredictability inherent in live performances.

[85] In Chapter 1 I discussed how designs imply a set of potential actions. In this context, a performer developing their practice acts as both the designer and the user, influenced by the genre in which they are situated.

Altering action-sound coupling in some way would break down the sequences Rosenwinkel accessed while improvising. The resulting instability would force him to be present with his instrument and technique in a new way, which perhaps would be perceived as hearing the music more directly. This would allow him to access a *beginner's mind*, while still retaining a highly refined ear that could actively listen and respond to the creativity generated within the instability.[86] Rosenwinkel sought the ability to switch between different listening modes. As he was hearing his technique, it was altering his mode of listening. By altering his instrument, he altered his body, which altered his hearing. De Souza describes the creative possibilities afforded by instrumental alteration, and the way it transforms listening:

> Whether retuned, prepared, or redesigned, altered instruments offer new possibilities in terms of harmony, timbre, texture, and so on. But at the same time, they play with habitual connections between action and sound, between performers' auditory and motor perception. They create new opportunities to relearn my instrument, moments when I become conscious of my bodily engagement with it, when I begin to listen to and think about and feel the sound differently. Changing the instrument, then, changes the player. Alteration illuminates everyday experiences of instruments, even as it disrupts them. (De Souza, 105)

If altered instruments disrupt our preconceived notions, does an "everyday experience" of an instrument represent its most natural state of play, free from our habitual influences? Perhaps it is the mode in which we interact with objects in a playful way, free of memory and expectation. Going back to Christian Rover's quote, an everyday experience is one that is not fully planned-out internally, and therefore less redundant. It is not *something*, it just *is*. And in that case, this experience is worth exploring because it is radically different from the way that I interact with my instrument when in goal-oriented performance settings.

[86] Beginner's mind, or *shoshin*, is a term borrowed from Japanese referring to an attitude of openness, eagerness, and lack of preconceptions when studying a subject, even at an advanced level. It was popularized outside of Japan by Shunryū Suzuki's book *Zen Mind, Beginner's Mind* (1970).

2.1.2 Freedom from Habits

The habits Kurt Rosenwinkel is referring to are influenced by the idioms of tonal, improvised music. To break free from habits, Rosenwinkel re-tuned the strings of his guitar, which remapped the pitch landscape; in other words, the physical location of pitches shifted within the instrumental topography. This is a common practice in players of tunable instruments like the guitar, where a location on the neck or fretboard of the instrument does not necessarily correlate with a specific pitch. As a flutist, my relationship to location and pitch is mediated by fingerings and airstream, which manipulate the airflow traveling across and inside of the flute. Instead of altering the instrument by changing the location of pitches (something I cannot do on the flute), my exploration focused on altering the tonal characteristics and feedback of the instrument. My practice as a performer of notated music focuses my attention on technique and sound production rather than on the construction of melodic and harmonic structures in real-time. The differences in our musical contexts resulted in different vectors through which we modified our instruments: re-tuning to transform the guitar's pitch mapping, versus altering perception of technique by displacing my listening perspective. Even though the exact mechanisms by which Rosenwinkel and I alter instrumental space differ, there are similarities in that our desire to modify our instruments both stemmed from an interest in finding new space for creativity.

As De Souza points out, habits can be unlearned and relearned. Unlike reflexes, habits are acquired, and influence the way we use objects (23). Objects are not neutral; they "afford particular kinds of motor and perceptual habits; they reveal certain possibilities, while concealing others. Like the body, then, each of these things can be understood as a medium for having a world" (De Souza 23). Rosenwinkel altered his instrument to break free of his habits, recognizing that he can re-learn his playing habits. The altered guitar changes how Rosenwinkel

interacts with it. In De Souza's analysis of Rosenwinkel's tune "Zhivago," he highlights Rosenwinkel's focus on a "haptic engagement with the music" (96). After breaking free of habit, the physical shapes on the instrument take precedence over harmonic labels. In a 2010 masterclass, Rosenwinkel noted how he was able to play chords without an intellectual relationship with them, describing this mode of playing as "pure sound and discovery." This analysis shows that motor habits and auditory expectations are formed more quickly than theoretical awareness. Altering instruments foregrounds its sensory, "aesthetic" qualities, rather than an intellectual perception of them (De Souza, 97).

The recording sessions Theocharis and I conducted demonstrate this concept of "pure sound and discovery." We created an environment where the outcomes were unpredictable. Each microphone placement and technique modified specific elements of the flute to see what new sounds would emerge. This approach allowed me to engage with the sounds directly, experiencing them as I played, without needing to classify them. We documented our sessions with audio recordings (of both the sounds and of our talking), and took detailed notes, giving us the flexibility to revisit and further analyze any particularly compelling ideas. This meant that in the moment of artistic exploration we were both free to be guided by our ears, knowing we could articulate or notate what I did on the flute with greater precision later in the project.

Habitual actions integrate hand and tool, body, and world. Fingerings are a sequence of *finger-key relationships*. On woodwind instruments, the same pitch can be played using multiple fingerings, which are referred to as *alternate fingerings*. Even though the pitch may be the same,

the tonal quality, resistance, and feedback the performer gets may change.[87] As action become habitual, playing feels like a single flowing gesture. When that flow is broken, playing demands conscious attention, as noted by De Souza when he states how when something is difficult or unusual, we have to act *on* the fingerings, as opposed to acting *through* them (De Souza, 18-19).[88] Retuning the guitar breaks the habits that make playing feel automatic, altering Rosenwinkel's listening mode and generating new creative spaces.

Is it possible to hear music completely free of habit? De Souza references Heidegger's perspective on experiencing sound, where Heidegger states that it "requires a very artificial and complicated attitude in order to 'hear' a 'pure noise'" (1927/2010, 153). Is Rosenwinkel trying to hear pure technique or pure sound? Various body-mind integration practices, such as the Alexander Technique, have shown me how to be attuned not just to what I play on the flute but also to how my playing affects my body's reactions. This may not be so much about listening directly to playing, but rather about tuning into the feedback loops that shape my overall awareness. While Heidegger might describe this as "artificial and complicated," I believe that even complex perceptions can be experienced simply if framed within a broader perspective. Creativity and musicality in performance hinge not on whether technique is habit-driven, but on whether there is intentionality in action. Instrumental agency is not a simple binary of chaos and stability; it is a multidimensional process continually reshaping awareness and perception. Rosenwinkel's approach to solving his creative dilemma involved identifying a habit (place-to-

[87] Alternative fingerings on the flute modify airflow, which impacts how the sound is produced. By placing a microphone inside the flute, we were able to exploit this physical aspect of flute-playing for our sample library. For instance, playing C6 with different finger combinations results in distinctly varied sounds when recorded from within the flute. This setup enabled a significant amount of tonal variability, particularly when working with a technique like *aeolian sound*, where air is added to the pitch.

[88] In Chapter 1 I discuss Heidegger's distinction between *ready-to-hand* and *present-at-hand* interactions. While in *ready-to hand* interactions, the focus is on an object's potential uses, *present-at-hand* directs action towards the object itself. In this example, the instrument becomes *present-at-hand* because it is being acted on.

pitch mapping enabling the predictive audiation of musical forms), deliberately altering his instrument's physical setup, and observing the resultant changes in perception. This mirrors the experimental nature of my collaboration with Theocharis. Our project also embraced altering playing techniques to explore new landscapes. The daily life of any performer is filled with countless micro-versions of this process. I see now how recognizing the continual evolution in my instrumental practice is crucial for fostering lifelong creativity, and for opening new dimensions of expression in my collaborative work.

2.2 Comfort and Instability

The development of a technical foundation in instrumental playing is deeply intertwined with the formation of habits. In my training, technique was often framed in terms of gaining control, which enables a sense of agency over musical materials. As previously discussed, the concepts of space and place are useful for analyzing the arrangements of objects and the interactions they enable (space), as well as the context of these interactions and the associated social and behavioral norms (place).[89] In acoustic, concert music settings, microphones are typically used to document playing. In pedagogy, microphones aid students in capturing their playing from an external viewpoint, which helps them translate their listening perspective and feedback into desired musical outcomes. In our project, the use of microphones goes inward—instead of projecting my playing outward to an external listener, we used microphones to allow me to go into the very core of my instrument, then using technology to amplify this internal perspective outward. Controlling a technique is often equated with making it comfortable.

[89] For example, the structure of a professional orchestra, which includes limited rehearsal time and a high volume of repertoire, impacts the rehearsal process and establishes specific musical expectations. This *place* structures time very different than a one-on-one creative collaboration with a composer.

What role does technology play in the development and disruption of comfort in my instrumental playing? What possibilities for action can be unlocked if technology is approached as an intentional creator of instability? Examining how and why performers intentionally create instability has helped me challenge my own understanding of flute technique, redefining the boundaries of comfort and control within performance.[90]

2.2.1 In(stability) is a Feature, not a Bug

Invariance of instrumental affordances allows me to form habits, which are used to develop instrumental technique, enabling comfort and stability in our playing. Comfort and stability can sometimes lead to creative stiffness, prompting performers to seek ways to form new habits and develop new ways of navigating the instrument. Stability and instability are part of an interconnected process—one cannot exist without the other. The ability of a performer to modify their playing requires the prior existence of stability. My goal was to use technology as an extension of my acoustic instrumental technique, which required an initial foundation in technical stability. My goal through this process was to ultimately bring this technologically-augmented flute practice to composers to co-create new compositions. Therefore, the methodology I developed to explore, document, and describe my approach to technology required me to eventually reach a certain degree of stability (invariance).

[90] In my experience, educators often use the term "control" to describe the development of a technical foundation in instrumental playing, where stability enables the formation of habits, supporting technique. Control is often used to judge the quality of performances, often in the music conservatory setting (place). Settings focused on technique-building sometimes perpetuate a narrative in which students feel they must achieve technical control before they can express creativity. This creates a dissonance between control and freedom, as students navigate a hierarchical structure that conditions perceptions of desirable and undesirable aspects of playing. I am personally invested in challenging this narrative by exploring how embracing instability as an intentional act can unlock creative potential, rather than being seen as a sign of poor technique. Generating instability that is targeted to a specific aspect of technique is a valid pedagogical tool that I am interested in exploring further beyond the scope of this dissertation.

As a flutist, I am used to playing an instrument that has a great deal of stability built into its design. My technique relies on my instrument's invariance. Assuming my flute does not have a leaky key or sticky mechanism, I am conditioned to perceive something going wrong as user error. As discussed in the previous chapter, performers rely on two-way feedback to guide their technique. Altering an instrument alters feedback, which then alters the perception of technique. A poorly-maintained instrument will, over time, warp my perception of my playing. Instruments with a high degree of stability and invariance rely on regular maintenance. Introducing unfamiliar technology that does not have strong habits associated with it obfuscates this feeling. Therefore, my perception of instability is affected by our embodied understanding of habit, technique, and feedback. Memory and expectation enable me to navigate spaces of stability and instability.

Early in the development of *PrismaSonus*, we experimented with various microphones to use for our project. While microphones provide extensive documentation that outlines their capabilities (affordances), experimenting with technology assumes a certain degree of user error as users get to know the technology. Theocharis had much more experience working with microphones, so I relied on his knowledge to help make up for my own lack of strong habits associated with that technology.[91] A creative team will therefore develop a shared understanding of an instrument or technology, something I will discuss later in this chapter.

[91] I recognize the feeling I have of not knowing microphones well-enough was conditioned by the spaces in which I worked with them prior to this collaboration. In a professional recording studio environment with strictly-delineated roles, I am the performer and not the engineer. Since beginning this project with Theocharis, engaging with microphones in a creative and experimental setting has increased my confidence and agency in making microphone-related decisions, even in other performance environments.

2.2.2 (Dis)comfort Zones

As a performer of contemporary music, I am sometimes asked by the music to explore techniques or instrument-technology relationships with which I have less experience. A composer's understanding of the flute's affordances may be unique enough to require re-mapping my own habits associated with a particular sound. Learning a new instrumental technique is a process of making me more aware of how it intersects with my existing technique. This awareness helps new techniques to become comfortable. As comfort increases, so do feelings of control.[92]

> For a fleeting moment, it may feel as though my body or the instrument or the music itself is in charge. Examining this paradox, the philosopher Eddy Nahmias argues that musicians and athletes do not make detailed, self-conscious decisions in the course of play. This kind of overthinking, in fact, would hinder performance. Instead, Nahmias suggests, the player has "a general intention or plan to play well" and then lets the details unfold (2005, 774). I monitor my playing as if from a distance, watching in wonder my own fingers move. (De Souza, 80)

Perhaps this sort of "overthinking" is what was limiting Kurt Rosenwinkel's creativity, as he noted that retuning the guitar allowed him to distance himself from intellectually analyzing his performance. Achieving comfort requires overcoming tension. Mind-body integration practices like Alexander Technique have taught me to have a certain *softness* to my technique, allowing a degree of movement to occur within control.[93] Comfort is equated with a sense of *ease* allowing movement within practices that otherwise feel rigid and predetermined.[94] Control becomes an intentional process, rather than something pursued blindly. This aligns with Nahimias's

[92] As discussed earlier, for some performers there is a paradox where the more you learn idiomatic playing, the less *in control* you feel. Sometimes control is perceived as a creative limitation.
[93] Even when focusing on a specific task, I remain connected to the rest of my body in an overall state of awareness.
[94] In an Alexander Technique class led by Eileen Troberman, I learned a powerful self-directed question that has influenced my practice: "Can I invite more ease? Is there more space for ease?" This promotes a mindset of seeking fluidity in performance.

suggestion of monitoring playing from a distance, which enables a more detached and observant approach to playing.[95]

For some musicians, control is a means to achieve comfort, making the instrument feel like an extension of their body. Comfort is often considered the ultimate goal of developing instrumental technique. Trumpeter Jens Lindemann describes it as a lifelong pursuit: "It's a lifelong pursuit trying to get to that point of comfort, but when you do arrive there you realize that you're just taking a piece of metal and you're blowing through it. It's that simple and that complicated at the same time." (Lindemann, as cited in De Souza, 48). Rather than seeking a universal definition of comfort for all instrumentalists, I view it as a dynamic process involving the balancing of habit, technique, and control. Mihaly Csikszentmihalyi might describe this balanced state as achieving *flow*.

2.2.3 Flow vs. Complacency

Optimally balancing skill and challenge enables a sense of *flow*. Flow combines increased feelings of control with a decrease in self-consciousness, allowing technique to tackle challenges before we realize what we did (Csikszentmihalyi 1990, 52-66). Flow enables comfort, stability, and heightened states of awareness. Comfort can manifest in different ways. Physical comfort is required for flow.[96] Establishing flow allows unconscious and conscious habits to lead instrumental technique—freely navigating between these states of awareness enables a mindful

[95] This connects to one of the key goals of *PrismaSonus* focused on displacing listening perspective. While recording the sample library, we used multiple monitoring perspectives, each creating a different sensation of distance between my playing and my perception of technique.

[96] Physical tension and discomfort takes performers out of their flow state. In addition to increasing mindfulness and awareness, mind-body integration practices like Alexander Technique help players notice discomfort without allowing it to disrupt a sense of flow, and before it becomes a more chronic issue. For more on the Alexander Technique, see *The Alexander Technique for Musicians* (2013) by Judith Kleinman.

approach to habit-formation and modification. Body-instrument interaction can be summarized with the following feedback loop:

(1) Setup of Interaction: How I set up an interaction affects its quality.

(2) Quality of Interaction: The quality of that interaction affects my perception.

(3) Changed Perception: My changed perception mediates my technique.

(4) Technique and Flow: Technique, guided by habit, mediates the degree to which I sense flow.

Throughout my collaboration with Theocharis, this framework empowered me to embrace and integrate my existing flute technique and mind-body awareness practice into our collaborative exploration of music technology.

There is a distinction between musical and physical comfort. In Kurt Rosenwinkel's case, his highly-developed instrumental technique, while providing physical comfort, hindered his creative spontaneity; stability and comfort had become barriers to creativity. To overcome this, Rosenwinkel altered his guitar's tuning, which disrupted the habitual mapping between his technique and the instrument, thereby transforming both his perception of the technique and the instrument itself. This created room for a new quality of flow state. It enabled him to monitor his playing while exploring a new creative space. Retuning the guitar changed the relationship between finger position and musical output, creating distance between action and predicted result.[97] I used microphones to similarly distance myself from the act of playing. This technology allowed me to explore new creative landscapes while still accessing my existing instrumental

[97] In *The Use of the Self* (1932), F.M. Alexander uses the term "end-gaining" to refer to the state of being that focuses entirely on the end result of the action. Retuning the guitar disrupts the unconscious link between technique and habit, intention and result.

technique, without being able to fully anticipate the results of my actions. Within this framework, microphones facilitate a new way to engage with my existing technique.

When I am in a state of flow, I lose awareness of the tools I use. Altering an instrument's feedback disrupts this flow by shifting my focus on the tool itself. In other cases, habits sometimes prevent me from entering flow states. Does focusing on a single technique detract from achieving flow, or is flow an overarching awareness that incorporates all elements? When I perform, I navigate constantly between ready-to-hand and present-at-hand interactions. Acting through the instrument in a flow state exemplifies a ready-to-hand interaction, where my focus is on the music. When I become distracted or otherwise focus on my instrument's "thingness," such as noticing a sticky key, I shift into a present-at-hand state in which my focus is on the instrument itself.[98] This distinction is blurred in practice because it takes engaging through my instrument to access music. The way I used technology in my work with Theocharis is an example of deliberatively invoking this state, where the instrument might surprise, resist, or provoke me.[99] In our project, the way technology created space for unpredictable interactions made our work remind me of the dynamics of chamber music. For me, one of the joys of small-group performances is the sense of surprise I get when connecting to another player's sound and actions. I believe my collaboration with Theocharis reached a chamber music-like quality, both in terms of our creative process, and in the dialogue I engaged with the flute through our use of technology.

Learning to play a new technique on an instrument often involves a degree of discomfort or instability. As the new technique becomes integrated into your embodied practice, it

[98] See the Section 1.1.1 for further discussion of ready-to-hand versus present-at-hand interactions.
[99] De Souza points out how altering affects the players' perceptual experience by surprising, resisting, or provoking (82-84).

transitions to being more comfortable and stable. However, some musical materials or techniques, such as multiphonics, whistle-tones, or subtle microtunings, are inherently unstable. This instability is a built-in affordance[100] of the technique, which composers sometimes intentionally utilize to invite performers to explore these unstable environments.[101] My comfort is not necessarily tied to stability, allowing for comfort within instability itself. Instrumental alteration further complicates this by disrupting and transforming habits. It challenges the connections between instrument, action, intention, and sound (De Souza, 82). I am interested in the way alteration allows me to distance myself from the flute's external memory, obscuring the links between instrumental idioms, topography, and embodied expectations of the instrument, and how this process generates creative energy.

2.3 Alteration as a Mediator

Throughout this chapter, I have explored instrumental alteration as a tool for disrupting habit and creating musical energy. I examined how comfort, instability, and flow states are influenced by these alterations. I focused on the internal dialogue between a performer's actions and their perception, and how this influenced the synthesis of electronics and my existing instrumental practice. This informed my approach to technology-mediated listening in my collaboration with Theocharis.

How does instrumental alteration functions within collaborative contexts? What emerges when two artists, each with their unique expectations and memories of an instrument, engage in a creative dialogue? How do they navigate their differing perceptions, and what mechanisms

[100] For more discussion on affordances, see Section 1.3.
[101] E.g., the piece I mentioned earlier where I was asked to slowly move my fingers between different fingerings.

facilitate a mutual understanding of the instrument's musical possibilities? How does technology facilitate or transform these interactions?

When a composer provides a performer with a notated score, the path of dialogue between performer and composer is *through* the score. Performers use technique to communicate between their instrument and the score. Does a performer act *on* a score, or do they communicate *through* it? The context—or *place*—in which this interaction occurs defines the relationship between performer, instrument, and score, influencing the nature of the collaboration. In this section, I will explore modes of communication that situate instrumental practice in a living dialogue that exists outside of/prior to fixed notation, which informed and inspired my approach to collaborating with Theocharis.

In *Listening to the Other*, Stefan Östersjö describes a collaboration with composer Richard Karpen where detuning the guitar became a crucial structural and communicative element of their piece. Alteration itself became a mediator within the collaborative space. Östersjö highlights moments where differing associations with the guitar's sound created tensions. Navigating these tensions through dialogue was pivotal in deepening their collaborative relationship. When I first read this text, it influenced my ideas on how to apply these conversational strategies to my collaboration with Theocharis. It also inspired me to document the collaborative process—similarly to how Östersjö recorded his meetings with Karpen—as a tool to analyze and refine the creative process.

2.3.1 Intersubjectivity, Common Ground, and Rationality

Composer-performer interactions are mediated by musical tools. These tools alter the collaborative dynamic by defining the topography in which collaborations are situated. Our perception of instruments is mediated by our individual experiences, habits, and embodied

practices. Instruments translate meaning between people who may have radically different embodied knowledge. Two individuals cannot have an identical embodied understanding of the same musical object. Placing collaborators within a shared environment highlights those perceptual differences. After recognizing the tension created by these differences in perception, collaborators establish trust by working through them via dialogue. Effective communication requires both individuals find common ground. In my collaboration with Theocharis Papatrechas, we used microphones to create a neutral listening perspective that was unfamiliar to both of us, which helped distance each of us from our habitual perspectives.[102]

Alfred Schütz's work on the phenomenology of the social world can be used to address the problem of understanding and negotiating the perceptual differences between two collaborators, specifically through his concept of *intersubjectivity*. This concept seeks to answer the following question: how can two people share an understanding of the world without having immediate access to each other's mental states? (Dourish, 110-11). Schütz believed that the meaningfulness of social action emerges within the context of the actor's own experience of the world. The foundation of Schütz's intersubjectivity is Husserl's *lebenswelt*, or "life-world," which incorporates our social understandings and influences how our actions are perceived by others and how we perceive others' actions. Schütz was responding to Max Weber's view that "society and stability of social facts are a given, existing independently of their application or interpretation by social actors" (Dourish, 111).[103]

[102] Neutral is not the same thing as "authentic," which I do not believe exists. I use neutral to refer to a perspective that is external to either me or my collaborator.

[103] Dourish's work employs phenomenology primarily to discuss human-computer interaction, emphasizing the subjective nature of reality and focusing on individual perceptions and their interrelations. While phenomenology offers a robust framework for examining various interactions, the way it contrasts with other approaches is beyond the scope of this dissertation. As a classically-trained performer, my engagement with these philosophical concepts is primarily through their relevance to musical performance rather than a comprehensive academic study of phenomenology itself. My practice-based training emphasized direct musical communication, and my exploration of these extramusical ideas is inspired by their applicability to understanding and enhancing this communication.

Perhaps Weber would say that the performer-composer interaction has a built-in structure in which objects imply action, defining the communicative process. The composer creates; the performer performs. Schütz would focus more attention on how I, as the performer, respond to the score, framing interaction within a richer web that includes my prior experience and the specific context in which this interaction occurs. Performers often refer to themselves as *interpreters*.[104] They are also creators of meaning, as the act of interacting with the score (the interface) creates meaning. Dourish articulates that interface designers delegate the creation of meaning to users because it is the act of using an interface that generates meaning. If musical collaborations involve interacting with such designs, then meaning is created once a performer's actions are mapped onto a score. This does not imply that a composer's work lacks meaning prior to performance; rather, composers should anticipate the additional layer of meaning performers will generate through the process of interaction. Musical notation captures gestures and lays them out temporally. A musical score is not an actual performance—it serves as a guide for navigating through musical space.[105]

None of the projects I created with Theocharis relied on conventional notation, contrasting with my prior collaborations with composers. Our project used recording, listening, and describing sound to communicate musical ideas. This process eventually led to written descriptions of techniques and textures, and a spoken "script" for the performance, but never became a traditional score. This was a significant shift in my practice given how many of my earlier collaborations were rooted in the use of scores. My expectations for the project were

[104] This comes from my experience as a performer where colleagues use this term conversationally. Being an interpreter leaves space for creative agency.

