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Computational Paideia through the New Media Arts:

Toward the embodiment of value, meaning, and holistic thinking in information

A dissertation submitted in partial satisfaction of the

requirements for the degree

Doctor of Philosophy

in

Media Arts and Technology

by

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Committee in charge:

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June 2022

The dissertation of Alexis Story Crawshaw is approved.

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March 2022

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2010-2012	M.A. in Music: “Musicologie, Création, Musique et Société”: Theory and Research, Université Paris 8 (Highest Honors).
2008-2010	Graduate Music Study in Composition, La Schola Cantorum de Paris.
2004-2008	B.A. in Music Composition, The College of Creative Studies, University of California, Santa Barbara (High Honors).

PROFESSIONAL EXPERIENCE

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2008 First Place, Sherril C. Corwin Award for Music Composition in the Electroacoustic Division: "like a submarine in a dream."

SELECTED PUBLICATIONS/PAPERS

Crawshaw, A.S. (2022, Expected). "La musique électro-somesthésique : approches spatiales. Théorisation et expérimentations créatives" [Working Title]. Dissertation, Université Paris 8, Saint-Denis, France.

Crawshaw, A.S. "Electro-Somaesthetic Music: Spatial Approaches" in Proceedings of the 2020/2021 International Computer Music Conference, Santiago, Chile, 2021, pp. 140–147.

Crawshaw, A.S. & Novak, M. (2018, Oct. 5–6). *Paper/talk: "Bridging the ancient to the digital contemporary through algorithmic intertextuality*." Presented as part of the Distributed Authorship Conference at UCLA, California.

Yan, J., Crawshaw, A.S., Rincon, G.A., Eds. *White Noise Media Arts and Technology Program 2016 End of the Year Show (2016) Catalog.* Santa Barbara, CA: Media Arts and Technology Program, UCSB, 2016. Print.

Crawshaw, A.S. "Towards Defining the Potential of Electroacoustic Infrasonic Music," in Proceedings of the 2014 ICMC-SMC, Athens, Greece, 2014, pp. 269-276.

Crawshaw, A.S., Lamp, R., & Fdida, N. "Avant-première de 'La galerie d'ondes,' une installation sonore et visuelle pour explorer l'intersensorialité des infrasons," in Actes des Journées d'Informatique Musicale (JIM 2013), Saint-Denis, 2013, pp. 183-186.

Crawshaw, A.S. (2012). "Le potentiel de la musique infrasonore: avec quelques applications intersensorielles," Second-year Master's thesis, Université Paris 8, Saint-Denis, France.

Crawshaw, A.S. (2011). "L'infrason en Art," First-year Master's thesis, Université Paris 8, Saint-Denis, France.

SELECTED ARTWORKS

Installations/Performances

"*Kroumatograph No. 4"* (2019): Installation. 2019 International Computer Music Conference and New York City Electroacoustic Music Festival (ICMC-NYCEMF). Fridman Gallery. (New York City, NY).

"Moon Moons" (2019): transLAB Collaborative Performance-Installation. M.A.D.E., 2019 End of the Year Show, Media Arts and Technology, UCSB. transLAB, CNSI Building, UCSB (Santa Barbara, CA).

"*Superadditive Musical Amuses-Bouches"* (2018): Installation in collaboration with Barbareño. Invisible Machine, 2018 UCSB Media Arts and Technology End of the Year Show. CNSI Building, UCSB (Santa Barbara, CA).

"<Future::Invisible::Tripping::Machine>" (2017–18): transLAB Collaborative Installation. Project Immersed. LA Live House (Los Angeles, CA). AND: June Santa Barbara 1st Thursday event. Invisible Machine, 2018 UCSB Media Arts and Technology End of the Year Show. Studio F, SBCAST (Santa Barbara, CA).

"Asclepias" (2018)*:* Installation in collaboration with brooke smiley and Barbareño. Alliance of Women in Media Arts Conference at UC Santa Barbara. CNSI Building, UCSB (Santa Barbara, CA).

"*Accords No. 2"* (2017): Installation with visuals by Mare Hirsch. October AIA Architect Walk event, October Santa Barbara 1st Thursday event. Studio F, Santa Barbara Center for Arts, Science, and Technology (SBCAST), (Santa Barbara, CA).

"