[105] The extent to which a musical score dictates action varies significantly based on notation style and musical genre. For example, the complex, detailed scores of Brian Ferneyhough suggest extremely precise rhythm, dynamics, expression, and phrasing. In contrast, the music of J. S. Bach provides a framework that relies heavily on the performer's knowledge of the musical genre, as well as personal interpretation.

shaped by this experience, and I found myself seeking out a score-like structure even when none existed. Reflecting on how this project has shaped my identity as a performer, I now find myself much more comfortable working without a traditional score in the early stages of a project, and actively seek out those opportunities with other composers. This journey has made me recognize the value of exploratory dialogue over predetermined notation, particularly at early stages of a project's development.[106]

Even though Schütz's concept intersubjectivity accepts the subjective experience of individuals, it assumes that the actions of others are *reasonable*, rooted in a shared reality where *rational* behavior is universal (Dourish, 112). Rationality is influenced not only by the reasoning of individuals but is shaped by the perceived roles within the collaboration. Power dynamics within institutional settings have a great impact on what is perceived to be rational. The pursuit of common ground, even with best intentions, can deny space for individuals within that dynamic. My work as a performer of contemporary music often places me in situations where I have limited influence on the structure of the interactions. The preexisting dynamics of the spaces in which I work influence the perceived boundaries of reasonable action. While a broader discussion of how social politics have evolved within the music institution lies beyond the scope of my dissertation, I recognize the way I am implicated in these dynamics, even if I believe my collaboration lies outside of the typical narrative of performer-composer collaborations.

[106] This transformation represents a widening of the scope of my practice. Even though most of my work as a performer remains within a fully-notated, score-based environment, my work as a performer-composer has allowed me to explore more open, improvisational interactions with composers as well as other performers. I have noticed the way this work has made me a more present and mindful collaborator as I navigate between these different environments.

2.3.2 Character Development and the Uniqueness of Collaboration

Strandlines (2007) is a work for guitar and electronics created by composer Richard Karpen and guitarist Stefan Östersjö. The work has no musical score and was developed through an extensive process of collaboration and rehearsal.[107] Several elements of this project significantly influenced how Theocharis and I structured our collaboration, both from a musical perspective, and from the design of the collaboration itself. In the liner notes for the project, the development of the piece is compared to the work of filmmaker Mike Leigh:

> Mike Leigh works with his actors to create their characters through an organic and rigorous series of directed improvisation and reiteration until the actors fully embody their characters, their utterances, and the relationships between all of the interacting characters and situations within the environment of the work. Through this process the film becomes its own screenplay. In the case of my own explorations in this mode of composing, the piece of music will itself also be the score. The piece is documented using video recordings of a performance along with instructions and demonstrations showing how to play it. This video document takes the place of a musical score so that the integrity of the work can be maintained over time and the work can be performed by other performers as well.[108]

The basic formal structure of *Morphés* also involved an exploration of characters. In a meeting on October 27, 2021, Theocharis and I defined the basic outline of what would become *Morphés*: 4 flutes, 4 characters. While this would evolve over time, the basic idea was to each instrument's affordances (as altered by microphone placement) to highlight these different characters. Each character would be a combination of a playing technique, a musical texture, and a processing

[107] https://richardkarpen.com/strand-lines-2007/

[108] While we did not create a video document of how to perform *Morphés II*, this is something I have considered adding to the project in the future.

method.[109] This idea of creating a "rigorous series of directed improvisations" is exactly the way we structured our recording sessions.[110]

Karpen's liner notes go on to identify the various ways Östersjö's role as the performer significantly influenced the work.

> *Strand Lines*[111] also explores the extension of musical instruments and performance through live computer enhancement and processing. It is a work not so much for guitar as for guitarist. The merging of person and instrument interests me greatly. Each player is one manifestation of the current state of a continuing history of their instrument and of performance generally. The history is physical, existing as a kind of "body knowledge" which I believe is real and substantive. Along with Stefan Östersjö's integral role in the development of guitar material for Strand Lines another key contributor was Joshua Parmenter who developed much of the key underlying control code for sound processing and synthesis in Supercollider.

Östersjö views on the project mirrors Karpen's and goes on further to point out the un-replicability of this collaboration, even though it was extensively documented. *Strandlines* relies on "specific relations between a specific performer and instrument. And because a performer's voice typically will transform over time, the identity of compositions like Strandlines will also shift. Its materials may expand or become more precisely defined" (Östersjö, 82). The continual evolution of the work is built into its structure. This creates a work that "merges the voices of composer and performer into a single, discursive voice" (Gorton and Östersjö 2019, as cited in Östersjö 2020, 84).

[109] We referred to this as a "library of processes."
[110] I should also point out that at no point did I listen to *Strandlines*. I separated my analysis of Östersjö/Karpen's collaboration and documentation method from the musical materials they created. I sought to apply their approach to collaboration and documentation, rather than any specific musical or aesthetic elements.
[111] In various sources, this project is referred to either as *Strandlines* or *Strand Lines*. Östersjö's text uses *Strandlines*, which I will use in my discussion of the text.

2.3.3 Instrumental Form Creates Communicative Function

In his collaboration with Richard Karpen in Strandlines, Stefan Östersjö tackled intersubjectivity and common ground from the start. Östersjö meticulously documented their collaboration, aiming not only to understand the steps they took in their project but also to extract lessons that could benefit others.[112] His focus was on the quality of the communicative process, not merely on tracking logistics and technicalities.

Östersjö sought to redefine traditional performer-composer interactions, which often do not account for individual perceptions. There are several parallels between Östersjö's approach to collaborating and documenting their process, and Dourish's discussion of a designer's role in creating interaction. Dourish suggests that while designs reflect the ontological commitments of the designer, they cannot impose an ontology on the user (13). Similarly, Östersjö and Karpen recognized their unique perspectives on the guitar, choosing to embrace these differences as part of their dialogue.

According to Dourish, users and designers inherently approach materials from different perspectives, making it impossible for them to have a singular ontological model (130-31). This necessitates trust and establishing an "ecology of musical collaboration" (Östersjö 12), which embraces how different modes of interaction and practices lead to varied understandings of the domain (Dourish 130-131). Their approach included listening through the guitar (Östersjö, 57), supporting a collaborative process that considered their distinct approaches and acknowledged their ontological differences.

[112] This included recording and transcribing their collaborative meetings. This is something I adapted for my collaboration with Theocharis. In addition to using those meeting recordings to help plan subsequent meetings, I revisited those notes after the completion of the project. For more, see Chapter 4.

Östersjö and Karpen engaged with the instrument's affordances to structure their collaborative process, using the instrument as a mediator for their dialogue. Östersjö draws on James J. Gibson's concept of resonance (also referred to as tuning) to describe the coupling between action and perception. Objects, including musical instruments, are not only perceived for their affordances but also for their potential uses (Gibson, 1979, p. 134 as cited in De Souza, p. 13). In "Strandlines," detuning plays a dual role, serving both musical and perceptual purposes, highlighting the interaction between the guitar's physical properties and the performer's sensory response.[113]

This form of interaction fosters a flow of musical intuition, where the creative process is seen as a network of multi-modal interactions linking perception, analysis, feedback, and action.

> Just as the 'resonance' between an instrument and the musician's body mirrors the touching hands, the affordances of a musical material are also experienced by the composer as a resonant subject in the ongoing musical dialogue, emerging from the particular interaction between analytic thinking and perception, which is the basis for the flow of musical intuition. (Coessens and Östersjö 2014b, 331) (pg.69-70)

This model of collaboration excited me because it allowed for spontaneous and unexpected creative outcomes as each participant's input influenced the other's responses. Identifying the moments in which there is potential for creative flow and then engaging with those moments epitomizes truly collaborative work. Throughout my collaboration with Theocharis, microphones serve a dual purpose, both as the tool through which we identified and interacted with our creativity, as well as the technology through which we document both the artistic output of our collaboration, and the collaborative process itself.

[113] The guitar is modified by de-tuning the strings and by electronics.

In *Strandlines*, the *tuning* of action and perception is altered by the *tuning* of the guitar. While Kurt Rosenwinkel used retuning to break free from instrumental habits by altering the instrumental space, *Strandlines* used the affordances of each tuning to influence the form of the piece and mediate communication between composer and performer. While my work as a flutist does not involve retuning the instrument, my collaboration used other processes to achieve similar creative effects. Microphone placement altered my listening perspective and uncovered a new instrumental space, which distanced me from habits. The affordances of each recording method influenced the form of our work. This process of uncovering affordances, termed *effectivities*, involves understanding the inherent qualities of an object that reveal its potential uses (Neumann 1966, 78, as cited in Östersjö, 18). *Strandlines* is informed by the physical and idiomatic qualities of the guitar, the methods of its alteration, and the mutual perception of these by both the performer and composer. Applying De Souza's terminology to analyzing Östersjö's collaboration provided me with a rich framework that I applied to my work with Theocharis.

A lack of musical score focuses attention on an instrument and dialogue-driven collaboration. In addition to the liner notes mentioned earlier, Östersjö also describes the work as the "merging of person and instrument" (11). This approach involved extensive verbal interaction in which the collaborators talked through musical ideas that were "hard or impossible to notate" (Östersjö 2008, 32). This method, while potentially seen as disruptive or radical within the context of Western contemporary concert music, is more commonplace when situated within a broader perspective on musical practices where verbal interaction and improvisation is more common. This illustrates how collaborations are shaped not only by the physical configuration of objects and the interaction between them, but also the social understandings providing a behavioral framework for the environment (Dourish, 89).

2.3.4 Tension as a Generative Process

As discussed earlier, the crucial step in this type of creative process involves navigating moments of tension. Östersjö and Karpen have established their ideal collaborative model, one that involves unpacking each other's perception of instrumental affordances. Moments of tension, which would be uncomfortable in a different context, are reframed to be generative.

At one point early in their collaboration, Östersjö suggests exploring scordatura tunings for the guitar as a source of musical materials.[114] However, Karpen is not interested. To him, it makes the guitar sound unlike a guitar, and he does not want to hide what he perceives as the guitar's important idiomatic qualities (60-61). But for Östersjö, the detuning process is part of his embodied practice. The mismatch between their perception of the guitar creates an opportunity for learning, where two musicians get to experience what happens when their viewpoints come together. The process of listening and unpacking their differences in perception affects their mode of listening. "…this musical listening is filtered through a particular listening through the scordatura of the guitar, and our dialogue is fueled by the novelty of the sonorities heard through the new tuning system" (71). Östersjö sees alteration as a tool for generating musical material, where "invention became a vehicle for creating novel sonorities, through instrumental techniques that were sometimes rather unconventional in themselves" (81).

What stood out to me in this description is how thoughtfully and intentionally Östersjö presents unfamiliar materials to Karpen. He goes through a process of retuning his guitar, and then demonstrating sounds to Karpen that he feels are musically relevant. This activates Karpen's *musical listening*. Östersjö notices how the change in Karpen's listening mode changes him, opening him to hearing things from a different perspective. This changes the quality of their

[114] *Scordatura* is an unusual tuning of a stringed musical instrument for some special effect (Merriam-Webster).

interaction. As opposed to earlier in the collaboration where Karpen was not interested in exploring scordatura because of its "foreignness," Karpen is now asking questions that engage with what Östersjö is presenting. Pierre Schaeffer calls this *musicianly* (as opposed to *musical*) listening (Östersjö, 62). Karpen overcomes his doubts about scordatura, and even finds his own voice in this sound world (60-62). At a certain point, Karpen begins offering his own suggestions for things to try. Östersjö describes this specific moment:

> …I am convinced that he is hearing something entirely different with his inner ear. The sounding guitar is certainly provoking this inner hearing, but Richard [Karpen]'s radical proposal results less from what I am doing and more from Richard's internal listening. Similarly, when I hesitate and look at the instrument, *my* musical imagination has been activated by my inner hearing. But, in both cases, this imagination is immediately further sparked by the concrete listening that follows. (Östersjö, 62)

What appeals to me here is the direct connection between creativity, imagination, and critical listening. To me, Östersjö is creating an environment in which both he and Karpen can listen to and engage with the materials in a rich and multi-modal way. Materials that initially felt foreign and unwanted by the composer have now become part of a shared language. Eventually, Karpen is not only convinced that Östersjö's suggestions fit into his idea of the piece, but Karpen himself feels as though he's able to contribute to the development of the guitar tunings. As Östersjö states, this is what enables dialogue between a composer and performer: "It seems fair to conclude that the development of a compositional practice through immediate engagement with a performer's voice has also provided an impetus to contribute to a dialogue with musicians through performance" (83). Developing a shared practice of instrumental alteration allows composer and performer to both feel equal ownership over the musical materials.

Imagine if their exploration ended when Karpen felt like Östersjö's idea of using alternative tunings did not fit into the piece, and they did not explore this idea further. Without

judging whether this would be a good experience, it would be a very different quality of interaction, aligning with a very different mode of performer-composer interactions. What allowed their collaboration to become the performer-instrument hybrid described by Östersjö and Karpen was allowing both parties to challenge each other to push against their traditional roles. Meaning-making within collaborations can occur outside of strictly-delineated roles. This discourse involves translating the internalized understandings two collaborators bring to the discussion.

I first analyzed this collaboration prior to beginning my work on *PrismaSonus*/*Morphés*. I acknowledged that achieving this level of rich, collaborative discourse is not an easy task. Furthermore, I understood that the approach outlined here might not appeal to all performers and composers and presents only one possible way to foster creative dialogue. What influenced me the most about this approach was Östersjö's ability to critically analyze the design of the collaborative process. Looking back at the achievements of my collaboration, I recognize the way increasing my awareness of communication and the processes mediating it has created space for me to step outside of my role as a performer. This has enabled my collaborative work with Theocharis Papatrechas to be a richly satisfying process that has been artistically productive, intellectually engaging, and simply much more fun than many of my other collaborations up to this point in my career.

2.4 Conclusion

I began this chapter with an exploration of how breaking habits creates space for dialogue between a performer, their instrument, their technique, and their perception of their own actions. I explored how instrumental alteration affects a performer's sense of comfort and stability, and the ways that context frames the way we perceive our instrumental technique. I then applied

these concepts to the interpersonal domain, applying Alfred Schütz's concept of intersubjectivity to the way that performers and composers develop common ground. My analysis of Stefan Östersjö and Richard Karpen's *Strandlines* demonstrated one potential collaborative model. I addressed how this exploration informed my approach to experimentation and documentation in my collaboration with Theocharis Papatrechas.

This chapter challenges collaborative models in which there is an all-or-nothing approach to agency. I challenge the idea of agency as a finite resource within a collaboration. Situating agency within a dialogue that involves the performer, their instrument, the composer, as well as the social context surrounding the collaboration empowers individuals to question the design of their collaborations, increasing the intentionality of their work. Increasing agency is not necessarily the goal but is part of the process in generating creativity and activating imagination within collaborations.

I cited Derek Bailey's idea that performers often refer to their instruments in polarized ways, either as best friends and collaborators, or as liabilities and intruders. This chapter demonstrates how behavioral expectations present in many of the contexts in which we perform music can lead us to feel a similar way about our collaborators: composers and performers are either best friends, or liabilities. Bailey's solution is that the instrument is not a tool but an ally; Jonathan De Souza develops this further by saying that instruments are creative partners for performers.

I suggest that healthy collaborations are a matter of creating space for freedom within structures. Learning about collaborative methods outside of my prior experience creates space for creativity. Externalizing my internal perception of external processes allows me to share my imagination with my collaborators. This feedback loop creates more joy in collaborations, and in

a way decreases feelings of agency in the traditional sense. The less collaborations are polarized between a perspective of *me* vs *them*, the more they are truly collaborative. I hope that the discourse presented here gives others a potential model for making the design of collaborations more intentional, more creative, and less dictated by predetermined models that do not necessarily aid the development of the project.

Chapter 3: Interaction Design

The previous two chapters explored how the affordances of objects influence the way we interact with the world. I discussed the relationship between habit, technique, memory, and control, supported by terms like invariance, effectivities, action-sound mapping, and instrumental topography. I discussed how the objects we use to connect with music influence our perception, and therefore our interpretation of it. I presented ways awareness of these terms helps establish a framework for incorporating technology into an existing acoustic performance practice.

The discussion also explored the way instrumental alteration serves as a mediator of communication, both between performer and instrument, and between collaborators. What happens when the act of alteration itself becomes the focus of a performer-composer dialogue? How do collaborators navigate the collaborative environment when they have a different understanding of an instrument's affordances? What practices enable successful communication? I provided an example of a collaboration where a performer used documentation of the creative process to learn more about their collaborative dynamics, which would later influence my own approach to documenting the work of *PrismaSonus*, something I will discuss in the next chapter.

In my collaboration with Theocharis Papatrechas, pre-existing design influenced every stage of our project's development: the physical design of the spaces in which we worked; the design of the software and hardware we utilized for the project; or the social design of the settings in which we presented our work.[115] But it also involved designs of our own: methods for mounting microphones inside of my flutes; audience seating arrangement at our performances; software presets for visualizing our sample library; the design of our collaborative process; the structure of our documentation methods.

[115] Using Dourish's terminology, the *places* in which we presented our work (the academic conference, the interdisciplinary artistic festival, the concert hall).

In this chapter, I will explore the communicative function of design. What happens when artists create interfaces that serve as communicators of meaning? In what ways does design mediate communication, and what is the designer's impact? What practices can a designer adopt to enable better communication? In my discussion, I will share the background research that influenced my contributions to *PrismaSonus*, which will be used in a later chapter to reflect on how we synthesized design theory with practice.

In *Where the Action Is: The Foundations of Embodied Interaction*, Paul Dourish outlines his vision of a design approach influenced by embodied interaction. Embodied Interaction is a set of principles that a designer can utilize in their design process. These principles emphasize the fact that it is the user who creates meaning in design, and not the design itself. Dourish outlines the ways that a designer can get out of the way of the user. He outlines the ways that designers often make decision for users that negatively impact the level of freedom and connection the user feels to the design. I cited Dourish's work in previous chapters in my discussion of instrumental affordances. In this chapter, I use Dourish to establish a foundation for the language I use to analyze design and explore the role of design within technologically-mediated performer-composer collaborations.

Ge Wang's *Artful Design: Technology in Search of the Sublime* connect Dourish's text on human-computer interaction and situate them in the modern world, presenting a practical approach to design that influenced the choices made throughout the development of *PrismaSonus*/*Morphés*. Wang focuses on the role of gamification in music design, as well as highlighting the humanity in human-computer interactions, which inform our ideas for the future development of *Morphés.*[116] These texts, combined with my knowledge of flute techniques,

[116] Our future work is interested in translating the fixed-media and live performance versions to the online domain, with the potential of adding interactivity to the musical experience.

notation, and contemporary music, represent the theoretical and practical concepts I brought to my collaboration with Theocharis.

The design of interfaces shapes the way we interact with data. When we introduce digital interfaces into interactions, our experience is shaped by the decision-making process the designers of those interfaces went through. My primary interest is not in the designs themselves, but the way humans interact with those designs. I am interested in the communication enabled through the interaction with design.

I believe exploring the mechanisms by which design mediates communication empowers collaborators to take a more mindful approach to the design of collaborations. This process has given me more tools to analyze the communicative function of scores. As a collaborator, this exploration has given me language I can use to define and shape the look and feel of the collaborative space. As an educator, this has opened me up to more possibilities for engaging with my students. By understanding the processes that go into interface design, I can better understand how the use of electronics and interactive technologies affect my perception of myself, my work, and my collaborators.

3.1 Design Foundations

In the previous chapter, I introduced the concept of intersubjectivity, using it to analyze performer-composer collaborations. I discuss how musical collaborations develop *common ground* to create a shared understanding of instrumental affordances, the role technology plays in mediating those processes, as well as methods for documenting and analyzing the collaborative process between performers and composers. I applied Paul Dourish's design concepts to my analysis of De Souza's discussion of body-instrument interaction, connecting software design concepts to analyzing how the design of musical instruments affects perception. In this chapter, I

will use Dourish to establish a broader theoretical foundation for analyzing the impact of software interfaces and hardware design within musical collaborations. What are the processes by which a designer enables communication? What are best practices for approaching design when they are meant to serve a communicative role for their users?

Dourish believes that to establish intersubjective understandings in interactive technology, there needs to be communication between a designer and user. The designer communicates a set of constraints and expectations about using the design. These intentions are communicated through the form of the interactive system itself, and its *usability*. Usability involves the way that a system reveals its purpose to a user. The user then develops an understanding of the meaning of objects and the consequences of actions within the system (132-133). To me, Dourish's approach can be applied to developing an interpretation of a musical score. The intention of a composer is communicated via the form of the score. As discussed earlier, composers map notation onto instrumental idioms. While designs suggest inherent meaning, it is created *after* a user (the performer) works with the design (the score).

Throughout the book, Dourish emphasizes that users create meaning by communicating *between* each other, *through* the system. Communities of users develop and communicate shared ways of using interfaces by *appropriating* systems to fit their needs. By focusing on what decisions people make and what expectations they have when using an interactive system, the focus is not just on what a system *can* do, but what it *really does do* for the people who actually use it (133). Focusing my analysis on the use of interfaces and communication through them will be one of my primary modes of analysis throughout this work.

Using Dourish's term, what does it mean to *appropriate* a system to fit the needs of a collaboration? How does understanding this terminology empower individuals within a team to

explore their creativity? How does this approach inform an approach to integrating music technology and acoustic performance? More broadly, how do these principles aid the contemporary music performer, composer, and educator in overcoming the rigid hierarchies of music institutions?

The principles covered in this chapter inform my perspective on design going into my work with Theocharis and will be used in my analysis of our collaboration in subsequent chapters.

3.1.1 Design in the Music Studio

Dourish's terms of *space* and *place* help emphasize how the setting in which a design is used greatly affects the perception of its meaning. When analyzing design, it is important to keep in mind the various contexts in which it might be used. Like many other educators and performers, my relationship to technology evolved throughout the pandemic. Virtual telecommunications limit the dimensions of interaction between a student and teacher. Software and hardware took on a much greater role in shaping the experience. Each design decision carried more weight in a remote environment.[117]

Listening is already a very subjective aspect of music when you are in the same room as your student or collaborator—a remote environment introduces even more elements. This experience made me consider how audio technology (e.g., microphones and speakers) are manufactured with objectively quantifiable affordances. Given two identical pieces of hardware,

[117] For example, teaching over Zoom meant that I no longer could hear my student playing within a live acoustical space, and I also lost the ability to see my students from multiple angles, greatly limiting the degree to which I can analyze their body language while playing. Therefore, I was limited in my ability to judge the reactions of my students, especially to their own playing. In this constrained information space, language became an even more important communicator of information. The degree to which my words express with clarity the action I would like my student to do now had a greater impact on the student's experience. The words my students used to describe their perception of their playing became an even more important vector of communication between us.

remote collaborators can exercise a certain level of control over factors otherwise creating differences in experience. It is worth keeping this in mind during my later discussion of how the *invariance* and *repeatability* influenced our approach to music technology.[118]

The pandemic underscored for me the importance of considering design as a crucial component of the music studio. I became interested in better understanding the ways that design can be used to mediate communication. What elements of pedagogy are geared towards *efficiency* and *performance*? What is the role of *user experience* within pedagogy? What are the similarities between how a pedagogy teaches a student to analyze a score, with how a designer guides a user through their interface?

One of Dourish's main points is that designers create *artifacts* within their designs that lead users through the process of working with the interface.

> …designers can create artifacts that lead users through the process of using them, with each stage leading naturally to the next through the ways in which the physical configuration at each moment suggests the appropriate action to take. The relationship between physical form and possible action can give designers some purchase on the problems of unbounded parallel action. (52)

When applied to a music lesson, consider how when leading a student through a difficult piece of music, the educator in a way takes on the role of designer, showing a student how to take advantage of their knowledge of instrumental topography to navigate the music. With notated music, there is already a pre-existing design, so learning a piece becomes a matter of deciphering potential physical moves. The work of music is like an obstacle course, that uses a combination of visual processing and habit to translate notation into physical movement. As I discussed previously, prior to my work with Theocharis, many of my collaborations with composers went immediately to notation to provide this design structure, upon which we developed our

[118] See Section 1.4.1 for more on *invariance*.

communication. In this project, we used a shared exploration of technology and instrumental technique to first form a shared listening practice, which meant that by the time we reached considerations of notation we already had a shared sense of instrumental topography (which was mediated by technology).

3.1.2 Flexibility in Design

Another important principle in Dourish's approach to design that I have alluded to in the previous chapters is that designs must support flexibility. Dourish points out that when designers create interfaces, they sometimes rely on formalized work processes to get an idea of what goes on in the practice they are designing for. This approach leads to software systems that do not account for the flexibility with which they will be put into practice (64). This forces the user to either change their practice to fit the model the program has prescribed or stop using the interface entirely because it does not seem to be useful. Another solution is to attempt to *hack* the interface to get it to do something that it was not designed for. I will explore this later in the chapter in my analysis of Khyam Allami and Jace Clayton's approach to interface design, two artists whose work influenced own ideas on how to apply design theory to practice.

Even when I began to explore electroacoustic music, interactive interfaces did not play a significant role in my musical practice. As discussed in the Introduction, the shift for me came during the pandemic, when I began to explore the role of interface design much more

seriously.[119] Ge Wang's book, *Artful Design*, describes *satisfying design* as an approach that combine usability, gamification, and humanity. I believe it is compatible with Dourish's philosophy of flexibility and Embodied Interaction. The synthesis of these two texts, combined with my exploration of music software[120], influenced our use of music interfaces throughout the work on *PrismaSonus*.[121]

Software should be informed by the practice. Allowing the software to shape the practice diminishes the benefit of bringing software into an otherwise analog practice. As Dourish points out, "Users are less predictable than planned-out systems. Users have different goals, and different ways of using the system" (Pg.83). The designer is not a neutral party. Each decision made throughout the design process influences the way users will interact within the system.

3.1.3 Mismatched Ontologies

Ontology deals with the existence of objects and entities. How can we individuate the world, or distinguish between one and another object? Ontology provides structure from which meaning can be constructed. From the very onset, software design involves making decisions about entities, their relationships, and how they *line up* (129). When software designers discuss ontology, they are mostly focusing on how the system will treat objects, and how those objects

[119] An example of this is my work analyzing *Droneo*. *Droneo* is a drone generating app that allows a user to build a drone with up to 8 voices over a given fundamental. Another way to describe it is that there is one fundamental, with 8 reeds that can be individually tuned. The fundamental's waveform can be static (sine, triangle, saw, etc.), or can shift between two sounds. Each reed can be tuned using Hz, cents, or a ratio. In theory, this app allows me to create any kind of drone to then practice with. However, there are elements of the interface that are frustrating to use within a practice session. For example, when selecting a pitch for one of the "reeds," it brings up the full iPad keyboard, even though I am typing in a frequency (440), a tuning ratio (5/4), or a note name (A4). For me, this small detail diminishes the enjoyment I get from working with this interface and limits the amount of time I want to actually be using it.

[120] As I read these texts, I found myself critically examining the design of software with more specificity than I had previously. Some questions that came up for me during this period included: What happens when I want to use an app differently from how it's designed? Do I invent a new app? Do I search for a different one? Do I adapt my own practice to the limitations (or prescribed workflow) of this app?

[121] In Chapter 4, I will discuss the way we used the audio editor iZotope RX 10 to visualize our sample library, which became an important part of our communication.

will be mapped onto features. Ontology in software design can also refer to a conceptual model, either the user's or the system's (130). System designers work to make a model that will fit the "user's ontology."

What happens when a design does not fit the user's ontology? What design practices enable a user to create their own ontological model? In the previous chapter, I point out how the pursuit of *common ground* in a collaboration has the potential of denying someone their own ground. In Chapter 1, I discuss how previous experience with an instrument shape the way we perceive its affordances and potential uses. I became interested in applying this to my collaboration with Theocharis. Our collaboration used recording technology to focus our attention on the flute from a shared listening perspective. This enabled both of us to step out our own prior experiences with the flute. I will later demonstrate how our approach to technology enabled a rich dialogue between composer and performer.

Dourish points out ontology is a participative process and is not something that is fully formed. However, designers often think of ontology of something that is designed. While a design may reflect a particular set of ontological commitments on the part of the designers, it cannot provide an ontology for a user (13). User and designers approach interfaces from different perspectives. Therefore, it is impossible for them to have the same ontological model. Different modes of interactions result in different ways of understanding the domain (130-31). In interactive design, there are several specific issues that arise from static ontologies. First, there is a mismatch between the assumptions of the system and the expectations of users. Next, it creates rigid procedures for accomplishing tasks, disregarding the fact that different people work in different ways. And finally, it creates brittleness in adapting new systems as practices develop and change.

As I considered the ways Dourish's principles map onto my experience, I reflected on the way pedagogy involves approaching a challenge from the perspective of your student, trying to remember back to the time when that aspect of music was challenging.[122] I also considered my previous collaborations with composers. In how many of those instances did I have the time to explore the difference in perception between me and my composer collaborator? In how many of those collaborations was it assumed that I would automatically adopt the composer's (designer's) understanding of the instrument? Considering these questions would influence me throughout my work developing *PrismaSonus*.

3.1.4 Abstractions in Music

The final concept from Dourish that I will apply to this discussion is the idea of *abstraction* and *implementation*. Abstractions allow us to make complex behaviors into a simple, higher-level object. An abstraction uses a single object to capture a range of potential uses and needs. Abstractions isolate one component from another so they can be managed and maintained separately (82). Abstractions hide implementation. Meaning, by isolating one piece from the rest, they represent a modular approach to design. An example of an abstraction in our collaboration was a playing technique, paired with a specific microphone placement.[123]

Abstractions manifest in music education and performance in many ways. For example, expression, articulation, and tempo markings are forms of abstractions. The relationship between two markings in music is also a form of abstraction. An *accelerando* (meaning: increase speed)

[122] This approach has its limitations. There are certain things that came more easily to me than my students. A good teacher learns how to simulate what it would be like to be a novice when solving a particular need that the student has. Perhaps good pedagogy is therefore a matter of constantly learning new ontological models that allow the teacher to become not just more effective, but also more empathetic. In my experience, students appreciate when their teacher seems to understand when something is difficult, demonstrate an attempt to approach the issue from the student's perspective, and create space for the student to voice their own perspective.

[123] Later I will refer to us creating a "library of processes," which combined playing technique, microphone placement, musical content (e.g., sustained tone, articulation, etc.), with specific audio processing techniques.

is an abstraction. Abstractions manifest on different instruments in different ways, which relates to the discussion of instrumental topography in Chapter 1. On one instrument, an accelerando might mean that a player's fingers move faster, while on another, articulation speed will increase.[124] When reading notated music, an *accelerando* increases the speed that you scan music. Therefore, the *accelerando abstraction* has a series of behaviors coded into it. The idea of being able to isolate one component from another is also very familiar to anyone who has worked on a difficult piece of music. Pitches can be isolated from rhythms, or vice-versa. Dynamics can be isolated from articulation. This is all done to make learning a complex piece of music easier.

The singular event of performing a work of music is broken down into a series of modules, which are themselves comprised of abstractions. Often, we practice articulation separately from intonation, technique separately from dynamics, etc. These individual aspects of technique ultimately combine into a general awareness of the instrument that enables the sort of unconscious playing I discussed in Chapters 1 and 2.[125]

Dourish discusses how abstraction hides implementation. By isolating one piece from the rest, the broad structure is no longer clear. The approach we developed in PrismaSonus would constantly bounce between this focus on micro-level sounds and techniques with macro-level structure and form. I believe the framework presented thus far went a long way towards enabling the quality of collaborative dialogue we strived for in the outset of our project.

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[124] Wind instruments combine air and tongue movements to control the beginning of notes. On the flute, modern articulation method can be represented by a diverse range of syllables but is broadly categorized into "front" strokes ("tuh" or "duh"), and "back" strokes ("kuh" or "guh"). Because of its directed nature, microphone placement can drastically change the perception of articulation on a wind instrument like the flute.

[125] This is often summarized as "playing musically," which means combining these modular abstractions into a single gesture. Recall De Souza's discussion of technique becoming a "single flowing gesture" (19). This does bring up a curious distinction between technique and musicality, and whether performers can act musically while also being conscious of their technique (I think so).

3.2 Artful Design

Paul Dourish's *Where the Action Is* informed the philosophy behind my approach to design, providing a knowledge base which I connected to aspects of human-instrument interaction and performer-composer collaboration in the previous chapters. Written in 2001, his book anticipated many aspects of interactive interfaces we take for granted a quarter of a century later. As I deepened my engagement with digital interfaces, I wanted to find a text bridging the philosophical foundation of Dourish with a modern approach to interactive design. This is what led me to Ge Wang's work, *Artful Design*, a text that has transformed my views on interactivity, visual design, and gamification.

Ge Wang is a designer/engineer/artist and professor at Stanford University. In *Artful Design,* Wang unpacks his approach to designing interactive music tools. By combining principles of human-computer interaction, game design, and know-how of music software, Wang presents a unique philosophy to design he dubs as "Artful Design." Ge Wang's work gained public fame with his design of the iOS App *Ocarina*, one of the first musical instruments designed exclusively for the iPhone.[126] Ge Wang entered the burgeoning world of touchscreen-enabled interactive music software, developing numerous groundbreaking interactive music apps.

I fully embraced my interest in software design in 2020 for two reasons. First, the sudden shift to remote teaching meant that I needed to find a way to transfer my entire flute and music theory practice into the virtual space. Second, my performance practice began to expand into electroacoustic and electronic music. What I discovered was an immense world of software and hardware, and a seemingly limitless supply of iOS music production and teaching apps. And yet,

[126] This was one of the first smartphone apps I ever encountered, having gotten my first iPhone (also my first phone, and first smartphone) in 2008.

even within that abundance of variety, I often found myself frustrated with interfaces that could not quite do what I wanted them to, or did it in a way that was incompatible with my own performance practice.

During this period, I invested time into building an awareness of basic programming. Up until this point, my engagement with technology was exclusively as a user. Even when performing electroacoustic music, I had never been involved in the design of the patches themselves.[127] I faced a huge gap between my technical skills, and what I wanted to design. I realized that in my exploration of hardware and software, I still lacked a clear design philosophy guiding my exploration. Ge Wang's book *Artful Design* provided me with a framework that influenced my later explorations of technology.

One of the elements of Ge Wang's approach to design that really spoke to me was his desire to reclaim the humanity within digital interface, rejecting the coldness of so many interfaces. Later in the paper I will analyze Jace Clayton's software design in *Sufi Plug-Ins*, whose own design philosophy has parallels with Wang's. In the introduction to his book, Wang writes:

> In our age of rapidly evolving technology and unyielding human restlessness and discord, design ought to be more than simply functional; it should be expressive, socially meaningful, and humanistic. Design should transcend the purely technological, encompass the human, and strive for the sublime.

What does it mean to strive for the sublime? What are the mechanisms that balance function and expressivity within interfaces? I am inspired by the way Wang describes it:

> Sublime design presents itself, first and last, as a useful thing, but nestled within that window of interaction lies the novel articulation of a thought, an idea, a reflection — an invisible truth that speaks to us, intimate yet universal, purposeful

[127] Around this time, I was taking an introductory course in Pure Data (Pd), as well as Max/MSP, two visual programming languages used in computer music.

> without necessity of purpose, that leaves us playful, understood, elevated. It is a transformation so sublime that it escapes our conscious grasp but that once experienced — like music — we would never want to be without again. Design should be artful.

Wang acknowledges the importance of design as a mediator between a user and a piece of technology. He focuses on the interaction as the source of meaning, similar to Dourish's approach in *Where the Action Is.* Considering the aesthetics of a design does not limit its functionality, instead, one informs the other. Wang believes that aesthetics goes beyond a thing's function. And yet, the aesthetics of a design are linked to its functionality.

> Aesthetics is how we experience a thing — how it emotionally, intellectually, psychologically, and socially affects us. It is everything **beyond** the thing's function. Yet aesthetics does not usurp or live apart from functionality; instead, it gives context, meaning, and essence to a thing, making it what it is....

Artful Design can be described as "design with fundamental emphasis on aesthetics." Wang believes that anything worth designing is worth designing beautifully. Combining problem solving and creative design becomes Artful Design. The aesthetics of Artful Design is a multidimensional approach to design that incorporates material, structural, interactive, emotional/psychological, social, and moral-ethical considerations. The focus is on where the human meets technology, and how that technology demonstrates both its own purpose, but also is aware of how it situates the user's purpose. Wang believes that design needs to have a humanist dimension, an ethos, a conscience. The social dimension of music-making is what appeals to me most in my practice. Therefore, this approach to design, one that focuses on the human using technology, is one that greatly appeals to me.

To me, Wang's focus on the space in which humans meet technology is an expansion of Dourish's concepts of *space* and *place*, which I discuss in Chapter 1. While *space* is the physical configuration of objects and their relationships, *place* is the social environment in which they are

framed. Throughout *Where the Action Is*, Dourish emphasizes the idea that meaning created during the act of actually using the design. This is compatible with Wang's approach: "Design is never complete until it accounts for the person experiencing it. The choices we make in design can compel a user to take action or influence the user's thinking. It is the art of making useful things that also make us feel, and feel human" (Wang, 46).

The form of *Artful Design* is itself a demonstration of Ge Wang's design philosophy. While it is technically a design textbook, it is in graphic novel format, with bright pictures, and charts. At the end of every chapter, Wang gives a set of etudes that allow the reader to apply theory to practice.[128] One of the etudes from Chapter 1 of *Artful Design* stood out to me: "Add aesthetics to something that doesn't seem to need it" (55).

An important concept in Wang's approach to design is the concept of *Inside-Out Design*. design works outward from available technological ingredients, considering their possibilities and constraints. I see a parallel between Wang's possibilities and constraints with Dourish's *artifacts*, De Souza's discussion of *affordances,* and Östersjö's description of *effectivities* (the process of discovering affordances). Wang's *Inside-Out Design* rejects *blunt transfer*, which is the direct *porting* from one domain to another. *Porting* would be akin to a literal translation between two languages, or an *instrumental transcription* that does not consider the nuance involved in changing domains.[129] Wang's approach to design embraces the medium that you are designing in. Like Dourish, Wang also describes this process as *appropriating* technology, which

[128] In notated Western classical music, etudes isolate one or more playing techniques as a self-contained practice material that is somewhere between a purely technical study, and a piece of music. I find it interesting to see how the concept of the etude applies to software design. As a performer, I greatly enjoyed this aspect of the text.
[129] Transcription in notated classical music refers to the process of adapting a piece of music originally written for one instrument (or voice) to another one. Successful transcriptions rely on knowledge of how the affordances and techniques of the source map onto the target, sometimes requiring the transcriber to adapt or modify the materials to fit the new instrument. In jazz, transcription refers to the act of using aural skills (listening) to notate or learn by ear something played by a different musician (who is sometimes playing on a different instrument). There are many parallels between the concepts of porting and Wang's Inside-Out Design and musical transcription.

then “imbues a sense of play and delight.” Wang embraces the approach of form inspiring function when transforming physical into the virtual.

In *Where the Action Is*, Paul Dourish discusses how designers need to think about their designs on multiple levels, and how users must be able to disengage and reengage in different ways. In Chapter 3, Ge Wang shares a similar thought:

> The artful designer is a planner and builder with aesthetic sense, able to shape technology with the understanding that we are multi-sensory, multi-modal creatures who experience the world through sight, sound, and interaction. We are aware of this “multi-ness,” make use of it, appeal to it, and ultimately fashion entirely new things out of it. (Wang, 56)

The multi-ness that Wang describes enables the development of flexible designs that account for different use cases. Wang believes that every part of the design’s form and how the components function contributes to the design’s personality and nuance. I was influenced by these ideas as I developed my own approach to designing my collaboration with Theocharis, the methodology for *PrismaSonus*, and the analysis techniques I have applied throughout my discussion.

3.2.1 Feedback and Constraints

In Chapter 1, I discussed how performers rely on feedback to play their instruments. In *Artful Design*, Wang describes how feedback is the mechanism by which someone learns about the personality of an interface. Feedback is what creates a feeling of satisfaction within design. I think what he means is that when action and feedback (and controls) are properly coordinated, using a digital design feels satisfying. Consider how successful video games are often described

as having "satisfying controls." [130] Here, Wang points out the importance of designing with the intent to create this satisfaction.

Because there is a lack of tactile feedback on the flat touchscreen, the visual language of design becomes a very important element (§3.1). This connects with my discussion in Chapter 1 of how different instruments manage feedback differently, and of re-mapping instrumental topographies. For Wang, the visual language of a design is what creates the expressive connection to the user (§3.2). Wang suggests designers to think using expressive verbs. To me, this highlights that Wang is focused on the actual act of interaction (§3.3). Visuals can enhance physical interactions by providing meaningful feedback for users (§3.6). For Wang, good design prompts users to experience substance, and not the technology itself. Good design uses the medium to highlight a narrative, while hiding the medium itself (§3.7). This is very similar to Dourish's distinction between *ready-to-hand* and *present-at-hand* interactions which I discuss in Chapter 1. For Dourish, when we act *through* an object, technology disappears from our immediate concerns (109), which is compatible with Wang's approach.

I first encountered these ideas after my first collaborations with Theocharis, but before *PrismaSonus/Morphés*. As I reflect on our work, I recognize how impactful visualizing the design of my collaboration (including its logistical, practical, and philosophical elements) was on its development. Ge Wang believes that visualization yields understanding. It helps the designer comprehend the design's inner workings by forcing them to understand their own work (§3.10). The elements of a project should be arranged in a way that allow the user to understand their

[130] Continually refining and improving my awareness of flute technique is a deeply satisfying process. As someone who enjoys other tactile processes away from music (including video games and cooking), I have noticed that I seek out similar dynamics between action and perception in all my activities. I have found that by analyzing what elements of interaction I find to be satisfying away from my instrument, I can seek out new spaces for exploration when I return to my musical practice. I am not unique in this, as many musicians throughout history have expressed the inspiration they gain from extra-musical practices.

purpose and relationship to each other (§3.11). Visualizing the elements of a project was a big step towards me defining the "why" behind my contributions to *PrismaSonus*.

In addition to underscoring the importance of visualization as part of the project development process, Wang discusses the how designs should invent *artificial constraints*, which connects to Dourish's discussion of how designers communicating a set of constraints for the user. As discussed in the previous section, Dourish sees constraints playing a key role in establishing usability. Wang defines constraints as the underlying rules that define how a system works, giving it shape, and ultimately specifying how a user engages with it. Constraints are what makes a system useful, safe, fun, and interesting. Furthermore, they provide the basis for creative agency (§3.13). Here, Wang takes Dourish's theoretical ideas and applies them directly to game design, relating the idea of constraints to rules in a game.[131] I think what Wang means here is that constraints give a user the ability to work through a design, which connects to Dourish's idea of meaning being created only after a user (or community of users) works with a design.

Another important element from *Artful Design* that inspired the collaborative design of *PrismaSonus* is the idea of feedback loops, specifically the role they played in both our exploration of microphone placement, and of the iterative process we used to record and analyze our sample library, something I will discuss in Chapter 4.[132] Wang suggests designers should "Savor Strange Design Loops" (§3.14), by *constructing* feedback and creating "recursive

[131] Wang connects with what De Souza says about instrumental affordances, which I explore in Chapters 1 and 2. I discuss De Souza's analysis of how habit and technique allow performers to exercise their agency. I think it is interesting to see Wang bring up the role of agency in interactive interfaces and game design.
[132] In previous chapters, I discussed the way feedback guides instrumental performance (using language from Jonathan De Souza), and how altering feedback pathways changes a performer's relationship to their technique. This influenced how I approached using microphone placement to alter feedback, which I will discuss in Chapter 4. In that case, feedback was something created through the process of interacting with an instrument. Ge Wang is referring to the way designers intentionally *create* feedback loops.

connections between elements," and by "[blurring] the distinction between medium and message, using some intrinsic property of the design." This idea intentionally building a connection between the independent elements by clearly defining their relationship served as a cornerstone of *PrismaSonus*'s research method, and of *Morphés*'s artistic development. Wang's approach to creating design loops connects to what I discussed earlier with how Dourish states that designers should simultaneously think on multiple, interrelated levels.[133] Wang writes that "strange design loops encode and enact notions of self-reference, self-reflexivity, feedback, recursion, paradox....[strange design loops] arise as uncanny connections between form and function, where elements in concept and elements in actuality are in conversation" (§5.1). Wang acknowledges how feedback loops are a dynamic process, and that "we are constantly evaluating the results of our actions." Synthesizing De Souza's idea of instrumental feedback with Wang's concept of feedback loops influenced my approach to exploring flute technique, microphone placement, audio analysis and visualization, spatialization, and ultimately live performance.

3.2.2 Design Enables Interaction

One idea from Ge Wang's *Artful Design* that stuck with me is that he believes computers should be used to create experiences that are not possible without them (§4.5). To me, this means that the designer should embrace the medium in which they are working in, instead of trying to emulate a different medium.[134] Wang goes further by stating that "just because something can be

[133] This also connects with De Souza's discussion of the binary between technology determining action (technological determinism), versus action being projected onto technology (voluntarism). For further discussion, see De Souza pp.51-52, who presents ecological perceptual theory as a way to avoid this binary perspective.
[134] At the time I first encountered these ideas, I was already considering ways remote music education could shift from trying to re-create the in-person experience, to instead embracing the unique landscape afforded by this tech-enabled space.

designed does not automatically make it interesting" (§4.10), and that interfaces are a "membrane of interaction" that enable the encounter between human and technology.

As I considered ways to invite technology into my performance practice and collaborations with composers, I synthesized the approaches offered by Wang, Dourish, Östersjö, and De Souza into a method that would guide the practical, logistical, and artistic decision-making process of *PrismaSonus*, as well as the documentation and analysis methods. All of these artists, technologists, and thinkers are focused on the way humans meet technology, and are interested in the communicative function of design. Ge Wang summarizes this approach by reminding the designer to be "cognizant of situations in which it is essential to design the human into the loop. Interfaces ought to extend us, make us feel a sense of embodiment…giving us new hands to interact with the world around us." I considered the ways technology (in the form of microphones, audio analysis software, etc.) could give me *new hands* to collaborate with my instrument, my listening, my collaborator, and my audiences.

The emphasis on the social power of design connects to what I discussed in Chapters 1 and 2 about the role of intersubjectivity when developing communication with a collaborator. As Wang puts it, designers should design for human connection (§7.1) "From one's self outward to the sum of humanity, there is a continuum of familiarity in how we relate to another person" (§7.2). A performer's instrument is an extension of "one's self," and is the pathway through which I communicate with a composer. Therefore, my exploration of technology begins with designing the relationship between my instrument and technology. Wang believes "it is not technology that determines the quality and meaning of those social interactions…it is entirely up to the people in them." Similar to what Dourish says about how designers are not there to define interaction for the user, Wang believes that designs should provide users with a medium for

interaction, and then get out of the way (§7.2). Designers should ask themselves whether their designs enrich the activity. Do they elevate the user?[135] Wang reminds us that designers should be mindful of the way their work impacts the user. "The heavier the touch of the design, the more responsibility the designer bears in shaping the result" (§7.4).[136] As discussed previously, the use of objects alters the user. Here, Wang connects this to the use of interactive designs:

> There are implications beyond the utility and surface novelty of technology. These affect us beyond their intended purpose, leaving us touched and altered. Deliberate or not, the result of an encounter with technology is always an aesthetic, but its meaning lies not in the names, or the objects, but in their significance to us, like the experience of music or poetry. To design beautifully is to seek a kind of truth — of technology, and also of ourselves. To design artfully is to imbue a certain authenticity and poetry into our creations — about who we are, and who we want to be. (§8.1)

This approach of combining awareness and analysis really speaks to me and demonstrates to me that beneath all the practical advice technologists like Ge Wang offer, there is a deeper level of meaning that remains undefinable. As a performer approaching technology, I recognized the ways my technical understanding of the design of music connects to my own artistic authenticity.

In Chapter 1, I discussed how objects create interaction, enabling us to experience the world around us, and shaping our perception of it. When virtual objects are created as part of interface design, it is crucial to be aware of the way their presence mediates communication. Wang offers designers several prompts to ask themselves as they make design decisions (§5.18):

- Does the end-product justify the technology?
- Does it do at least one thing that can be achieved by no other means?
- Does the design use the medium to support the right interplay between technology and humans?

[135] Perhaps "elevate" refers to whether or not the design enriches the user's ability to communicate with other users or strengthens the ability to relate to another person (or themselves, the world around them, etc.).
[136] I am curious about the equivalent of this within compositional pedagogy. What role does "responsibility" play within the compositional process? In electroacoustic music with complex electronics, how does the design of software (in the case of patch-based electronics) shape the result? How does this mediate communication with a performer? These are all questions I asked myself in preparation for my project with Theocharis.

What I appreciate about this design philosophy is that Ge Wang is aware of the impact that designs have on humans. As a flutist exploring electroacoustic music and software design, I extended Wang's questions to a set of questions that would guide my own work:

- How does the inclusion of technology influence my relationship to my instrument, my listening, and my artistry?
- Does it augment or obfuscate an element of my technique?
- Does this technology extend my technique in a way that is impossible without the inclusion of it?
- How do constraints built-into the technology create new resistance for me to work with, and how does it influence the way I interact with my instrument?
- Finally, how does it alter the way I communicate with my collaborator, and how does it influence my role within the collaborative process?

Another good reminder from Wang that impacted me is his discussion of gamification in design. Wang believes that play is essential to design because it is an integral part of human life.

> Play is an essential aspect of artful design, because it is an integral part of human life, having everything to do with purpose and a deep commitment to activities that have no extrinsic purpose. Play is about engaging in an activity for its sheer intrinsic value — its design entails the crafting of such internally meaningful experiences. It is psychology in motion — how we set the conditions to motivate specific behaviors and induce certain mindsets in the player. We design play into pure games and toys, and can incorporate game-like elements into practical contexts.

Recall how Dourish believes that designers must give up control to their users. Here, Wang emphasizes the fact that games require interaction and active participation. The designer "must relinquish significant curatorial control to the player." Games cede control to the player, just like instruments (§6.7). In my own flute practice, I balance methodical and playful approaches to exploring the instrument, especially when learning new techniques.[137] I considered how to apply gamification to my exploration of electroacoustic music. Wang believes games can be applied to non-game contexts. For example, in music education, gamification can be used to overcome

[137] In many languages, "play" in both senses (games and playing an instrument) is the same word.

habits, or develop new ones §6.13).[138] As Wang points out, gamification can lead to what he describes as a *pure play* state, which he describes as being *in the zone*, also known as a *flow state.*[139] Gamification in design allows users to balance goals and challenges with rewards, provide a sense of satisfaction, and set the conditions for flow (§6.17). "Gamefulness" and fun do not have to come at the expense of expressiveness—and vice versa (§6.18). I would go on to seek out these *pure play* states in my work with Papatrechas as we developed our project, and believe this is another key element that led to the success of our communication.

3.2.3 Humanity, Communication, Education

Ge Wang advocates for a nuanced integration of technology and humanism, suggesting that the essence of art and design transcends mere problem-solving. He argues that in the arts and humanities, the solution is not to resolve issues but to deepen our understanding and expression as human beings. This perspective challenges the solution-centric approach to engineering.

> In order for us to truly move forward, the narrative of our educational and technological institutions must evolve — from a primarily need-driven and problem-solving narrative to a value-based, self-defining (and still problem-solving) ethos. As an engineer myself, I obviously champion problem solving, but a core issue with the solution-centric narrative is that much of the humanities and arts (and life itself) is not about solving problems (e.g., music, philosophy, history aren't 'problems to be solved'). Rather, they are about ever more fully understanding and expressive ourselves as human beings. At the same time, I, for one, believe engineering is capable of more than 'simply' solving problems. Through how we shape the world, we can speak authentically to who we are (not

[138] Wang brings up the example of playing something and then raising the metronome speed. Gamification is a big part of music education. I recently asked my flute student (who has piano experience) to imagine her hand playing a piano, while singing the pitches on note names. I used this exercise to allow my student to access the habits she had with the piano, because of the difficult she was having with flute fingerings. But on a more fundamental level, what I was doing was introducing an element of gamification that increased my student's enjoyment of playing.
[139] For more on flow states, consider *Flow Experience: Empirical Research and Applications* (2016), a collection of recent research on the subject from a wide range of authors and disciplines. Also consider the work of Mihaly Csikszentmihalyi (1934-2021), seen as the first scholar to recognize and define flow within the field of psychology, as described in *Flow: The Psychology of Optimal Experience* (1990). I am interested in the way this approach to performance analysis links the perceived challenges of a given task with one's perceived skills. The ideal balance of the two leads to a state of confidence in which perception and action blends together (flow state).

> unlike art and the humanities). The ethos of the humanist engineer ties this together!" (§8.15)

As I considered ways to incorporate technology into my performance practice and collaborations, I considered ways it can facilitate a more meaningful co-habitation of the creative space. This approach necessitates holding space not simply for the technical aspects of instrumental performance and music technology but also for the intangible moments of understanding that emerge as a result of creating shared experiences with a collaborator. I began to see the way Wang's human-centric approach to technology synthesized with the conceptual frameworks offered by the other authors I had been exploring. Reflecting on Wang's philosophy, I recognize its profound influence on my approach to incorporating technology into my collaboration with Theocharis Papatrechas. It suggests that musical collaborations, much like designing technology, should transcend functional objectives to embrace the expressive dimensions of human experience. By viewing technology as a partner in the creative process rather than a means to an end, we create new pathways for exploration and creativity. This approach not only shaped the methodology of our project but also deepened our engagement with the music itself, highlighting the interconnectedness of technology, art, and human expression.

Wang emphasizes that valuing the worth of things beyond their function is a core condition of being human, and that designing without a human-centric approach to aesthetics is no longer a viable path for the designer. For Wang, the designer must "evolve into a synthesis of a technological artist, a moral-ethical inventor, and a compassionate system designer" (§8.15). What stood out to me is how Wang sees "beautiful" and "sublime" design as not something that can be intentionally created, but as something that emerges as a by-product of a user's engagement with that technology.

> We can design for the sublime no more than we can design for beauty, for these are not features of products but consequences of experience, manifested through the gridwork of sense and cognition. Yet, when we design with intention, as we do in art, we can create things that invoke the sublime, that bring into focus a truth and a beauty despite our limitations and chaos. Design cannot forsake the practical needs of humanity, but it — no less than art — can transcend them, seeking beauty in the authenticity of things, reaching for something more than we are, while speaking to precisely what we are. Sublime design is design that understands us.

Ultimately, what influenced me the most in Ge Wang's *Artful Design* is the invitation to continually seek out more intention behind my design decisions, by synthesizing technique with a desired quality of interaction between me and my collaborator.[140] In order to develop my own design philosophy, I wanted to see how the practical and philosophical suggestions offered by Wang and other authors applied to practice. To do so, I conducted several case studies of artist-technologists, which will be the focus of the remainder of the chapter.

3.3 Jace Clayton

Jace Clayton is an artist and writer known for his work as DJ/rupture. I became interested in Clayton's work because of the way he explores how software is used to enable communication within and across communities. In his book, *Uproot: Travels in 21st Century Music and Digital Culture,* Clayton describes his vision of applying software design to communities that are outside of those who traditionally get attention of software engineers. I am interested in Jace Clayton's approach to software design, particularly his concept of "software-as-art." I see parallels between Clayton's approach to design with Ge Wang's philosophy outlined in *Artful Design.*

[140] Ge Wang's "Laws of Artful Design" provide a summarized approach to his design philosophy: "Anything worth designing is worth designing beautifully. Design is an act of alignment with our notions of the purposeful and the good. Design is the radical synthesis of means and ends. Design not only from needs — but from the values behind them. Design is the embodied conscience of technology. Design should understand us. What we make, makes us."

As I analyze Clayton's work, here are some notes to consider: What happens when software considers the communities that use it? What if by design, the software accommodates the culture and lifestyle of its users? How does decolonization intersect with computer music software design?

3.3.1 Auto-Tune and Communication

As discussed in Chapters 1 and 2, instruments mediate communication between performers and their instruments, performers and composers, and performers and their audiences. What happens when a piece of software mediates communication? Performers rely on feedback to guide their instrumental technique. How does the digital alteration of feedback affect performance?

Jace Clayton discussed the impact of Auto-Tune on music production. As he describes it, "the most important piece of musical equipment of the last twenty years is not an instrument or a physical object. It's a specialized piece of computer software called Auto-Tune and is now used on a staggering 90 percent of all pop songs" (26). What happens when human voice and software mix? What happens when the human voice is altered by software? How does this affect the perception of the voice?[141]

While earlier effects were applied evenly over source material, Auto-Tune actively responds to what it "hears." While in-tune notes will pass through unaltered, others might be radically different after processing. Corrective Auto-Tune often goes unnoticed by the artists themselves, other than the signature lack of vibrato on auto-tuned notes (29). There is a

[141] See Section 1.4 for an overview of the role feedback plays in mediating a performer's perception of their instrument, and Section 2.3 for a discussion of how instrumental alteration mediates communication.

conversation between different sources.[142] With Auto-Tune, the interaction itself creates an instrument. The dialogue between human and computer creates an entirely new object. Auto-Tune created something that did not have a physical equivalent, creating a new dimension of interaction with sound (30). In my opinion, this means Auto-Tune passes Ge Wang's test (as described in *Artful Design)*, of whether a piece of software creates something that does not exist in the physical domain.[143] Clayton argues that Auto-Tune has expanded the plane of interaction a performer (user) has with music (via an interface).

As discussed throughout this dissertation, I have been interested in incorporating technology into my existing acoustic instrumental practice. In Chapter 4, I will discuss how in my collaboration with Theocharis Papatrechas in *PrismaSonus*, we designed our work in a way to allow us to peel back layers of technology to return to the original, acoustic performance.[144] What struck me was that in his discussion of Auto-Tune, Clayton mentions how some artists do not even record an untreated version of their vocals, for example the rapper Lil Wayne. Clayton describes this as the "cyborg embrace" (29), and a "strategy for intimacy with the digital" (30).[145] Looking back, I recognize the way intimacy with technology has influenced my work. By connecting more closely with technology, I deepened my existing connections with my acoustic practice. The idea of using technology to augment intimacy will be something I will explore in more detail later in this dissertation.

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[142] In Chapter 2, I explore what happens when the act of instrumental alteration becomes the process of interaction between a composer and a performer.

[143] For further discussion, see Chapter 3, Artful Design, Design Creates Interaction. Also consider my discussions of De Souza's musical dimensions and Dourish's levels of interaction from Chapters 1 and 2.

[144] As I will discuss in the next chapter, we first created a sample library of flute techniques, which were then sampled and processed. We meticulously catalogued the samples so that we could return to the original, un-processed and un-treated version of the recording.

[145] Expanded quote: "Far from novelty, Auto-Tune is a contemporary strategy for intimacy with the digital. All this vocal negotiation is neither a fight with technology nor an embrace of it; it's more like glossy coexistence, a strange new dance of give-and-take. Quite literally, this is the sound of voice and machine intermodulating" (Clayton, 30).

Jace Clayton's analysis of Auto-Tune demonstrates how it combines the creativity, skill, and artistry of a human musician with technology. Some artists choose to hide the use of this tool, while others embrace it as a part of the process. There exists a wide range of use cases for Auto-Tune, from traditional approaches (using it to create a "better" version of an acoustic product), versus exploring the unique possibilities that its affordances provide the user, and the way it transforms the instrumental (or vocal) landscape.

3.3.2 Design is not Neutral

In *Where the Action Is*, Dourish emphasizes the fact that design cannot be neutral because designers make decisions on behalf of their users. In *Uproot*, Clayton focuses cultural background as an additional factor preventing neutrality. "Virtually all music software is made in the United States or Europe. These programs all tend to do the same thing, in varying amounts, and that thing defaults to a narrow concept of what music can or should be" (178). The similar cultural environment from which many designers come from "[reinforces their] blind spots and biases and, once widely distributed, play an active role in maintaining those assumptions" (178). Clayton's focus on culture as a mediator of design decisions enriches the foundational principles outlined by Dourish. Dourish emphasizes the fact that designers can avoid making incorrect assumptions about users will use their designs by remembering that *meaning* is created within communities of users, not by the designers themselves. While this cannot eliminate a designer's biases entirely, it does mean that in order to understand the impact of a particular technology, one must focus on how it is used by people, and not simply analyze its technical construction.

To demonstrate how the biases of designers influence the way communities of users create meaning, Clayton explores the way Auto-Tune struggles to interpret musical *melismas*, an important stylistic element of many non-Western vocal traditions, because of nuance involved in

distinguishing "between world-class melismatic pitch control and off-key drunken shouting."[146] To solve this, Dr. Andy Hildebrand (the creator of Auto-Tune) had to "encode into the software his beliefs about what constituted appropriate singing" (45).[147] In order to create the software, Dr. Hildebrand had to define boundaries for the user. These boundaries create tension when the musical understandings of the designer are different from the cultural context in which the design is used. Communities of users create new uses for the technology that could not be anticipated by its creator. I believe both Clayton and Dourish would describe this as the "meaning-making" process communities of users bring to technology. In some cases, interfaces are entirely ignorant to the specific musical needs of a community, necessitating the creation of new software tools increase a specific culture's visibility.[148]

In Chapters 1 and 2, I discuss the ways habits enable instrumental playing, and how performers can break free of habits for creative purposes by modifying their instruments. Dourish focuses on the mechanisms by which a designer alters a user's experience, and Wang suggests a design language that creates an optimal experience for a user. Clayton emphasizes the ways social and cultural dynamics influence the way users experience design. Throughout *Uproot,* Clayton emphasizes the huge creative potential that can be unlocked by expanding access to design to new communities, discussing the benefit of having software design occur far away from the traditional design hubs. What happens when the use of an electronic music tool occurs outside of the usual environments?

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[146] A *melisma* is a group of notes or tones sung on one syllable, and/or a melodic embellishment (Merriam-Webster). One of the key functions of Auto-Tune is that once it determines what musical pitch the singer is trying to sing, it can adjust the tuning of that pitch. However, in highly ornamented vocal traditions, the software struggles to determine what is primary pitch, what is the embellishment, and what is unstable vocal technique. The vocal traditions the designers or Auto-Tune were familiar with determined the biases they would introduce into the design.
[147] There is a parallel here with Paul Dourish's comments on the issues that arise when a designer creates an ontology for a user.
[148] The next section of this chapter will explore the work of Khyam Allami, specifically his *Leimma* and *Apotome* software for microtonal intonation.

3.3.3 High Tech / Low Tech

Technology is not always used in spaces it was initially designed for. When that happens, the work occurring outside of the environments anticipated by the designer is not always recognized at the same time or to the same extent. Jace Clayton spends a significant portion of *Uproot* exploring the use of Auto-Tune among Berber folk musicians in North Africa. He points out that these musicians began actively using Auto-Tune before T-Pain, who gained fame in the West for his extensive use of it in his music.[149] Clayton is curious what happens when high-tech software is used in low-tech music environments, and the effect of the democratization of music software.[150] Clayton describes an occasion where he saw Auto-Tune being used in a studio in Morocco. "The transformation of twenty-first-century music production from expensive hardware studios to a haphazardly democratic scatter of home computers has made it possible for bare-bones studios such as Moulouk to exist" (41).[151] Clayton's description of how Auto-Tune was used within this environment demonstrates the concept I explored in previous chapters of how communities of users *appropriate* design to fit their needs.

> The banjo…sets the reference note, the rest of the band tunes to the banjo, and the singer, days later, adjusts her intonation to fit the band. Auto-Tune then gets tuned—or rather, detuned—to whatever results. I say *detuned*[152] because in

[149] There is a well-known video from NPR Music's Tiny Desk Concert in which T-Pain sings without Auto-Tune. The combination of the intimate performance setting (NPR Music Office) with the intimacy afforded by stripping away technology (Auto-Tune) contributed to the popularity of this performance. At the time, most listeners had never heard T-Pain's unaltered vocals, many surprised at how good of a singer he was, leading to article titles like "People are blown away by T-Pain's singing voice without auto-tune" (UNILAD) and "Rapper T-Pain has a simple message for people who think he can't sing - shut up" (NPR).

[150] The emergence of low-cost and free audio software in the 90s and 2000s because of the massive increase in computer processing power (and resulting decrease in price) allowed people previously priced-out of music production to enter the market, as well as allowing for more mobile and compact audio production environments.

[151] I recognize here that as a DJ whose musical practice is primarily with electronic music, Clayton's own bias leads him to describe music environments based on their relative technological complexity. For me, this is interesting to notice, because the vast majority of my music experience is in acoustic performance settings in which there is little/no technology involved.

[152] In Chapter 2, I discuss Jonathan De Souza's analysis of how Kurt Rosenwinkel intentionally detuned the strings of his guitar for creative purposes (breaking the action-sound mapping of his technique). In this context, tuning (and detuning) relates to an entirely different creative process.

> studios across Morocco, I watched time and again as the people who used Auto-Tune the most relied the least upon its interface. The software offers many ways to customize its effects, including settings called Arabic and Pentatonic—registers that wouldn't be hard to tailor-fit to Berber songs. Nobody bothers with any of that. Instead, people click a single knob—Pitch—and twist. Ait Bouzid and others simply listen to the vocals and adjust the software on the fly, using broad, impressionistic settings until things start to sound the right kind of wrong. (Clayton, 48-49)

The designers of Auto-Tune include settings like "Arabic" and "Pentatonic," but musicians from this community do not see a use for these settings. What does it even mean to have an "Arabic" knob, considering the fact that North African music uses different scales that could not be accommodated with one preset? [153] The cultural assumptions made by the designers of Auto-Tune do not align with the needs of users of Auto-Tune: Were they meant for musicians at the Al-Maarif Studio, or for someone in Berlin or New York City? Dourish and Wang both use the term *appropriate* in the sense that communities of users *appropriate* a design to fit their community's needs. Here, the culturally appropriated preset settings built-into Auto-Tune with the "Arabic" and "Pentatonic" settings are ignored, and the musicians *appropriate* the design by using the single pitch knob. The way that the designer planned out the use of the interface does not necessarily align with the way that a community will use the design. It is incorrect to assume that every community will use a design the same way. Who were these preset settings intended for? Later in *Uproot*, Clayton points out a similar situation with Soulja Boy's use of FL Studio, where an entire song was made using default software presets.[154] Not all users require a high degree of modification built-into the software that they use. That means decisions made by designers who create those software presets has a great effect on the result.

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[153] *Maqams* are collections of pitches (similar to Western scales) used to guide composition and improvisation. They contain *microtones* (intervals narrower than a Western half-step), resulting in fine tuning distinctions (Encyclopedia Britannica).

[154] Fl Studio (formerly known as FruityLoops) is a digital audio workstation (DAW) used in electronic music production.

3.3.4 Auto-Tune and Gender

Later in his discussion examining the intersection of technology and culture in music production, Clayton discusses the nuances in how Auto-Tune is employed across different genders. In the studios he visited, female voices were subjected to more extreme modifications, amplifying traditional perceptions of femininity within the cultural context of Berber pop music. Clayton Describes the implications of this technology on gender representation as follows:

> Auto-Tune activates deep-seated and conservative ideals of Berber womanhood by making those high-pitched voices cut even more keenly. The software amplifies old ideas of the rural and the feminine. Music made with it enjoys widespread, lasting popularity. Shockingly contemporary sonic radicalism grafts onto long-standing ideas about gender. The processed female voices in Berber pop are unavoidably spectacular, yet their pleasures are not precisely of the flesh. With the software, one can simultaneously flaunt that rough-and-pure womanhood while preserving its modesty via a synthetic veil. The cyborg sheen makes bodies less carnal. This hiding and showing at the same time is part of how Amazigh Auto-Tune functions culturally and sonically. It parallels the main Koranic arguments for the veil: 'so that they may know who you are' and 'to hide your charms from their eyes.' (Clayton, 54-55).

In my analysis, I argue that the cultural and musical practices that preexist within a community significantly influence how technologies like Auto-Tune are utilized. As discussed in Chapter 1, the context and framing within a community shape the development of musical interpretations. A key question that arises from Clayton's observations is whether the unequal application of Auto-Tune across genders represents an intentional musical decision or if it is rather a manifestation of deep-seated social and cultural conditioning. Clayton seems to suggest that the use of Auto-Tune serves as a cultural filter, imbuing the technology with meanings that are specific to each community's unique cultural landscape.

This indicates a dual function of technology: while it imposes certain cultural assumptions, it also allows communities to reinterpret these assumptions through their specific uses. The critical tension that Clayton illuminates—between technological imposition and

community interpretation—underscores the complex interplay between technology, culture, and gender in music production.

Clayton further explores this interaction by highlighting how the Amazigh community uses Auto-Tune not just as a tool for vocal correction but as a medium for cultural expression. He notes:

> In pushing the American software to the limits with such dedication and flair, the Amazigh have elevated the struggle between human and machine into artistic expression, with all the history of how hard it is to be a woman, here or anywhere, embedded in it at unsettling angles. Auto-Tune sound-tracks the twenty-first-century Amazigh condition, that of a bucolic nation made real only in its digital diaspora. Villagers subsisting with a minimum of state infrastructure (tax inspectors yes, phone lines and garbage pickup no, in many cases) suddenly enjoy smartphones linked to satellite Internet. Ancestral ties strengthen—on Facebook. Auto-Tune is a compelling call-and-response between pastoralist and robot, although nobody's steady enough to point out who is who (Clayton, 56).

This passage vividly illustrates how Auto-Tune, a piece of technology originally designed for subtle pitch correction in Western pop music, becomes a tool for expressing complex socio-cultural realities in a completely different context. Jace Clayton captures a specific instance of transformation in how technology is engaged by a community distant from its origin.

It is apparent to me that Clayton would align with Dourish's perspective that technology acquires meaning only through its use within a community. The way a community employs technology can fundamentally alter its impact, imbuing existing tools with new significance. This notion challenges us to consider not just the functional capacities of technologies like Auto-Tune but also their potential as tools that can reshape and redefine societal narratives.

3.3.5 Frustration with Existing Designs

What are the implications when software fails to accommodate the unique needs of its users? Clayton provides a compelling anecdote from a jam session with Abdelhak Rahal, a

violinist from Fez, Morocco. He observes a critical mismatch between his technology-based electronic music practice, and Rahal's violin playing, as Rahal's rhythm appeared "off" against Clayton's computer-steady, 95bpm, 4/4-time FruityLoops beat.[155] Clayton reflects, "…my beat was suffocatingly, unbelievably square to Abdel, steeped as he was in the robust rhythmic diversity of Maghrebi music. We may have thought similarly, yet out 'default settings' were so far apart as to be almost incompatible" (Clayton, 185). This clash highlights an ontological mismatch between Rahal's fluid, complex rhythms and the rigid digital framework provided by the software.[156]

Clayton's experience underscores the challenges that arise when software design does not account for the ways fundamental concepts like pitch and rhythm manifest in different musical cultures and contexts. He expresses his frustration, stating "I didn't use software, I fought with it. I got a pretty good idea of what values the good programmers in Berlin and Silicon Valley believe are important. Their assumptions became my roadblocks. I kept a running wish list of what I wanted in my musical tools. I began to wonder about other musicians from traditions not represented in software. What concepts would they be most excited to bring into the digital?" (Clayton, 186). This sentiment echoes Paul Dourish's criticism of designers attempting to define an ontological model for users without a deep understanding of their unique cultural and practical needs.

Realizing the limitations imposed by conventional software, Clayton advocates for a tailored approach to music software design—one that prioritizes the specific needs and

[155] Beat or loop-based electronic music programs like FL Studio place tracks on a grid (in this case, time at 95 beats-per-minute) quantizing rhythm within a specific time signature (4 beats of quarter-notes per measure, or 4/4).
[156] Without a recording of this particular jam session, it is hard to determine what exactly was causing the issue. Was it that Rahal's rhythm would fluctuate slightly relative to Clayton's beat, or was Rahal switching between time signatures that did not line up with the grid of the accompaniment?

preferences of its users over the proliferation of generic features. “I didn’t want more choices. I wanted fewer, better choices. I wanted the entire experience of using my software to give what musicians call a vibe. I could do that by incorporating different defaults, different assumptions, different blind spots. Virtually every software update claims new features. Rather than focus on making new things possible, I wanted to rethink ‘old things” (187). This approach emphasizes the importance of redefining software to better align with situated musical practices, thereby enhancing its relevance and usability.[157]

3.3.6 Cultural Invisibility in Designs

In Chapter 1 and 2, I explored how the design of technology sometimes fails to account for all potential uses of it. This issue becomes particularly pronounced in Jace Clayton’s critique of how Western-oriented software systems often struggle to accommodate polyrhythms, an important rhythmic element of many non-Western musical traditions. Clayton describes polyrhythms as:

> [Polyrhythms] occur when two or more irreducibly distinct rhythmic points of view (points of hear?) coexist within a single song. That’s how I’d describe the phenomenon — others might use a totally different framework to explain polyrhythms, and this plurality of understandings is part of what makes them so stubbornly human, and so resistant to digital encoding. Which is precisely the magic. Computers can’t handle paradox or ambiguity, and polyrhythms are built from the stuff. Their notoriously subjective take on time and pattern exists smack in the middle of one of music software’s many blind spots. Polyrhythms spring from an understanding of music, if not life itself, as shifting relationships of patterns, each with its own internal logic and timing (Clayton, 181).

This passage illuminates the mismatch between rhythmic fluidity and multiple perspectives of polyrhythmic musical practices and the rigid, quantized frameworks of most music software,

[157] For more on the concept of usability, see my discussion of Paul Dourish’s Foundation of Embodied Interaction in Chapter 1. In it, usability is defined as the way that a system reveals its purpose to the user. The user then develops an understanding of the meaning of objects and the consequences of actions within the system (132-133).

which often fails to capture the essence of these complex patterns.[158] Clayton further elaborates on the technical limitations faced by these software systems in accommodating such rhythmic diversity:

> So we're faced with a structure that forms the backbone to so much delightful music, especially in sub-Saharan Africa, that is illegible to the machinery. The closest thing to polyrhythmic compatibility in music software is the notoriously unfunky technical work-arounds that aggressively measure out the beats, which may be fine for math majors, but not for people like me, since it's not at all how folks from those traditions conceive of it (181).

Here, Clayton critiques Western commercial music software's inability to translate the culturally embedded understanding of rhythm into its digital framework, highlighting a significant cultural disconnect. This critique ties back to Paul Dourish's discussions in *Where the Action Is*, where he argues for designs that accommodate multiple levels of engagement, allowing users to interact with software that are meaningful to them.[159]

Clayton's reflections are particularly poignant when describing the *Zar* ritual ceremony he experienced in Egypt, which emphasized the power of live, interlocking rhythms.

> …as I watched three women pound out interleaved patterns on a variety of frame drums, I understood how it is said to chase out malevolent spirits. Their drumming pivoted between complexity and simplicity, never quite resting in either end. The room's energy crystallized. When I focused on the drum line any individual woman played, I found it easy to follow, yet the sum total of interlocking parts left me wondrously confused: I couldn't count it out (Clayton, 181).

[158] Some music software solves the issue by measuring out and dividing the beats mathematically. As with many other concepts, computers often encode materials in a way that is different from how humans understand it. What happens when the designers of the software think about rhythm in a fundamentally different way from how performers think about it?

[159] In my own brief exploration of interactive tools for working with polyrhythms, I have found Ableton Live's ability to incorporate custom-built objects in its Max for Live tools to be extremely useful.

Clayton worries about the digital erasure of such traditions given the existing software limitations, and ponders the role new software might play in connecting these cultural expressions to a broader, digital audience:

> Of course, software could never replace Zar's subtleties; it's as much a culture as a musical genre. What software could do is spark a connection between what these women create and what a younger, more wired generation could make of it. Software functions as an archive of what we want to be possible at any moment; wouldn't it be nice to see what happens when we try to get stuff like *zar* in there? (Clayton, 182).

Clayton is not seeking to replace an existing tradition with a digital format, but instead wonders what would happen if those interactions gain a space within the digital realm.[160]

Clayton speculates about a "Zar 2.0," a hypothetical future in which the perfect piece of software is created that will connect this existing culture to electronics. He believes that what limits this from happening is that so often the most talented software programmers go into the most lucrative fields, so there remains a lot of untapped creative projects. Clayton's perspective provides a compelling argument for the need to expand the digital musical landscape to include traditions that have historically been marginalized by the dominant paradigms of software design. His call for broader inclusion underscores that importance of creating software that is not only technologically innovative but also culturally responsive and inclusive.

> …this is why we need programmers from far-flung corners of the globe making digital instruments to share. To strike up intergenerational conversations. To think about what a digital environment that respects the wisdom bound up in *zar* would do differently. To give some of the incredibly varied methods people use to make music a fighting chance in our electrified present. To keep things culturally polyrhythmic (Clayton, 182).

[160] There are parallels between his approach, and what Ge Wang outlines in *Artful Design* about making sure that software design enriches what already exists in the real world, as discussed in the previous section of this chapter.

By widening the perspective of programmers, software design becomes a more culturally engaged practice that acknowledges, respects, and amplifies the diversity of varied musical traditions.

Clayton's reflection on the history of electronic music as a history of "misusing" tools further emphasizes the creative potential in approaching technology from unconventional angles. In his analysis, Clayton highlights how some of the most iconic sounds in electronic music have resulted from pushing equipment beyond its intended limits[161], suggesting that there is much to be gained from exploring and embracing the "wrong" ways to use technology.[162] This approach encourages experimentation and innovation, allowing for the emergence of new musical expressions that challenge and expand our understanding of what is possible within the digital domain.

3.3.7 "Software-as-Art"

Jace Clayton's *Sufi Plug-Ins* for Ableton Live represent a response to the limitations he perceived in electronic music software. Integrating North African maqam scales with their quarter-tone tuning, these plug-ins challenge the constraints of grid-based electronic music software, embedding cultural significance into their functionality. They embody Ge Wang's design philosophy as outlined in *Artful Design*, where technology not only serves practical purposes as a utility but also acts as a medium for expressive art.[163]

[161] "One of house music's most iconic and alien sounds is the 'acid' squiggle, a slithery earworm that leaps out of a Roland 303 drum machine pushed beyond its limits" (Clayton, 183).
[162] Clayton wants more folks to "wield those [software and hardware] tools incorrectly and blow our minds. More forks in the road, more left-handed turns. Give me new ways to be wrong" (Clayton, 183).
[163] "Riddle and tool, provocation and dream. Why shouldn't software be able to be all these things at once?" (Clayton, 187).

Clayton describes the *Sufi Plug-Ins* as being between "art provocation and instrument," aiming to serve as both practical music production tools and as provocations that challenge embedded cultural assumptions in software design. The interface, which features Tifinagh script and Sufi poetry, counters the "grimly efficient" and "macho visual environment" of typical software plug-ins (187), reflecting on the inclusivity of design aesthetics.[164]

These plug-ins include virtual keyboard synthesizers tuned to specific maqam scales. As Clayton puts it, "you can play all sorts of amazing music on these scales, from Umm Kulthum classics to Emirati pop, but you can't use them to perform Beethoven or Rihanna."[165] Clayton has created what Dourish describes as *artifacts* in the design, built-in limitations that the user pushes against. Another parallel is with Wang's emphasis on encouraging *play* within design. Instead of presenting things clearly (or efficiently), Clayton was interested in creating a playfully frustrating experience of working with the interface. By designing an interface that is intentionally less user-friendly, Clayton engages users in a unique way, encouraging them to explore sounds guided more by their ears than by visual or numerical feedback.[166] The playful frustration induced by the *Sufi Plug-Ins* nudges users towards a more intuitive and exploratory interaction with music.

The design of these plug-ins raises intriguing questions about their intended audience. While users familiar with synthesizers will eventually find their way around the interface, there exists a deeper layer of meaning encoded into the design that can only be understood by certain users. Instead of labeling knobs with what they do, he labels them using the Tifinagh script of the

[164] This connects with Wang's emphasis on the need to reclaim humanity within digital designs.
[165] Clayton is emphasizing the distinction between North African and Middle-Eastern music written using quarter-tone maqams, and Western classical and pop music written in twelve-tone, equal temperament music (tuned to the black and white keys of the keyboard).
[166] This approach resonates with De Souza's analysis of Kurt Rosenwinkel's practice of de-tuning the guitar to disengage from overly intellectualized and habitual playing, which I discuss in Chapter 2.

Moroccan Berber language. This balance of artistic ambiguity and specific cultural references highlights a key aspect of Clayton's work: exploring how digital tools can bridge cultural gaps without diluting their unique musical heritages.

> There is some English, however: whenever you hover the mouse over a knob, button, or fader a "roll-over" infotext pops up.[167] Instead of saying something literal such as "volume" or "pitch," a fragment of Sufi poetry from twelfth-century Persia to today will appear, such as this one: "Here eloquence can find no jewel but one, / That silence when the longed-for goal is won." (Clayton, 188)

The *Sufi Plug-Ins*, by embedding layers of cultural and artistic nuances within their design, prompt us to consider who the intended users might be and whether the software needs to have a specific audience in mind.[168] This ambiguity is a crucial element of Clayton's design philosophy, challenging traditional notions of user-centric software by introducing elements encouraging creative exploration.

My analysis of Jace Clayton's work leaves open questions about the interaction between technology and cultural expression. This exploration sets the stage for a discussion of the work of Khyam Allami, a British-based Iraqi oud player who adopted a more targeted approach to software design. Allami's efforts are directed towards creating tools designed for his own musical community, addressing gaps left by existing software offerings. This contrast highlights a spectrum of possibilities in music technology, from Clayton's broad, exploratory tools to Allami's targeted interventions, each responding to unique needs and challenges within their communities.

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[167] A very useful feature of Ableton Live (also present in other software) is that users can learn about the role of virtually any element of the software by hovering over it. Max/MSP (and its open-source analogue Pure Data or Pd), an object-based visual programming language for music and multimedia has similar functionality, where users can click on an object and learn about its construction or follow an accompanying tutorial.

[168] Recalling the frustration Clayton experienced while jamming with Abdelhak Rahal, the violinist from Morocco: are these plug-ins for Clayton to use to connect with Rahal's playing, or for Rahal to use to connect to Clayton's grid-based, quantized music software?

3.4 Khyam Allami

Khyam Allami is a British-based musician and musicologist of Iraqi descent who is a performer of classical and contemporary works for oud.[169] Like Jace Clayton, Allami explores the communicative function of software design, yet their approaches subtly differ. Allami has developed *Leimma* and *Apotome,* two browser-based tools designed to facilitate digital experimentation and composition with non-Western tuning systems.[170] *Leimma* is a practical utility for creating and exporting scales to various software and hardware, while *Apotome* is a platform for generative music creation using the tunings created in *Leimma.*

Allami's design language in *Leimma* and *Apotome* uses a lighter hand compared to Clayton's *Sufi Plug-Ins*, which are explicitly described as "software-as-art." Allami opts for a clear, user-friendly aesthetic that emphasizes functional beauty and ease of use.[171] While both designers aim to blend utility with an artistic design aesthetic, their visual and functional approaches reflect different priorities. While Jace Clayton created the *Sufi Plug-Ins* to engage with a music-making community he was not himself a part of, Khyam Allami's software responds to specific gaps he identified in his own musical practice. Each is committed to the decolonization of electronic music software, challenging biases encoded in software design, and expanding the capabilities of digital music tools.

This section aims to explore how Allami's vision for decolonizing electronic music software intersects with Paul Dourish's principles of software design. By comparing Allami's

[169] An *oud* is a fretless stringed instrument, a type of lute.
[170] https://isartum.net
[171] In my opinion, Allami's design aesthetic also pushes back against the "grimly efficient" and "macho visual environment" of typical software plug-ins (Clayton, 187) critiqued by Jace Clayton. *Apotome* is a step-sequencer and randomizer that is very fun and intuitive to interact with, and I found myself inspired to go back to *Leimma* to try out new tunings.

methodologies with Clayton's, I intend to deepen my understanding of how designers can appropriate existing technology for specific needs of their community.

3.4.1 "Decolonizing Electronic Music Starts with Its Software"

Khyam Allami's frustration with electronic music software echoes a theme prevalent in Jace Clayton's *Uproot.* An article in *Pitchfork* titled "Decolonizing Electronic Music Starts with Its Software" captures Allami's journey. In 2004, disillusioned by the software's inability to "write the melodies that sounded like the music in his head," Allami was ready to give up electronic music. Raised in London by Iraqi parents and playing in punk bands growing up, he was exploring Arabic music for the first time. The problem was that the software he had access to could not accommodate the music's quarter-tones.[172] "It felt like the software was leading me somewhere that wasn't my intention, and I couldn't understand why that was," Allami reflects.

Faced with a software environment that failed to include non-Western musical tunings and was hard-wired to fit the needs of music based in European classical music theory, Allami experienced what he described as "fighting" against the technology, relying on complex workarounds to get the sounds he desired. This mirrors the way Jace Clayton discusses similar experiences of "hacking" technology to fit musical needs. Driven by frustration and the lack of suitable tools, Allami embarked on creating his own software, leading to the development of *Leimma* and *Apotome*—two browser-based music plug-ins tailored for his community's specific needs.[173]

[172] As discussed in the previous section, *maqams* are scales containing *microtones* (intervals narrower than a Western half-step), common in North African and Middle Eastern music.
[173] The processes that drove Khyam Allami to pursue creating his own software is an example who, using Jace Clayton's terminology, is creating music software outside of the environments in which it is normally done.

Allami's main critique of mainstream electronic music software is its inherent bias towards Western tuning systems. Although the MIDI[174] protocol accommodates microtonality, most of the software and hardware assumes the user will work within the 12-tone equal temperament (12TET) system.[175] Allami articulates a profound sense of injustice for global musicians compelled to conform their sounds to Western standards, which he argues strips their music of its cultural authenticity: "It's not that the music they make will sound 'more Western,' but it is forced into an unnatural rigidity," he explains. "The music stops being in tune with itself. A lot of the culture will be gone. It's like cooking without your local spices, or speaking without your local accent. For me, that's a remnant of a colonial, supremacist paradigm. The music is colonized in some way."

The default settings in music software—such as a 4/4 beat and equal-tempered tuning—imply a dismissal of other musical systems, or at least their devaluation, argues Tom Faber, author of the *Pitchfork* article. This perspective is aligned with Paul Dourish's assertion that software design can never be neutral. Dourish and De Souza might note that the preset configurations in music software enforce a specific ontological worldview and a rigid place-to-pitch mapping, imposing a narrow frame on the needs of users within diverse music-making communities.

3.4.2 Approaching Design

In his article, "Microtonality and the Struggle for Fretlessness in the Digital Age," Khyam Allami articulates the challenges faced when confronting the conventional approach to software design. "Persistence is a powerful word. It implies a sense of arduous effort – taken to

[174] MIDI is a technology standard allowing electronic musical instruments to communicate with one another and with computers (Britannica).
[175] I.e., the black and white keys of the piano, tuned to equidistant half-steps.

go against the tide. To be insistent, to go on resolutely in spite of opposition. It is markedly different from the idea of perseverance, which implies a sense of focus and determination in one's continuation but doesn't really communicate the effort involved."

Both Jace Clayton and Khyam Allami seek to address the systemic inadequacies in software that affect performers of non-Western music, often exacerbated by the limited resources allocated to these markets by software and hardware companies focused on Western markets. Allami recounts his experience with a "well-known" piece of music notation software that failed to support MIDI playback in non-12TET tunings—a seemingly simple feature absent because of assumptions made by software designers about a user's needs.[176] He shares a conversation he had with the company's senior product manager who admitted that playback tuning could not be modified, even though he could offer workarounds for notation requests.

> But when I asked him why, if these musicological needs were easy to accommodate through workarounds, they weren't made explicitly possible in the programming of the software, his answer was straight to the point: there was no market, and therefore resources weren't assigned to develop this kind of functionality at a time when the market was demanding other kinds of developments (Allami, 2019).

Thus, Allami found himself at a crossroads—accept the software's limitations or invest considerable effort into developing his own tools.

This scenario underscores a significant disparity between the perspective of designers and potential users in software development: the entrenchment of a "default" or "standard" mode makes anything outside the norm appear specialized or rare, even if it would serve as the norm for many potential users. Thus, designs that adhere strictly to Western musical standards inadvertently marginalize a wide array of global musical practices, illustrating a lack of

[176] The MIDI protocol supports re-tuning pitches, so allowing the user to encode specific tunings which are added to the XML notation file would not require a significant re-working of the software.

flexibility software platforms can have for diverse musical ontologies. Echoing Paul Dourish, this demonstrates how design is never neutral; it reflects and reinforces specific cultural biases, often at the expense of others.[177]

3.4.3 MIDI as a Creative Filter

In the early 1980s, the develop of the MIDI Tuning Standard (MTS) marked a significant evolution in music technology. Allami describes MTS's capability to finely tune electronic instruments with unprecedented precision—dividing the octave into 196,608 equal parts. This allowed for both octave-repeating and non-octave-repeating tunings with adjustments to the tuning of notes in real-time, potentially accommodating the harmonic intricacies of all music traditions.[178]

However, the promise of MTS was largely unfulfilled due to its inadequate implementation by hardware manufacturers. Despite its capability to offer extensive tuning flexibility, the actual inclusion of MTS in hardware and Digital Audio Workstations (DAWs) was limited. Manufacturers often excluded mechanisms for MTS to communicate effectively with DAWs, and most DAWs did not support the SysEx messages necessary for MTS adjustments.[179] This resulted in a situation where even if MIDI supported extensive microtonal capabilities, musicians were unable to utilize them uniformly across their electronic setups.

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[177] In *Where the Action Is*, Paul Dourish discusses the implicit biases embedded in software design, asserting that the digital tools we use are imbued with the values of their creators.

[178] "Developed together with composers Robert Rich and Carter Scholz, MTS allows the use of both octave-repeating and non-octave-repeating tunings to a resolution of 0.0061 of a cent, which essentially divides the octave into 196,608 equal parts. It also allows the changing of the tuning of one or more notes in real-time, and even gives the user the choice of changing all currently sounding notes, or only the new notes that follow the tuning change message. This is a phenomenal level of detail that covers all the melodic needs of all musics from across the world, past, present, and future" (Allami, 2019).

[179] "MTS messages are part of a MIDI data group called SysEx messages (System Exclusive). Most Digital Audio Workstations (DAWs) do not allow for SysEx data to be generated within them or pass through them, nor to go from them and out to hardware. The same applies for the majority of software instruments and samplers" (Allami, 2019).

Allami writes “tunings need to be set on an instrument-by-instrument basis in accordance with its manufacturers’ implementation, and very often on a preset-by-preset basis. This is totally counterintuitive and creatively inhibitive” (Allami, 2019).[180]

Furthermore, even when software and hardware support microtonality, they often fail to provide adequate documentation or contextual information about the tunings available. Pre-loaded tuning files lack explanations on their origins, intended use, or even basic operation details like the starting note on a keyboard, which Allami criticizes. This is similar to the effect the superficial and culturally unaware “Arabic” and “Pentatonic” presets of Auto-Tune discussed by Jace Clayton. Khyam Allami sees the superficial inclusion of microtonality more as a marketing tool than a functional feature, enhancing the perceived value of the software without genuinely integrating the musical practices it supposedly supports.[181]

Allami argues that this tokenization of microtonality not only perpetuates the exoticization of non-Western music but also reinforces a cultural asymmetry in the tools available for musical production. He highlights how this approach alters musicians’ perceptions and even their auditory experiences, stating “In the Arab world today, I don’t know a single musician that doesn’t use a tuner—set to the default [Equal Temperament]—to tune their instrument” (Allami, 2019). This means that the fundamental tuning of their open strings is set to

[180] A partial solution to this issue was invented by Manual Op de Coul, who created the digital tuning file format called Scala. However, this did not solve the issue of sending data to instruments in real-time (Allami, 2019). Individual software manufacturers have created tools for users to set tuning parameters within their projects, but even then the tuning only applies to that specific program.

[181] “That the inclusion of such capabilities is so tokenistic and counterintuitive is really a shame. Rather than allowing users to discover such wonderful worlds and experiment with them, tunings are treated like stocking-fillers, used to make the main gift seem bigger and more exciting, knowing they will be thrown aside within minutes of opening. More importantly, this “othering,” whether innocent or intentional, is detrimental on many levels” (Allami, 2019)

12TET and the way these musicians approach intonation is manipulated.[182] The default settings of Western-designed tuning software distort traditional musical practices, demonstrating the profound impact of software design on cultural expression.

3.4.4 Breaking free of 12TET

Khyam Allami's initial exploration of software development that breaks away from 12TET was through *Comma*, a Max4Live device designed for real-time tuning adjustments.[183] This tool enhanced Allami's engagement with maqam scales, which were now "unlocked in unlimited timbres, colors, and shades, allowing me to explore [them] in compositional and sonic ways I could only have dreamed of." Allami believes that "tuning should be about the celebration of difference—of cultures, ideas, methods, opinions, and tastes. It should also celebrate the choice of individuals to sound however they please." To do so, artists require music technology that can support this level of diversity of personal and cultural expression.

Building on the potential of *Comma*, Allami developed *Leimma* and *Apotome*—browser-based tools that are freely available, designed for maximum accessibility and integration into various settings. Allami specifically points out the educational potential of his software:

> For too long, the world's tuning systems have been presented as an academic concern—something to be studied rather than heard. Leimma offers an intuitive, tactile introduction for anyone. Even if you know nothing about the musical systems of Indonesia, Japan, or Iran, you can jump in and hear the differences immediately.

[182] "The Arab world is suffering even more because of a misconception that the Arabic musical system is based on quarter tones, i.e. an octave divided into 24 equal parts. This is a grave misunderstanding and has led to the norm of musicians using electronic instruments to tune their »quarter tones« to -50 cents, which is not only incorrect but also sounds horrendous."

[183] Max4Live is a feature of Ableton Live Suite, incorporating the objects of Max/MSP directly into Ableton. This allows users to create their own synthesizers, utilities, effects, or other tools, that integrate the rest of the software.

This approach mirrors Jace Clayton's initial development of *Sufi Plug-Ins* as Max4Live devices, later adapter to the VST format.[184] Allami's tools are specifically designed to function entirely within web browsers, emphasizing ease of use and broader accessibilities, providing a tool for experiential learning.

The transformative impact of Allami's software is seen in the experiences of Tunisian producer Deena Abdelwahed, who expressed a newfound awareness and connection to non-Western musical scales through using *Leimma* and *Apotome*. Abdelwahed's revelation that major and minor scales were not universal —contrary to her prior understanding—illustrates the influence of software on musical perception. She notes, "I had always felt oppressed by my melodic phrases in Ableton… [Leimma and Apotome] brought me close to something familiar, closer to what I truly want to express" (Faber, 2021). This demonstrates how the design of music software plays a significant role in influencing someone's cultural identity, even if they do not realize it at the time. In *Music At Hand,* Jonathan De Souza discusses the malleability of musical habits, as discussed in Chapters 1 and 2. *Apotome*, in particular, is designed to encourage exploration and experimentation, helping users untrain their ears from the constraints of equal temperament.

3.4.5 Digital Intent

In the user guide for *Leimma* and *Apotome,* Khyam Allami articulates the intent behind these tools. He envisions them as "attempts to create the transcultural, digital music-making tools that can facilitate the exploration of melodic possibilities from musical cultures long repressed by Western music theory, modern music technology, and the hegemony of 12-tone equal temperament." Allami underscores the pervasive influence of standard tuning systems,

[184] VSTs are stand-alone pieces of software that can be integrated into DAWs and/or used independently.

emphasizing their impact not only on non-Anglo-European musical cultures but also on Western 20th-century experimental composers. He suggests that the subtleties lost to 12-tone equal temperament are precisely what these "transcultural" tools seek to reclaim.

Leimma and *Apotome* accommodate a diverse array of hardware setups. Echoing Paul Dourish's principles in *Where the Action Is*, Allami aims for these tools to be adaptable across multiple levels of engagement, considering a broad spectrum of potential applications.[185] This flexibility is central to Allami's philosophy, as he intends for these tools to resonate with each user's unique creative process.

Allami's vision extends beyond individual artistic use; he emphasizes the educational potential of these tools, particularly their utility in both in-person and online teaching settings. The browser-based nature of these tools simplifies access, and their intuitive interfaces make them approachable for newcomers while still meeting the needs of advanced users.[186] This dual capability addresses a significant gap I have personally observed in tuning software, where resources are often geared towards users already with significant prior experience in navigating the technology.

By prioritizing accessibility and usability, Allami's approach to software design invites a broader audience to engage with complex musical concepts, while also addressing a need he identified in his own musical community. This democratization of music technology not only facilitates a deeper understanding of diverse musical traditions but also encourages a more inclusive and expansive exploration of musical creativity.

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[185] Because of the ease with which these tools integrate with other hardware and software used by users, there is an extremely wide range of potential use-cases, from simply exploring them in the browser, all the way to integrating them into a complex set-up for music production, composition, and performance.

[186] "Tuning is a complex subject and has occupied countless hours of some of the entire world's greatest minds for millennia - but the tools to aid us in teaching, learning, and exploring it, need not be. Think of the bamboo pipes of ancient China, or even the monochord used by Euclid - simple tools, behind which lie incredible philosophical, technical, scientific, practical, and musical ideas."

3.5 Conclusion

Exploring interaction design has helped me analyze the complexities in performer-composer relationships, and the implications of design in practice. This chapter engaged with ways performers, designers, and users interact with music, using the frameworks provided by Paul Dourish and Ge Wang to situate these interactions within the real world. I explored the cultural dimensions of design, as discussed through the lens of Jace Clayton's and Khyam Allami's work, demonstrating an important link between culture, functionality, usability, and meaning of technology. The work of these artist-technologists challenges designers to think beyond conventional models for design. A pivotal realization from this journey has been that design is never neutral. Any decision made during the design process carries with it the biases and perspectives of the designers, influencing the potential use of instruments of technology. This understanding has increased my awareness of the way tools mediate musical expression and collaboration.

Flexibility in design empowers artists to realize their creative visions without the constraints of rigid technological frameworks. My collaboration with Theocharis Papatrechas exemplifies how the way technology is framed influences both the dynamics of our interaction and creative outcomes. This chapter, along with the preceding ones, inform my discussion of the specific processes I underwent in my collaboration with Theocharis on *PrismaSonus* and *Morphés I/II.* The goal of these three chapters was to demonstrate the impact extramusical methodologies and conceptual frameworks have had on my development as an artist.

Reflecting on how my role has evolved throughout this process—from a performer to a co-creator engaged in the design of collaborations and implementation of technology—highlights the impact of integrating design theory into musical practice. This shift was guided by a deeper

understanding of the intersection between co-composition, technology, and interface design, influenced by the theoretical and practical explorations detailed in this dissertation. These discussions set the stage for further exploration into the specific processes of my collaboration with Theocharis, which I will discuss in Chapter 4. This discussion, along with its subsequent conclusions, demonstrates the way these methodologies are continually reshaping my artistic identity.

Chapter 4: PrismaSonus and Morphés

Chapters 1-3 of this dissertation shared the various topics I explored between the first few collaborations with Theocharis, and the project that culminated in fixed-media work *Morphés I*, the live performance version *Morphés II*, as well as the research project *PrismaSonus*. Both works drew from similar source material but were heavily modified to adapt to the different venues (including the technology we could use, audience seating), as well as the mode of interaction between us (live electronics).

In this chapter I will provide an overview of the history of our project, its key findings, and share the various settings in which we presented the work. I will also situate our work in dialogue with the various resources I shared in the previous chapters.

In the previous chapters, I shared how a variety of methodologies and concepts have shaped my exploration of my flute practice. I explored the interplay between performer, instrument, technology, and collaborator. I shared various ways these ideas influenced my approach to collaborating with Theocharis. In this chapter, I will share the narrative of the research phase of the project (PrismaSonus), as well as the two works created as a result of this collaboration (*Morphés I and II)*. This chapter will share the step-by-step evolution of the project, from the initial spark of curiosity to the final performance in June 2023.

I will discuss how the different settings in which we presented our work, which include academic conferences, interdisciplinary artistic festivals, and the concert hall, shaped the development of the work. I aim to analyze how these environments influenced not only the reception of our work but also our conceptual approach, applying Paul Dourish's concepts of *space* and *place* to situate these interactions.

This chapter also provides insight into the iterative nature of our collaboration, the methods we used to document the artistic process, and the role of visualizing sounds played in deepening our understanding of musical materials. I will describe the method we used to categorize and classify our materials, which allowed us to revisit and refine our ideas throughout the project development process.

Our initial collaborations, *Hearing Earth* and *Pythmenas,* involved interacting with pre-existing sound libraries—Rex Beverly's environmental samples and sounds of undersea mammals and sea ice formations, respectively. We used these external sounds as a medium through which Theocharis and I began to explore how each of us perceived and interpreted sonic materials. Using sounds external to our individual practices allowed us to engage in a more neutral exploration.[187] I should note that in *Pythmenas*, the fact that we were working with underwater recordings was twofold: it was the focus of the "Hearing Seascapes" seminar in which we began our collaboration, and also the subject of Theocharis's work on acoustical research at the Scripps Institute of Oceanography. I was inspired when I learned about the projects going on at Scripps, especially by projects using hydrophones for continuous, long-term recording of previously under-documented sonic landscapes.[188]

My growing interest in recording technology, particularly my experiments with binaural microphones as a way to capture flute playing from the perspective of my ears, prompted a question that formed the core of my exploration: What would happen if I could listen to sounds

[187] My collaborations with composers often begin by exploring their interests and influences, which typically include a wide range of extramusical ideas. This project was a continuation of that approach, but instead of starting with references to completed musical works, we explored non-musical sonic materials.

[188] One of the projects I learned about involved placing a hydrophone in a location that would record continuously for many months at a time, which was used to observe whale movement patterns. Professor Lei Liang's seminar connected musicians and artists to marine biologists and oceanographers in an interdisciplinary dialogue. Since then, the "Lei Lab" has deepened its connection to multiple departments at UC San Diego.

happening *inside* the flute while I play?[189] It was at this time that I was exploring the materials shared in Chapter 1 of this dissertation, and this made me curious about the ways altering listening perspective could potentially alter my technique. This was not only a technical interest but also connected to my exploration of using technology to mediate my creative expression. I was inspired by the synthesis of exploring various external listening perspectives of the flute with the idea of sonically immersing myself within the instrument.

The meeting that was the formal beginning of PrismaSonus occurred on October 5, 2021. During this remote recording session[190], I explored the idea of moving around the microphone to affect the timbre and perception of tongue rams on the bass flute.[191] The second recording perspective was recorded by of the binaural microphones attached to the end of the flute.[192] Both audio channels were then streamed to Theocharis, who could listen to them separately or together, juxtaposing several visual and auditory perspectives. Despite the technical limitations of this binaural microphone in handling high sound pressure levels (SPL), this session sparked curiosity into exploring further the idea of using microphone placement to alter the sonic environment of the listener.[193] It demonstrated to us the feasibility to capturing the intimate, internal sound world of the flute, if we were able to work through these initial technical hurdles.

[189] This is not the first time I have explored the theme of going inside of the flute. In 2016, I made an experimental music video where I attached a microscope lens and camera to the end of my flute, moving my fingers in sync with my recording of Edgard Varèse's Density 21.5 for solo flute. At the time, I was very interested in exploring the connection between light and sound and came up with this simple idea to use the fingerings of the piece to create a light show visualization of what was going on inside of the flute.
https://youtu.be/ST2RxVUFBvc?si=Xw9G0_R7ujo-BjXV

[190] For this session, we used a low-cost Audio Technica 2020 Condenser Microphone which I was already using for teaching remotely, and *SonoBus* for live streaming.

[191] Tongue rams are technique in which the flutist creates uses air and tongue movement to create a seal with the embouchure to create a "thunk" sound, which is pitched a minor 7th below the fingered pitch.

[192] SP-TFB-2 In-Ear Binaural Mic I was already using for my earlier experiments.

[193] In our final project, we opted for several DPA 4061 condenser microphones, selected for their ability to handle the high sound pressure levels within the flute, an essential upgrade from our initial microphone setups.

These early meetings established a framework for how we would approach sound capture and technology. The work we had been already doing in our remote collaboration helped guide our choices in what microphones to seek out and gave me practice with setting up the recording environment. It also underscored the importance of documenting each step of our process, enabling us to revisit it in further stages of the project.

4.1 Recording

The workflow of our project was structured around a design loop characterized by recording, listening, and generating new ideas based on the results of each session. This iterative cycle, which included note-taking and reflection, proved crucial for creating the complex sample library we later used for the musical works. Our previous collaborations relied on extensively documented and catalogued source materials. Inspired by this, we created our own system for categorizing and processing the content we were generating in our recording sessions. This allowed us to trace each element of the final compositions back to the original recording sessions.

I was inspired by Ge Wang's concepts in *Artful Design*, particularly the idea of purposefully constructing "recursive connections between elements", to facilitate a continuous evaluation and refinement of our collaborative process (Wang, §3.14).[194] Each session influenced our approach in subsequent sessions, creating a feedback loop that was crucial to our workflow. Whether or not I was directly inspired by Wang, or if his work simply articulates the development of a performer-composer workflow, I recognize how this project enabled me to take on a more active role beyond just playing the flute. Throughout this collaboration, I found myself deeply engaged in planning, production, and documentation, which I found particularly

[194] For more, see Section 3.1.2

fulfilling. Coming into each recording session, I asked myself the question: "What am I most curious about?" During this time, I found that I was having some of my most engaging practice sessions. Each time I practiced it felt like I was discovering something new about my instrument, and I would write down ideas for what I wanted to explore in my next recording session with Theocharis.

This initial work phase of the project spanned two months of intensive recording sessions in a room equipped with both stereo and octophonic speakers.[195] In each session, I did my best to consistently set up my microphones, creating an environment that enabled us to compare each day of recording session. Although keeping a permanent setup throughout the recording phase of the project would have greatly simplified logistics, the necessity to repeatedly set up and tear down our equipment each recording day enhanced my familiarity and comfort with the technology involved. Prior to the first recording session, on October 27, 2021, we defined the foundational structure of what would evolve into *Morphés:* a narrative involving four flutes, each representing a unique character. Although our concept of the four characters evolved over time, the core idea of combining an instrument's specific affordances with unique microphone placements and playing techniques remained.[196] This approach created a "library of processes" that synthesized technique and technology, serving as the conceptual framework that guided our approach to recording.

[195] We used both headphones and a stereo speaker setup to monitor recordings and tested the sounds in an octophonic speaker arrangement. Octophonic sound involves eight discrete audio channels, allowing us to experiment with audio spatialization, a key component of *Morphés I and II*. The specific technical processes involved in the audio spatialization of these works lies beyond the scope of my dissertation, as this was a key aspect of the project that relied on Theocharis's technical expertise.

[196] The initial idea was to somehow combine each of these characters with a video feed, an idea I later abandoned to fully focus on the aural elements of the project. We felt as though adding visuals to the project would detract from the level of immersion.

Throughout our recording sessions, we largely avoided musical notation, choosing instead to explore texture and sonic fragments through descriptive language. One example of this was when I experimented with venting one key at a time on the flute, the end of which was plugged with a rubber flask-stopper, with a microphone placed inside it.[197] This setup allowed me to alter the location from where air was venting, creating distinct sonic contrasts. The sound captured by the internal microphone was significantly different from what was picked up by an externally-placed cardioid microphone, aimed at a specific point on the flute.[198] The differences in sound varied depending on which key I vented. This allowed us to record each technique from both inside and outside the flute. On the piccolo, with its smaller tone holes, I developed a technique where I covered the embouchure completely with my lips and inhaled through a single vented key, which created a whistle from the sound going *into* the instrument. Amplified by the internal microphone, this created a technique I had never experienced before without the use of technology. An inherent affordance of the flute, which uses vented keys to lengthen or shorten the tube and determine pitch, was transformed into an element I could further manipulate through the addition of technology. Although we were not notating these finger combinations, I explained to Theocharis how I might hypothetically notate such techniques. His ability to engage with and understand without actual notation relied on his extensive experience with notating them. This underscores that, even though we were not using traditional notation, our process relied on preexisting experience with musical notation.

[197] Typically, the flute operates as an open-pipe instrument, where air is blown across the embouchure hole on the headjoint, rather than being blocked into a mouthpiece like on a clarinet. By plugging the end of the flute, it is transformed into a closed-pipe instrument. Even with all of the keys closed, it still allows for pitch production. Closed pipes have a different acoustic properties, significantly altering the instrument's resistance and feedback.
[198] Unlike omnidirectional microphones that capture sound equally from all directions, cardioid microphones, a type of directional microphone, are highly sensitive to sound coming from directly in front of the microphone and have reduced sensitivity from the sides.

Figure 1: DPA 4061 Microphone with Rubber Flask Stoppers

This exploration was driven by a curiosity about the movement of air and sound of the mechanism inside the flute, aiming to make the physical aspects of sound production and technique audible. This included capturing extraneous noises that are a by-product of technique.[199] For example, the flute's mechanism uses springs to return keys to their raised, resting position after being pressed. Releasing a key quickly causes a very quick bounce in the mechanism as the spring releases tension and the key returns to the open position. By recording this sound with a close microphone at a very high *sample rate* and then significantly slowing

[199] Contemporary flute technique includes various percussive sounds that invite the player to accentuate something an aspect of performing. For example, *key clicks* are a more forceful striking of the keys, creating a pitched, *tongue* or *lip pizzicato* is an over-pressurized articulation (e.g., "tuh" or "puh").

down playback, we were able to isolate and explore these fleeting sounds that are typically obscured by the flute's tone.[200]

Composer Ann Cleare's *unable to create an offscreen world (c)* for piccolo and percussion features a technique described as "sound of key lifting only," which is similar to the effect of the key bouncing back I am describing here. However, unlike in our work, Cleare does not use amplification. In my experience performing this work, when considering the distance between performer and audience, along with the percussion accompaniment, this technique is very difficult to make audible in performance context.[201] The boundary between intentionally subtle techniques for expressive effect and those that are functionally inaudible is blurry. In our work, amplifying micro-techniques does not necessarily imply an increase in volume but rather enhances the delicacy I can bring to these quiet sounds, using technology to bring the listener's perspective closer to my actions. This idea is part of my broader commentary on the aesthetics of contemporary flute music that involves a high degree of percussive effects. Without amplification, many of these techniques need to be performed at a very high intensity level to be perceived by the audience. I believe compressing the dynamic range of these techniques narrows their expressive potential. Consider how volume and tone color does not necessarily mean the same thing—a soft, delicate timbre can be performed at a relatively high volume level. Creating this color change involves very small changes in technique. This idea has inspired my approach

[200] Measured in cycles per second using kilohertz (kHz), sample rates define how many times a digital recording takes a measurement of an analog signal. A standard sample rate is 44.1 kHz or 44,100 samples per second. Recording at 96 or even 192 kHz gives more room to slow down a recording before introducing digital artifacts. This is useful when wanting to greatly slow down a quick action. In this example, a high sample rate functions similarly to a high frame rate on a high-speed camera.

[201] I accept that composers sometimes write techniques that are intentionally quiet in a way where the act of performing is sometimes more important than hearing the technique itself.

to amplification, using sound reinforcement to create more space in quiet, small, and delicate environments.[202] Amplification brings the listener's perspective closer to my actions.

Our sessions created a library of processes that synthesized specific playing techniques with recording methods and monitoring perspectives. Each session sparked further curiosity, prompting us to consider our next steps:

- How might the same technique, recorded simultaneously from different perspectives, be used in a musical composition?
- How would the same technique recorded on a different flute be altered by the unique internal sonic landscape of it?
- What artistic metaphors could we explore using this approach to technology?

This process was informed by my prior experience with flute technique, and Theocharis's experience working with scientists who use acoustical data to learn information about the qualities of a particular environment (e.g., underwater below an ice shelf). Gathering sonic information from an environment we could not physically inhabit (the inside of the flute) was connected to our artistic concept of then using audio spatialization to transport the listener within that hidden environment.

As our exploration deepened, we became increasingly interested in experiencing minute sounds and micro-techniques from inside the instrument that were not perceived from the outside, developing the idea of an instrument having a double personality: its inner and outer sound worlds. Recording technology served as a form of instrumental preparation, as well as a compositional tool.[203] After 10 rounds of recording sessions following this model, we created an audio library organized by instrument (Piccolo, Concert Flute, Alto Flute, Bass Flute) and

[202] Amplification as a way to increase the delicacy I can apply to various percussive techniques mirrors the artistic metaphor of our work, which uses technology (microphones, audio spatialization) to situate listeners within a very small physical environment.

[203] I am referring to the experimental music practice of temporarily modifying an instrument's characteristics by adding materials to it. In the context of Western music composition, this practice was developed by American composer John Cage (1912-1992), who himself cited Henry Cowell (1897-1965) as his inspiration for this technique. For further reading, see *American Experimental Music 1890-1940* (1990) by David Nicholls.

playing technique, further categorized into three subfolders: Raw, Sampled, Processed.[204] Each clip we recorded would be focused on a particular technique or textural idea, which would then be named with a descriptor. For example, one of the clips we recorded was titled "Bass_Flute_Articulation_Flutter," recorded from a footjoint-mounted microphone, and a front-facing microphone. In this clip, I played various pitches on the bass flute while flutter-tonguing. Other clips were titled more expressively, having to do with musical character as opposed to playing technique (e.g."Flute_Meandering").

We set aside this collection for a few months, allowing us time to return to our recordings with fresh perspectives. This deliberate temporal separation between the recording and listening phase of the project diminished the immediate intensity of the recording sessions, helping me distance myself from the act of playing to more objectively evaluate the sounds produced.

4.2 Listening

In addition to being temporally separated from the recording phase of the project, our listening sessions took place in a space separate from the recording environment. These sessions were conducted both individually and together in a listening room. At this stage, we were still engaged in research mode, curious not only about the narrative and musical potential of the sounds but also looking to engage more deeply with the technical elements. We used *iZotope RX 10* to visualize the samples. Using a *spectrogram* not only aided our analysis of the recordings but also created a shared listening space in which we disengaged with the distinct roles we had in the recording sessions.[205] Our goal at this stage was to explore the technical details and musical

[204] As of June 2024, this library remains work-in-progress. In the conclusion of this dissertation, I will discuss some potential future directions for the project and how we might further develop and utilize these recordings.
[205] A spectrogram is a visual representation of sound frequencies over time.

potential of these sounds, develop our collective understanding of the materials we had, and align our artistic vision for the next stage of the project.

The structure of our listening sessions followed a similar loop as the recording sessions. Given the large volume of materials we had created, we balanced open-ended prompts (What are we curious about?) with a more methodical approach (Listen to: Session #3, Alto Flute). First, we opened the folder that contained clips from that day of recording. Then, we checked our notes to see if there were specific sections we had already identified during the session that we wanted to extract. After that, we listened through each clip, identifying moments of interest we wanted to extract from the longer segment. We adopted a unified file naming system to categorize these multiple stages, allowing us to situate any sound in our library within the broader timeline of the project.[206]

As we loaded samples into the spectrogram, elements we had not identified aurally during our sessions became visually apparent. The combination of the memory of the recording session (and accompanying documentation) and the objective visualization provided by the spectrogram created a holistic view of each sound. I found this process to be fascinating; I had never analyzed my playing using visuals. Each technique, recorded from multiple perspectives, brought a new dimension to familiar sounds.[207]

In previous projects, our work began with listening to pre-recorded sound libraries, which would spark our creative process. In this case, we were revisiting our own recordings, tied to our

[206] For example, one clip was described as "Flute_Air_1," a 56-second clip exploring various air notes on the flute. This clip was recorded using a FOOTJOINT mic and a FRONT mic. The clip had a sample we found to be interesting, labeled 00-23.5_00-34.5_Flute_Air_1_FOOTJOINT. This allowed us to extract short samples from a longer clip, which was in turn recorded on a particular day, which had notes associated with it.

[207] I was familiar with using spectrograms as part of the audio production process (e.g., when applying equalization or other sound editing to my recordings). This was the first time I used spectrograms not as a tool to manipulate sound for a specific goal, but simply to explore the sound. I had done that before when listening to sounds I was curious about (e.g., spectrograms of birdsong), but never with my flute playing.

own memories and accompanying documentation. This altered the dynamic of our collaboration, and further blurred our distinct roles as performer and composer. In the recording environment, our engagement with the space was defined by our interactions with technology. I was engaging with my flutes and the microphones, Theocharis with the computer and audio interface. Headphones and speakers situated us within the same environment, and we communicated via dialogue. In the listening phase, we were both interacting through the same interface in an environment like a traditional studio setting. This blurred the lines between our roles and created a space where we were operating like co-producers.

As we sat together and explored the sample library, we engaged with the memory of each recording. One moment I remember involved a sound we recorded on an alto flute, where Theocharis heard something that piqued his interest, asking: "How did you do that?" As I listened to the sound and watched the spectrogram, I found that I could very easily remember the exact fingerings I had used in that sample, even though it was not notated. I was surprised by the clarity with which I remembered the specific actions I did. I believe part of this has to do with the fact that when recording this sample, I had made so many creative and technical decisions that were each associated with a specific physical action: where to place the microphone, what to play, how to manipulate the instrument. This was further augmented by the active discussions Theocharis and I had during the recording. Some of the samples included annotations where I would describe how I was creating a particular sound. The recording and listening phases of our project were therefore both forward-thinking and reflective. Each phase was designed with an awareness of the broader structure, facilitating a continuous dialogue that enriched our collaborative process.

The image below is of a sample recorded on the stopped alto flute that stood out as an example of how the spectrogram enhanced our listening and allowed me to engage with my technique in a new way.[208]

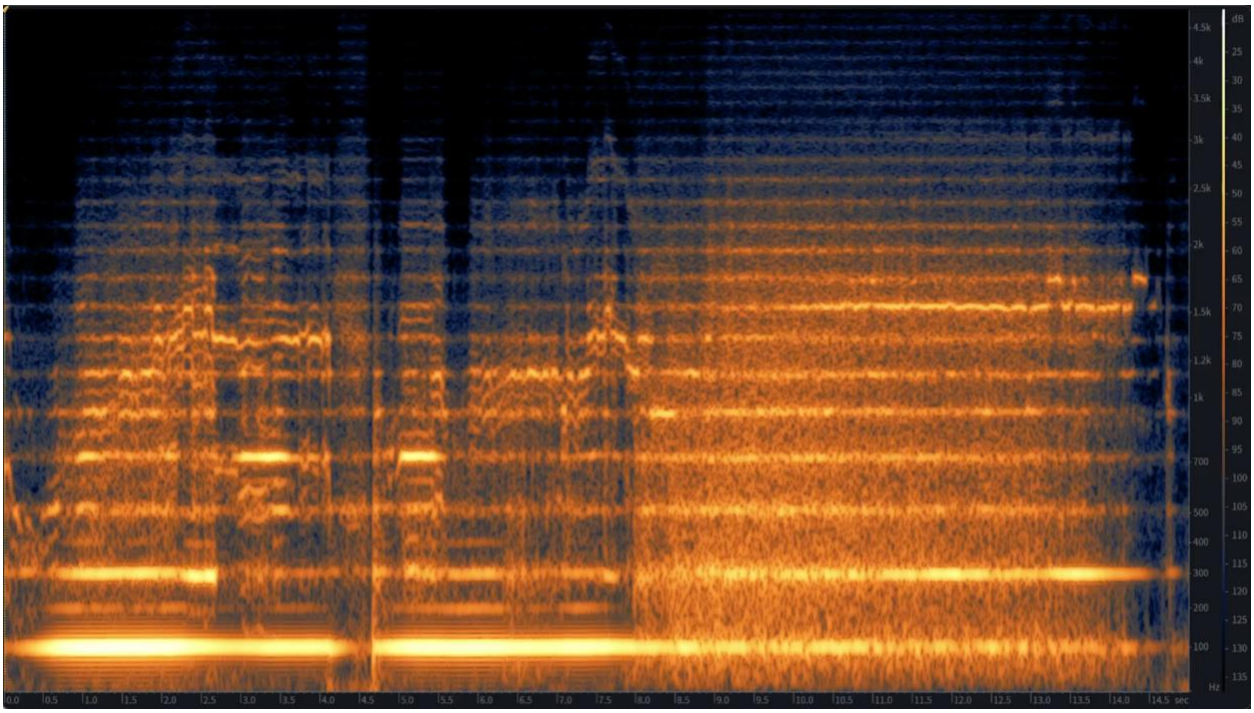

Figure 2: 00-46.5_01-01.5_Alto_Stopped_Sustained_2_FOOTJOINT

As we listened, I saw how different elements of my technique divided into distinct layers in the spectrogram. Being able to point directly at the image and analyze what was going on in my playing was a new way of listening to my technique that I found to be very generative. The sustained pitch at ~100hz is the fundamental, which was the pitch I was fingering on the flute. Plugging the end of the flute transposes the resulting pitch down a M7, turning what would be normally a fingered C4, sounding G3, into a sounding Ab2. The two short lines at ~700hz are partials created by overblowing the fundamental pitch (notice how I am able to produce them

[208] This is the same technique I mentioned earlier that used a rubber flask-stopper to plug the end of the flute. I created individual ones for each of my flutes, corresponding to the bore diameter. I found alto flute to be the most interesting to explore using this technique.

while still keeping the fundamental pitch).[209] The higher frequencies is what I call "melodic whistle tones," which I am able to layer on top of the fundamental pitch. Roughly half-way into the same, the "fuzz" is air noise, which I incorporate into the tone by altering my embouchure. The slightly more distinct partial at ~1.5k is a sustained whistle tone, which I produce by focusing my embouchure and airflow.

As I write this in Spring 2024, I vividly remember recording this sample over two years ago, as well as the listening session in which we initially analyzed it. To me, this demonstrates the utility of using spectrograms in this way to engage with technique and listening.

Below are several additional images of various samples. One of my future goals to it share these materials in an interactive format that combines spectrograms, notation, and descriptions of technique.[210]

[209] Converting the flute into a closed-pipe instrument by plugging the end produces square waves, consisting of only odd-numbered partials (which is why there is no partial at ~200hz). This radically transforms the acoustical properties of the flute, which normally produces all even and odd partials of the harmonic series.
[210] A placeholder version of this is currently on the project's website at https://prismasonus.com.

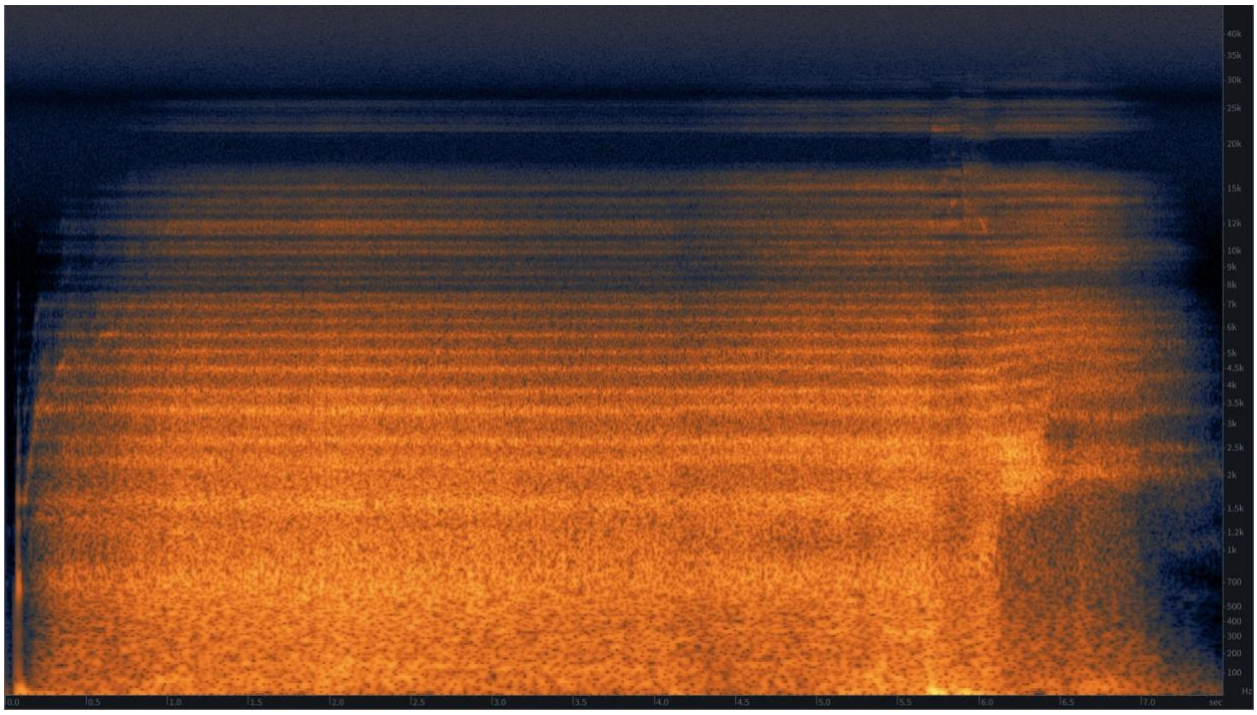

Figure 3: 00-57.5_01-05_Piccolo_Stopped_Air_1_FOOTJOINT

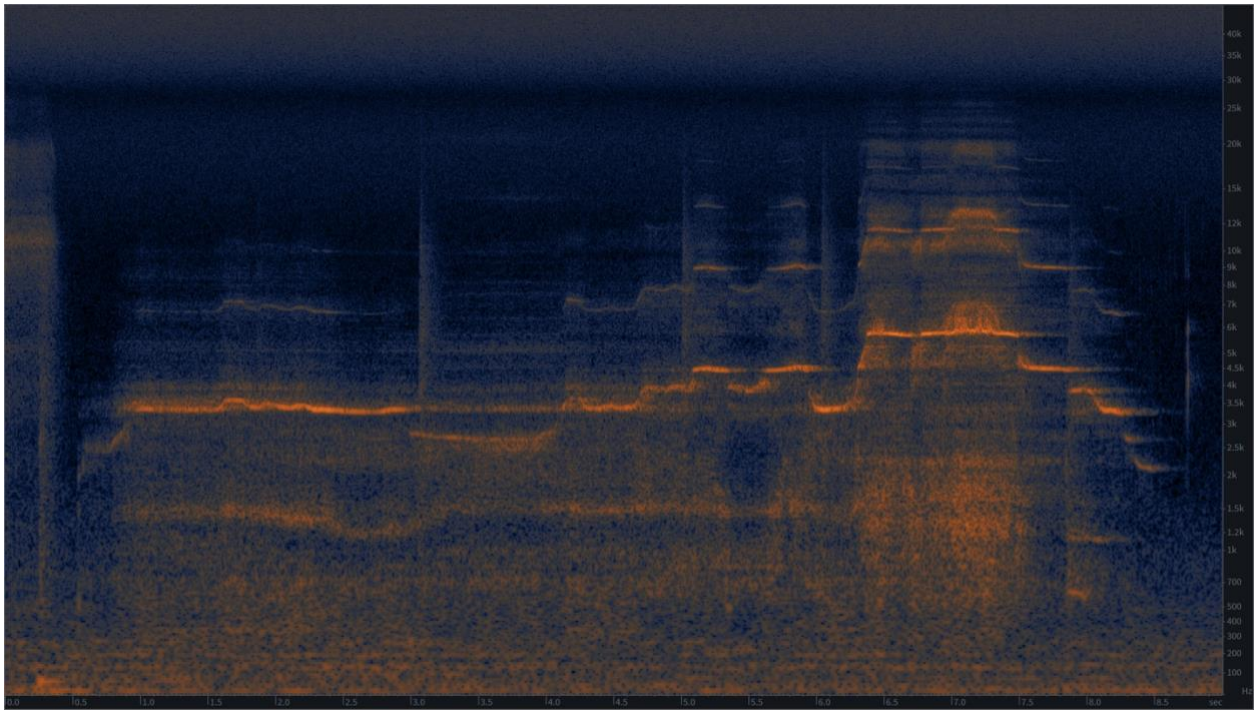

Figure 4: 00-48.5_00-57.5_Piccolo_Stopped_Air_1_FRONT

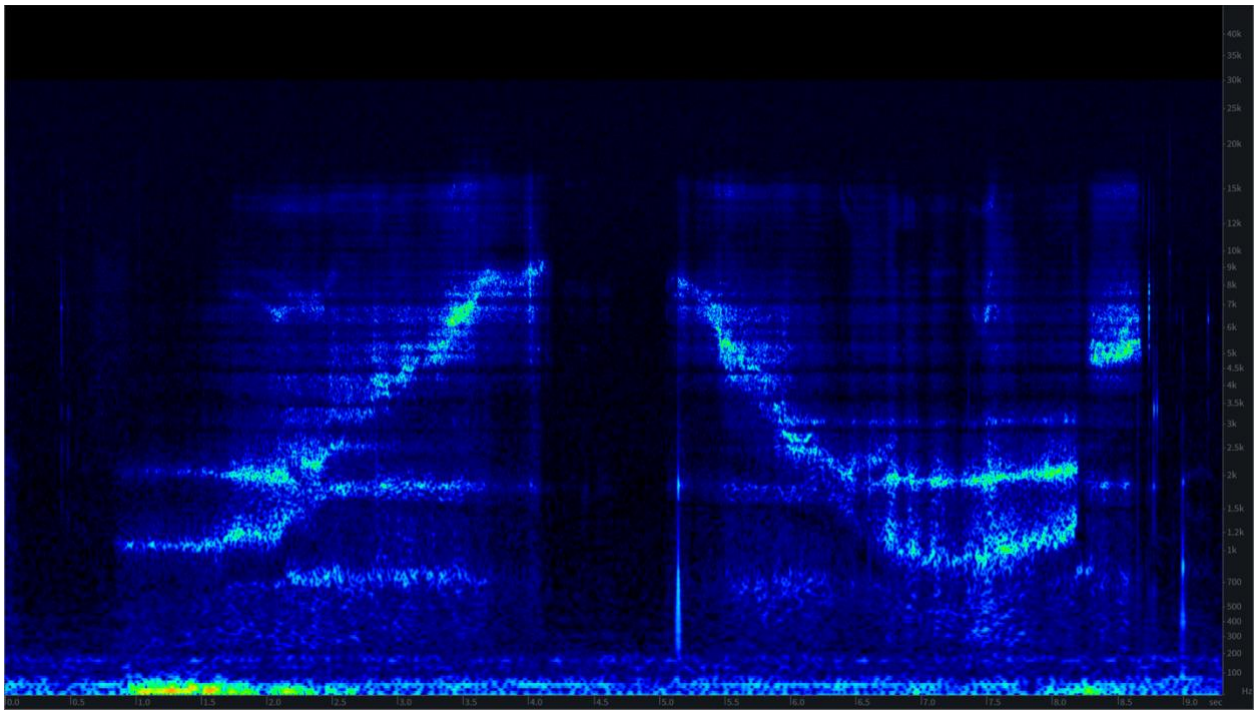

Figure 5: 00-14_00-23.3_Piccolo_Air_1_FOOTJOINT_3

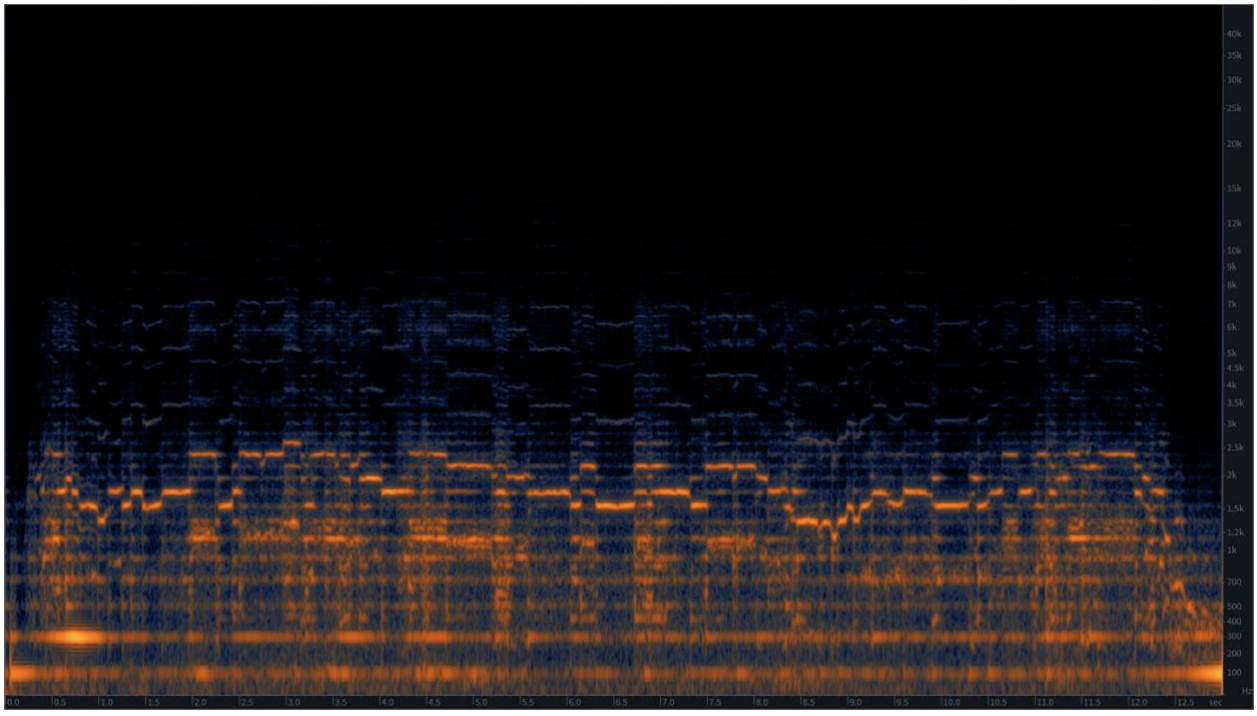

Figure 6: 00-34_00_47_Alto_Stopped_Sustained_2_FOOTJOINT_2

As we added more detail to our sample library, I noticed a transformation in my perception of techniques that previously felt familiar. Each sound we explored sparked ideas for further musical exploration. Focusing on these micro-moments exposed elements of my playing that had previously been overlooked.[211] This phase of exploratory listening maintained a connection to the raw acoustic material recorded on the flute. The flute itself became the location of action, a space inhabited through technology, echoing our earlier explorations of sound libraries. This approach was influenced by Theocharis's collaborations with scientists, where sound was used as a tool to explore and understand inaccessible environments. Using technology to magnify these flute sounds, we engaged in a process of sonic exploration that uncovered layers and nuances that were not perceptible in conventional listening settings.

4.3 Processing

The transition from the recording and listening phases to the processing phase was fluid, and led to into the production phase where we developed the musical compositions *Morphés I* and *II*. The listening phase of the project focused on extracting specific moments from the larger recordings that contained moments we wanted to develop further. This next phase involved augmenting and altering these selected materials through various processing techniques as well as crafting environments to recontextualize these sounds.

The project began by exploring microphones to explore sonic environments, capturing hidden techniques of the flute, and engaging with my listening habits. Audio spatialization allowed us to transfer these sounds into newly constructed acoustic environments. This phase of the project extended our exploration of the flute into the digital realm.

[211] Or simply not part of the instrumental space and place.

Our approach to processing focused on the interplay between the raw, unprocessed samples and the listener's experience. Each processing technique altered the perception of the original sound. For example, slowing down a sample not only changes the perception of time but also enhances the clarity with which we hear audible details of the micro-techniques we were capturing. Applying reverb modifies the listener's perception of altering the acoustic environment in which the sound is situated. Detuning or filtering subverts a listener's expectation of what sounds from the flute should sound like.

Audio spatialization was used to construct sonic environments in which the listeners—and we as the performers—engaged with sounds. Working in multi-channel spaces allowed us to add movement as a creative element of the work, which we described as "the choreography of spatialization." This approach allowed us to use spatialization for dramatic and narrative effects, which became an important aspect of the fixed-media work *Morphés I*. In the introduction to this dissertation, I mention the program notes Theocharis wrote for *Pythmenas*, which described using rings of speakers to create layers of sonic activity surrounding the listener from floor to ceiling. In *Morphés I*, different elements of sound, sometimes derived from the same sample, were distributed across various layers, while in other instances, different characters inhabited distinct layers.

Some samples underwent subtle modifications, such as reverb or noise reduction, whereas others experienced more radical transformations, significantly altering their sonic characteristics. Despite these changes, our primary objective remained to preserve a palpable link to the original performance. This intentional desire to remain connected to the act of performing became a central theme, especially as we got further into the Processing Phase. The intimacy of the recording techniques—capturing audio from within the flute—created a unique relationship

between technique, listening, and remembering the act of performance. This nuanced relationship, diverging from the traditional separation between performer and their auditory self-perception, demonstrated a shift in how I engaged with my own musicality. The decisions made in sound processing, and later in the choreography of the audio spatialization, were influenced by this evolving connection between me, my instrument, and my collaborator.[212]

Each step in the processing change creates a new scenario for how the sound can be perceived, while maintaining a connection to the original source material. Each step brings out new aspects of the sound. Building a sample library is also a process of building a library of processes, which breadcrumbs that lead back to the original materials at each stage. As discussed earlier, each clip was placed in a root folder that had the following subcategories: 1. Raw; 2. Sampled, and 3. Processed. Each digital manipulation of the recording was done in stages, so we could see the story of the sample going from a fully processed sample, all the way back to the unprocessed clip.

One sample we recorded of bass flute singing and playing was ultimately used to power the subwoofer in the opening section of *Morphés*.[213] One of the rules we stuck to was that all sounds in the final musical compositions would be derived from the flute recordings. Singing slightly out of tune from the fingered note on the flute creates a *beating pattern* that has irregular fluctuations (getting faster and slower) since the voice will have slight fluctuations in tuning.[214] This creates a very musically expressive texture that is an equivalent of using low-frequency

[212] Audio spatialization involves deciding where the sound is coming from, as well as the movement of sound around the listener. We considered the ways spatialization could be used for dramatic, narrative effect, which became an important aspect of the fixed-media work *Morphés I.*

[213] Singing and playing is a technique where the flutist uses their embouchure and air to create pitch on the flute, while also activating their vocal chords. This creates two distinct pitches.

[214] *Beating* is the interference between two sounds of slightly different frequencies. The speed of beating corresponds to the difference between the two frequencies. For example, a pitch with a fundamental frequency of 440 Hz (cycles per second) and another one played simultaneously at 441 Hz will beat at 1 cycle per second, which is equal to 60 BPM (beats per minute).

oscillators (LFO) to slightly and irregularly de-tune two pitches.[215] The first step in this process was to add a band stop filter to remove minor feedback, followed by a 76% speed reduction with pitch shifting, along with +6dB amplification, finally followed by an additional 59% speed reduction of the previous step. The result was a "wobble" that powered the subwoofers in the opening of *Morphés I* and *II*. Using my voice and the flute as the source material for this texture, as opposed to synthesizing these sounds digital stayed within our rule of relying on the flute as the source of all sounds.

We modified the dynamic, temporal, spectral, timbral, and spatial dimensions of the audio samples. The techniques included amplification, noise reduction, temporal modification, spectral modification, timbral modification, and spatial modification. Each technique has specific parameters and an acronym that was added to the file name to document the process. The techniques were used to shape and sculpt the sound of the samples, and in the live performance version were applied using predetermined presets. This system solidified the thorough documentation of our work process, helping navigate easily through the ever-growing library.

4.4 Morphés I

From the outset, Theocharis and I were connected through the music. Our explorations of technology and sonic materials were always in service to the musical compositions we envisioned creating together. Each phase—recording, listening, and processing—was building towards the creation of *Morphés I* and *II*. This section will discuss how these works were constructed and how their form was shaped by the varied venues in which they were presented.

[215] Re-creating this digitally would involve having two waveforms (corresponding to the flute and to my voice), which are modified using one LFO to alter the tuning, as well as a second LFO to randomly alter the speed and width of the first LFO.

The 2022-2023 call for proposals for the Initiative for Digital Exploration of Arts and Sciences (IDEAS) festival helped pivot our project from an exploratory phase to concrete musical aims.[216] This interdisciplinary festival provided an ideal platform to showcase our work, allowing us to transform our explorations into a musical experience. Our application for IDEAS, submitted in December 2021, came after several months of preliminary explorations, but before the recording phase outlined in Section 4.1. This committed us to deliver a musical work in a yet undetermined venue, which influenced the way we structured our recording sessions.

We proposed an audiovisual installation at the Audio Spatialization Lab (Spat Lab) at UC San Diego.[217] The Spat Lab, with its unique 360-degree sonic environment, provided an ideal setting for realizing *Morphés*, having previously hosted Theocharis's composition *Pythmenas*. This "dark, cave-like space"[218] offered us a neutral space in which we could materialize the sonic environments we were exploring, inviting listeners into the intimate world of the instruments, enhanced by audio spatialization. The title *Morphés,* suggested by Theocharis, is derived from the Greek word for "form" or "shape," reflecting the project's focus on the transformation and outward expression of inner essences. In an email exchange discussing the title, Theocharis described it as "an existence that carries and changes to a distinctive shape, form, and presence," perfectly encapsulating the themes of our work.

Our aim was for attendees to experience the flutes from both the performer's and the instrument's perspectives, utilizing audio spatialization to enhance the sensation of moving within the sound body. The proposal was for a work featuring pre-recorded and processed sounds from four members of the flute family (Piccolo, Concert Flute, Alto Flute, and Bass

[216] https://ideas.ucsd.edu
[217] Our initial plans for the project included visuals captured from the inside of the flute to connect to the audio, but ultimately we chose to focus solely on audio for the project.
[218] https://sonicarts.ucsd.edu/facilities/index.html

Flute), each representing a unique musical character and occupying a specific spatial point. The narrative of the work would shift between textures that amplify or obscure the distinctions between characters (each associated with a specific instrument).

The initial concept was for the work to follow an episodic structure divided into two phases: a "stable" phase where each character is distinctly represented and the environment is stable, and a "shifting" phase where the characters and environment transform, blurring their boundaries. While the audience remains seated in a fixed location, the space around them gradually transforms. Eventually, the next scene settles in a new, fixed environment, and the process repeats. The philosophy behind this approach to narrative is akin to a field recording in which the recording perspective moves through different environments, or a video game in which a character moves in and out of different spaces, with the sound environment around the character changing. When listeners enter the space, they experience what it's like to be inside of the flute, hearing the instrument from the perspective of the performer and the perspective of the instrument itself. Spatialization amplifies the sensation of moving in and out of the sound body. The dramaturgy of the work is created by the overlapping, fusing, and merging of elements within the acoustic space.

One of the challenges of presenting in a compact environment like the Spat Lab was related to its complex audio capabilities. The space was designed with multiple rings of speakers, all calibrated to create a *sweet spot* in the center, where the convergence of sound from all directions achieves perfect balance. In a typical stereo environment, the ideal listening position forms an equilateral triangle with the two speakers, balancing the audio from the left and right channels. However, in a multi-channel environment like the Spat Lab, the positioning of the audience becomes even more complicated, and greatly affects their auditory experience. Our

approach aimed to balance creating an optimal listening experience, while accepting a degree of variability in each audience member's experience. We strategically limited seating to ensure that most listeners could be placed near the ideal center. Yet, each seat offered a distinct sonic perspective: for instance, if a scene's action originated from the north (0 degrees), an audience member facing south (180 degrees) would perceive it from the opposite direction. This meant that each listening position yielded a unique experience of the soundscape.[219]

Figure 7: Audio Spatialization Lab at UC San Diego

[219] Already at this stage, we were considering ways to adapt this work for an online format, which would potentially include interactive elements allowing listeners to change their virtual orientation within the sound environment. As of June 2024, this aspect of the project remains in development.

Creating *Morphés* involved arranging the samples we had collected, grouping them into potential characters of themes. This processed unfolded within the Spat Lab, where we experimentally combined samples to experience their interaction within the acoustic space. Initially conceived as four distinct characters, our concept evolved into four distinct environments, structured as a through-composed work with four scenes. Theocharis led the formal and technical development of the work, utilizing his extensive knowledge of how to engage with the Spat Lab's interfaces.

My contributions during this phase were primarily supportive and focused on the overall narrative of the work, unlike in the recording phase where my interaction with the flute was much more technical. In one session, I suggested we explore a more distinct differentiation between the ambient environment and the distinct characters within it. In other words, how could we sonically separate the general environmental background, like the sounds of trees in a field recording, from specific actions occurring within that space, such as a bird flying past? We explored how to further distinguish between elements that constituted the background versus those that defined the foreground character, and how we could use spatialization to blur this distinction.

While our listening sessions in the office environment were devoted to listening and reviewing samples (as detailed in Section 4.2), it was during our limited time in the Spat Lab that we truly sculpted the experience of *Morphés I*. Throughout Fall 2022, Theocharis and I transitioned from listening to individual samples to constructing larger segments of the piece. By December 18, 2022, we had developed concepts for several scenes, each characterized by a distinct texture and featuring foreground material taken primarily from a single flute. Our typical workflow began with listening to an unprocessed sample or section of it in the Spat Lab.

Sometimes, Theocharis would apply the processing techniques outlined in Section 4.3 beforehand, and then we would test various spatialization methods during our lab session. We always prepared a plan to optimize our limited lab time, leaving space to test elements we could not anticipate beforehand. After playing a segment, we would discuss potential layer with other textures or describe possible movements within the scene. Not being involved in the technical implementation on the computer and without my flute, I found myself in a producer-like or choreographer-like mindset, which was a new experience for me in this project.[220]

One particular session illustrative of this process began by focusing on a sample extracted from a clip recorded on the alto flute.[221] In this sample, I play the fundamental tone with whistle tones layered on top, recorded from inside the flute where breath sounds were distinctly audible. We explored the idea of the breath sound becoming increasingly disconnected from reality throughout the scene. Initially, the breath would be unprocessed, gradually morphing as the scene progressed. We imagined starting the scene with the flute sound localized in one part of the space. Then, the fundamental tone would begin to encircle the listeners, followed by the whistle tones and breath sounds. The sound environment morphed until the audience felt like they were fully immersed within the environment. The exact moment when this shift occurs was deliberately ambiguous. While the final work did not necessarily include this exact structure and this particular sample, the discussion in this session illuminated core concept of *Morphés*, where morphing the sound source from an external to an internal focus revealed new sonic characters, blurring spatial distinctions, and immersing the audience within the instrument.

[220] While in the recording phase, I was involved in technique and Theocharis was the listener, in this phase our roles were reversed.
[221] This sample was labeled 00-07_01-11_Alto_Stopped_1. Meaning, it was a 64-second sample from a clip we recorded where I was exploring various textures on the alto flute with embedded microphone.

We continued our work through December and January, during which there were periods when Theocharis worked independently due to the technical demands of preparing for a multi-channel space.[222] The performance on February 2, 2023, was a success, and experiencing the audience's reaction to the work was immensely satisfying. We presented the 25-minute piece in two sessions, each limited to 25 guests, which included a brief introduction to the project and a question-and-answer session.

Audience feedback was particularly intriguing, not only for their reactions to the work but also for their suggestions on potential future directions for the project. One response that stood out was how the piece seemed to transport listeners to other realms. An audience member remarked that the experience evoked memories of disparate elements: Jimi Hendrix, Federico Fellini, and Tibetan monks—none of which were direct influences of ours but demonstrated how unfamiliar sonic environments always allow for personal associations. This perhaps stemmed from the novelty of the acoustic spaces we created, particularly given that our project was framed as an "exploration of the flute," but then subverted those audience expectations.

Another attendee questioned the connection between the research elements of the project and its artistic representation, questioning the clarity of that connection. We acknowledged that *Morphés I* was intended as an artistic distillation of the research, not the research itself. Another guest described feeling as if the ceiling above them was opening, suggesting a transformative spatial experience. This person, who was not a regular listener of electronic music, felt that the work had triggered a new auditory perspective. We were curious whether the audience was listening "musically" or engaging with the piece on a different sensory level.

[222] While this dissertation primarily focuses on the conceptual background I brought to this collaboration as well as my contributions as a flutist, future publications might explore the technical production aspects and acoustical analysis of the work, an area largely handled by Theocharis.

Reflecting on the performance, we recognized how the final stage of the piece's development could have used some additional time to fully evolve the musical materials. The work was crafted by expanding and combining brief moments, layered with additional materials. We listened to each module and decided if it needed new elements, more space, or further repetitions of existing materials. We focused on distinguishing between sounds that contributed to the environment in which they were situated and those that contributed to a musical character.

For some audience members expecting a concert work with conventional formal structures, our piece presented a different experience, aligning more closely with an ambient soundscape than a typical work of electroacoustic concert music. This prompted us to consider a crucial question for the next stage of development: How do electroacoustic works differentiate between live playing as a sculptor of the sonic environment versus as a character within that environment? This distinction became essential as we prepared for Morphés II, the live performance version of the work. After the conclusion of this phase, we decided to take a few weeks off before commencing the development of Part II.

4.5 Presentation and Reflection

Between the presentation of *Morphés I* on February 2, 2023, and *Morphés II*, we participated in two conferences that helped refine our approach and give us the opportunity to reflect on what we had created already. In March 2023, at MOXsonic, the Missouri Experimental Sonic Arts Festival, we delved into the details of our collaborative method and sample library.[223] We articulated how our recording, listening, and processing phases informed the development of *Morphés*. Although we had not fully documented this process as detailed in the earlier sections of this chapter, our accumulated library of samples, meeting notes, and insights enabled us to

[223] https://moxsonic.org

reconstruct and share the project's evolution. This reflective pause helped us assess our project's trajectory and prepare for the June 2023 live performance. This presentation demonstrated the value of stepping back from the immediacy of artistic development and day-to-day logistics. Discussing our collaboration, particularly the co-creation aspect of *Morphés*, introduced a new narrative dimension to my experience, shifting from a performer-composer dynamic to a shared storytelling narrative. The technical constraints at the conference, which limited us to a 4.1 speaker setup, focused our discussion on collaboration and the recording process, rather than the spatialization experience of *Morphés*.

In many ways, we considered our experience working and presenting in the Spat Lab to truly be a laboratory of sound: an ideal listening space where we could test out audio spatialization and musical narrative. Relying on extremely high-end spaces like the Spat Lab for regular presentations is not feasible, simply due to the rarity of such spaces. Innovations in spatialized binaural audio, including built-in Dolby Atmos on Apple products, have simplified the production and distribution of spatialized audio. We are exploring the use of this technology for the next stage of our project.[224]

In May, we presented our work at the "Instruments, Interfaces, Infrastructures" conference hosted by Harvard's Department of Music. Our initial goal was to replicate the MOXsonic presentation. However, I ended up presenting at this conference without Theocharis, which shifted the focus to discuss my role within the collaboration. This unexpected shift not only enhanced my understanding of my contribution to the project's technical and artistic development but also underscored the fluidity of our roles within the collaborative process. It

[224] Dolby Atmos is one of many standardized formats for mixing multichannel audio, which is calibrated to work natively with Apple products. I am interested in exploring ways to use the head-tracking feature on Apple devices (including AirPods and AirPods Pro) to recreate how *Morphés II* had a unique listening perspective for each listener, depending on the direction they were facing.

also influenced the way I have described my contributions to this project throughout this dissertation.

In addition to being the first collaboration with a composer in which my role expanded beyond that of a flutist, Morphés was also the first project I presented at a conference without performing. This demonstrates the diverse roles I embraced throughout this project, informed by the interdisciplinary methodologies discussed in Chapters 1-3 of this dissertation. Paul Dourish's concept of *place*, which acknowledges the influence of environment on behavior, helped me navigate and understand the distinct dynamics of each conference setting.

At MOXsonic, attended mostly by composers and composer-performers focused on electroacoustic and electronic music, the technical and sonic aspects of Morphés were highlighted. The audience's interest leaned towards the intricacies of sound manipulation and spatialization techniques, reflecting the conference's emphasis on technological exploration. My presentation at Harvard's "Instruments, Interfaces, Infrastructures" conference, organized and attended by musicologists, shifted the focus towards the social dimensions of our collaboration. This was the first time I had presented the same project in two distinctly different academic environments, leading to different interactions and feedback. These experiences not only deepened my understanding of how *Morphés* resonates within various communities within the academic music landscape but also highlighted our engagement with different modes of analysis.

Looking forward, presenting this project at a flute conference would reveal yet another perspective, focusing on the flute-specific innovations of the work. My collaboration with Theocharis has therefore transcended merely combining our artistic and technical expertise; it has become a medium through which I engage with interdisciplinary research environments

beyond my reach as a performer. This expansion into new academic territories has continued to shape my approach to music and research.

4.6 Morphés II

Transitioning from a fixed media work to a live performance required navigating several technical and logistical challenges, namely determining how my live playing would interact with pre-recorded electronic elements. This would ultimately make *Morphés II* significantly different from *Morphés I* in its structure, even though it contained a large amount of shared musical materials with *Morphés I*. Throughout this period, we continued working in a room equipped with an 8.1 channel system—the same room where we initially recorded our sample library the previous year. The experience working in the Spat Lab, as well as the two conference presentations, helped structure our work timeline between February and June.

Our approach to creating the live version involved reinterpreting existing materials from *Morphés I* and integrating new elements to facilitate live interaction. As we re-evaluated the fixed-media work in various formats (8.1, 4.1, stereo), we identified points where live flute playing could interact with pre-recorded scenes, comment on them, or merge with them through real-time sampling and playback. This interplay would ultimately create a much more dynamic interaction between us. It also led us to approach *Morphés I* as the audio document we were now engaging with, much like how in *Pythmenas* and *Hearing Earth* the initial stage involved engaging with pre-recorded materials.

Considering that the final work would be performed without a score and instead would follow a pre-planned script, a key aspect of our preparation involved defining specific moments where my playing would "activate" transitions. These cues were essential for Theocharis to

advance the *electronic patch* to the next scene.[225] For example, at the beginning of the piece, I start with the alto flute and eventually transition to the piccolo. As this transition occurs, the pre-recorded electronics continue in the background. From his station across the stage, Theocharis, monitoring my playing through headphones, needed an audio cue from me indicating my readiness to shift to the next scene in which I switch to the piccolo.[226] The following excerpt from our work session on May 30, 2023, one of our final rehearsals before the live performance, illustrates how we navigated this scene transition.

First, there is the initial setup and intention for the scene, indicating the primary role of the piccolo:

> Theocharis: "So blow into the microphone with your mouth only, and then take the piccolo, which is going to be the main protagonist in this scene, the piccolo. Blowing into the microphone, then take the piccolo, do the same"
>
> Alexander: "Start with these kind of simple inhales and exhales?"
>
> Theocharis: "And then the electronics will bring the piccolo stuff as well, the more active [breathing in and out].
>
> Alexander: "Do I [then] go into more active [playing]?"
>
> Theocharis: "Yes. You are [first] alone, and then there's a build-up. You stay alone and then I'm recording [you]. You continue with that material on your own, and then I [start] sending your different instances of your signal around the space with different transpositions. And then at some point, I will bring in the key click, the first key click." (Alexander Ishov and Theocharis Papatrechas, May 30, 2023)

In this scene, moving to a more activate phase of breathing triggered the electronics, as well as the live sampling. We connected the scenes by first having me blow directly into the microphone, freeing up my hands to switch instruments. After that, I continue a similar texture,

[225] In electroacoustic and electronic music, a *patch* refers to a sound setting, effect, or plug-in. The name comes from the era of analog synthesizers that required users to physically *patch together* components with cables.
[226] Given the multiple layers of sound happening, Theocharis was monitoring the sound levels coming in from my live microphones, so in a way this was also a visual cue communicated via the sound meter on his interface.

but am now breathing through the piccolo itself, venting air into the microphone to create pitched wind noise. My cue for the next scene occurs once I hear distinctly different materials in the pre-recorded track, which is triggered by Theocharis. This excerpt from our meeting demonstrates the way we planned out transitions between scenes, integrating my live playing with pre-recorded and live electronics.

In addition to requiring a new approach to scene transitions, the transition from *Morphés I* in the Audio Spatialization Lab to *Morphés II* in the Experimental Theater required a new approach to spatialization due to the differing layouts. The Lab's spherical speaker arrangement, centered around a central listening point, contrasts sharply with the Conrad Prebys Music Center Experimental Theater's layout, where speakers are arranged to project sound downwards from above the audience. *Morphés II* would be the final piece on a recital featuring other works for flute and electronics, so the audience would be seated in a semi-circle facing the front of the room. The technical differences between the halls, which included different software systems, required a period of technical rehearsals before we could begin working on the piece.[227]

These adjustments were not only technical but also artistic, impacting how the live audience would experience the new version of *Morphés*. Balancing our artistic goals with the practical limitations of live performance underscored the complex interplay of technology and performance practice in live settings.

A major challenge in adapting *Morphés* to live performance was the inherent limitation of live flute playing—I could only play one flute at a time, unlike in the fixed media version where multiple samples and techniques could be layered simultaneously to create a complex soundscape. We used pre-recorded materials alongside live performance, synthesizing my live

[227] Simply connecting to the interface of the hall's loudspeaker system brought unforeseen technical challenges, some of which were worked on up until the day of the performance.

playing with materials from the fixed-media piece. This required careful planning in selecting which flutes I would play and what point in the piece and how to integrate them with the pre-recorded elements.[228] The final setup for the live performance was limited by the number of channels the hall's beta firmware could manage in real-time, as well as the number of microphones we had, adding another layer of complexity to our planning.

To maintain the sonic diversity and depth of the fixed-media version within the constraints of live performance, we carefully selected microphones and their placements:

- 1 KSM-137 Microphone at the Embouchure: Captured subtle breath sounds, whistle tone, and articulation.
- 1 KSM 137 Microphone at the Footjoint: Amplified sounds from vented keys and air movement, particularly important for the piccolo section.
- 1 DPA 4061 Microphone on a Clip: This microphone was used for quick switching between the C Flute and Alto Flute, allowing for quick transitions between instruments without detracting from the immersive experience of the performance.
- 1 DPA 4061 Microphone in a Plug: Used to capture sounds of the "stopped flute," this setup involved a microphone embedded in plug that could be inserted into the end of the flute. This was crucial for capturing the internal sounds of the flute, amplifying sounds that are typically inaudible in traditional contexts.

This microphone setup for the live performance was designed to re-create the richness of sound in the fixed media version and mirrored the setup of the recording sessions.

Another aspect of performance logistics we had to solve was how I would monitor my playing during performance. One of the challenges of live electronics and amplification is that performers often need to hear the raw microphone input, their own playing as it sounds in the hall, and any processing done by the speakers. Traditional in-ear monitors that function like earplugs block out sound, requiring that the performer gets a monitor signal sent to them. In the case of *Morphés II*, which featured unprocessed, processed, and pre-recorded materials spatialized throughout a hall, I would also need to hear the hall through unobstructed ears. Some

[228] The choreography of this mirrors the way *Strandlines* ultimately involved electronics as a way to fill the time Östersjö needed to re-tune the guitar.

performers solve this by wearing a monitor only in one ear, and/or taking them off during certain parts of the piece. We solved this by using a unique in-ear monitoring system I now use for all my live performances, which can pass-through sound from binaural microphones embedded in the monitors themselves.[229] This system features a belt pack with volume buttons that allowed me to control the degree to which the monitors allowed me to hear the room while I was performing.[230]

Another excerpt from our work sessions that illustrates how we integrated live flute playing with pre-recorded materials is from May 6, 2023, where we discussed how to produce beating effect without using synthesized audio to complement the sounds produced by my voice and flute playing:[231]

> Theocharis: "You know, [when] adding the whistle tone, the texture changes. It's a different color. Are we interested in changing the color, or building on top of the pure tone? There are two directions: either changing [the flute sound] into a whistle tone and then changing the timbre and the texture, or creating the beating that is coming with the tape."
>
> Alexander: "Can you create some beating?"
>
> Theocharis: "Well, there's two ways, I think. Either I can create the beating, maybe recording or playing and then playing back, pitch-shifted. Or just adding a C2 or something, like an oscillator. But it wouldn't be the same [timbre]."
>
> Alexander: "I think recording and pitch shifting is probably the best, and having that enter [the texture]."
>
> Theocharis: That will work, maybe recording your first instance [that you play]. It can happen live or it can [be] pre-recorded. Or I can record your first instance and then [play it back] pitch-shifted. The second step would be to create beating. The natural way would be to create the beating with your voice."

[229] https://asiaudio.com/products/complete-3dme-btg2-system-in-ear-monitor-system
[230] In addition to adjusting volume on the belt pack, the system includes an iOS app that allows the user to create custom presets for volume levels and equalization. In performance, this allowed me to independently adjust the volume of the signal being sent to the monitors, with the volume of the passthrough audio from the hall.
[231] Beating in music occurs between two sounds of slightly different frequencies, which I discussed in an earlier section.

> Alexander: “That’s what I thought. But it’s… I can’t sing that low.” [Tries singing and playing into the flute]
>
> Theocharis: “I don’t think the voice should be introduced at the beginning [of the piece]. So let’s not do that. Let’s create beating via recording the first instance of the pure tone, and then by playing back pitched-shifted live. Okay, and then from there maybe that can happen a couple of times. Some [pitches] fade in and fade out. It’s like breathing, and then that will lead to the [pre-recorded] tape again. Cool. Okay, let’s just start then.” (Alexander Ishov and Theocharis Papatrechas, May 6, 2023)

This segment highlights our problem-solving strategies and demonstrates decisions we faced when translating *Morphés* into a live performance setting. This process involved many more instances like the two excerpts shared above, which tackled technical issues related to operating the electronics and audio spatialization, logistical considerations for managing multiple flutes and microphones, and artistic discussions about pacing. These meetings culminated in two days of tech rehearsals in the hall on June 1 and 2, where we integrated all of the components we had previously rehearsed. The performance of *Morphés II* on June 3, 2023, was the concluding work on my final doctoral recital at UC San Diego, which also featured works by Kaija Saariaho, Toru Takemitsu, George Lewis, and a co-composed work with Wang Ziyu.

As of June 2024, Theocharis and I are in early stages of planning *Morphés III*, which aims to create a binaural version of the project for online experience. We are also seeking venues to present new versions of the work. One of our future goals is to develop a version that I can perform independently without Theocharis, which requires creating a patch that I can operate myself. This is a challenge due to the complexity of managing the spatialization mix in real-time while performing.

4.7 Discussion

The structure of *Morphés II* was influenced by the previous collaborations between Theocharis and me, our individual interests, the evolution of our work as we developed

PrismaSonus, and the feedback we received from audiences at *Morphés I* and the two conferences we presented at. Each successive experience in our collaboration built upon the last, creating a cumulative dialogue. As discussed in previous chapters of this dissertation, communities over time develop idioms that guide instrument use and structure work processes.[232] My interactions with Theocharis built on our history of a multi-year collaborative process, allowing us to reference sounds, techniques, and concepts from earlier stages of our work. This has been a depth of engagement I had not experienced in my previous, more self-contained projects with other composers.

During a meeting on November 16, 2022, while working on the fixed-media work *Morphés I*, I mentioned to Theocharis my memory of a sample we had recorded earlier that year. I felt this sample would integrate well into this scene of the piece, although I was unsure of the specific clip and recording session it had been recorded in.[233] I did remember the overall texture and instrument used. Our documentation enabled us to find this sample, labeled Bass_Flute_Detuned_Singing_7, which triggered memories of its original recording, and allowed us to revisit our notes from that day. This multilayered system of documentation helped reinforce the relevance of our materials, creating an ongoing dialogue between our current and past work.

In addition to aiding the production process, our documentation added context that situated this sample within the broader performance practice we were developing. In Chapter 3, I discuss how Khyam Allami noted that software and hardware features, as well as sample libraries, often lack context for the specific purpose of their features. Our documentation not only connected sonic materials to their specific context but also their intended artistic purpose.

[232] See Section 1.3.1 for more on how communities develop idioms.
[233] Like how Östersjö suggested a technique for Karpen to explore.

Because of how connected our materials are to the specific performance practice Theocharis and I developed, I have been hesitant to publicly share the full sample library we created without fully documenting the purpose of each's sound, which is a future goal of mine. Decontextualizing these sounds from the context of our collaboration would significantly alter their meaning and impact.

Unlike my project with Theocharis, *Strandlines* was not originally envisioned as an electroacoustic piece. Instead, electronics were added to the work to solve a structural issue that arose during the collaboration. Because *Strandlines* is a single-movement work that involves multiple tunings, Östersjö needed to retune the guitar mid-performance. Karpen wanted Östersjö's act of tuning to be "theatrical and intentional," so it would not seem like mere tuning (71). One particularly challenging retuning required the performer to disengage from the act of performing. They decided to incorporate electronics to obscure the retuning process. The electronics thus became a structural element of the composition, used to bridge two sections of live playing. Karpen proposed recording the live materials and using those materials to create a cadenza (solo material) for the electronics, allowing Östersjö to retune his instrument without distraction (§4.3). Adding the electronics creates another layer of listening. Karpen frames Östersjö's tuning as an act *on the instrument* abut aims to conceal it.

In our project, electronics were a central aspect of our collaboration. In the live performance version of *Morphés*, we faced challenges due to the logistical limitations inherent in live performance. Our use of electronics as a structural element shares similarities with *Strandlines*. For instance, during a specific section of *Morphés II*, I perform a piccolo solo using a technique that involves plugging the end of the piccolo and venting air from individual keys. Prior to this scene, I am playing on the alto flute, and need time to make the switch between

instruments.[234] This texture was present in the fixed media *Morphés I*. Once these materials begin, it signals the activation of the next scene by Theocharis. Materials for the pre-recorded track were derived from the fixed-media piece, which I engage with in the live performance. As the scene intensifies in its density, Theocharis starts sampling my playing in real-time, which is layered on the pre-recorded materials. At a certain point, I finish my solo, and Theocharis plays back the sampled materials, creating the impression for the audience that my playing has activated the speakers. This gives me time to stop playing, put the instrument down, and switch to the concert flute for the next section. We utilized electronics not only to bridge the pre-recorded and live playing, but also for structural effect, similar to the use of the electronics cadenza in *Strandlines*.

Live performance introduced many additional factors that complicated our project, aspects I aim to explore further in future stages of my work. How did live processing influence my perception of sound? What filtering techniques did Theocharis employ to integrate my live playing with the pre-recorded materials? How do other producers and performers of electroacoustic music integrate elements recorded in different recording environments? Additionally, I plan to investigate the spoken and unspoken rules that guided our decision-making process, shedding further light on the dynamics of our collaborative practice.

4.8 Conclusion

Morphés II represents the conclusion of this stage of collaboration between me and Theocharis Papatrechas. This chapter discussed the evolution of our work, from the initial recording stages which began in October 2021, up to the live performance in June 2023. The iterative nature of our work process, alternating between recording, listening, categorizing, and

[234] This is described further in Section 4.6.

reflecting, highlights the cyclical nature of long-term artistic collaborations. The methodology we developed to structure our work not only generated creative output but also solidified the framework guiding us to each artistic goal. The documentation and categorization of our sound library allowed each technical and artistic decision to be informed and purposeful, enriching the impact of the final compositions.

Throughout the production process, we engaged with a wide range of audiences in a variety of settings, including academic music conferences and interdisciplinary arts festivals. Each setting in which we presented our work provided us with a lens to reflect on our progress, influencing successive stages of the project. I personally found the process of preparing presentations to be incredibly satisfying, which has opened my practice to presentation settings away from my typical role as a flutist.

Shifting from a controlled studio environment early in our work to the unpredictability of the live performance environment helped us gain further confidence with our materials, deepening trust within our collaboration. Looking ahead, I anticipate *Morphés III* to present its own set of challenges and creative opportunities, as we explore the way our work can be situated in a fully online environment.

Conclusions

The journey described in this four-chapter dissertation mirrors the journey of my research over the course of the last four years. It encapsulates a significant portion of my scholarly interests which complement my primary identity as a flutist. This document, part of my larger portfolio of work[235] completed as a graduate student at UC San Diego, represents my evolution from a performer primarily working within traditional ensemble settings, to a co-creator, collaborator, and independent scholar. It collectively gathers materials I take with me into the professional world, laying the foundation for future explorations, publications, conference presentations, and course proposals. This work has also helped me engage with my own identity as an artist, creating a platform for exploring sides of my curiosity and artistry previously under-examined in my practice.

The narrative of this work was shaped by an ongoing dialogue with my collaborator, Theocharis Papatrechas, who deeply influenced the development of *PrismaSonus* and its resulting compositions *Morphés I* and *Morphés II*. I believe this work has helped me become a better listener, collaborator, and presenter, committed to shaping the future direction of the field of music performance, composition, and scholarship.

I have shared how my interdisciplinary engagement with fields outside of music has given me a broader perspective on my practice, demonstrating how concepts from human-computer interaction, cognitive theory, phenomenology, and digital musicology not only fueled my artistic and intellectual curiosity, but informed our project's approach to capturing,

[235] This includes 2 full-length solo recitals featuring newly-commissioned works, 2 major chamber music recitals, 2 album recordings (one of which is currently in progress), countless additional ensemble and chamber music engagements, premieres, and interdisciplinary projects.

processing, and documenting sound. This has helped me situate my work within a broader academic and artistic community, opening new venues for future exploration.

A central aspect of my work has been exploring the role of technology as an enhancer of musical creativity and interaction within the collaborative environment. In my work, technology was used to explore the acoustic properties of the flute, engage with the habits guiding my performance practice, and reimagine the environment in which audiences are situated. Looking ahead, I am eager to apply the terminology and methods I have embodied to analyzing collaboration more broadly. I am especially interested in exploring how music institutions structure performer-composer interactions, and how my work can engage with ongoing discussions about the future of composition and contemporary music pedagogy.

Although this work was not part of my dissertation, I recently read *Composition in the Digital World* by Robert Raines, which offers perspectives on how technology is shaping contemporary music composition. This interview book explores the broadening in the backgrounds of composers, and the wide range of technological competencies and interests they bring to their practice. It engages with technology's impact on pedagogy and composition, discussing various approaches to integrating digital tools into existing practices. Throughout the book, there is a recurring discussion about technology serving as a creative collaborator as opposed to a crutch; an integral, yet balanced part of the creative process. This approach mirrors the quote I shared from guitarist Derek Bailey in Chapter 2, which describes musical instruments not merely as a tool but as an ally, a creative partner within the collaborative process.[236] The book also addresses concerns about the expressivity and authenticity of digital tools versus

[236] For more, see my Introduction to Chapter 2.

acoustic instruments, and the impact of music technology on the broader music industry (Raines, 2015).

Although Raines features several composer-performers in his book, it is still a composer-centric perspective on technology. I am interested in situating my work within a broader discussion of performer-driven analyses of musical practice, along the lines of Stefan Östersjö's *Listening to the Other*. I hope to dive further into texts that feature practitioners self-analyzing their work. I believe continuing down this path will further deepen my ability to engage with collaborators outside of my direct field. It also represents a trend I see in contemporary music practices where the roles of composer and performer are increasingly blurred. While I remain strongly tied to my practice as a performer, I see a future in which I can use my identity to advocate for a broader approach to teaching composition including not only the perspective of composers but also the perspective of performers.

Another important insight from this project has been the fluidity and evolution of my roles within the artistic development process. The scope of the work shared in Chapters 1-3 of my text represent the influence of theory on real-world application. Chapter 1 provided me the framework for analyzing the role of instrumental affordances, feedback, and habit on shaping my musical experiences. Chapter 2 examined intentional interventions in the performer-instrument relationship, ways alteration can shape the collaborative process, and the role of documentation as a method for deepening understanding of the collaborative process. Chapter 3 demonstrated the far-reaching impacts of decisions made throughout the design process, as well as presenting specific case studies of how artists can appropriate technology for the needs of their community. Finally, Chapter 4 told the story of my latest collaboration with Theocharis Papatrechas, demonstrating the way concepts outlined influenced the final development of the work.

Looking ahead at the next stages of my work with Theocharis, the planned development of *Morphés III*, a binaural rendition of our work, represents the next stage in our artistic development, broadening the accessibility of our work. As the dialogue between me and my collaborator will evolve, so too with the rest of my performance practice. I recognize the ways my exploration of music technology is only beginning, and anticipate how, with time, I will move even further towards projects in which I embrace all aspects of my artistic voice, widening what it means to be a flutist, collaborator, educator, and scholar in the world of 21st century music-making.

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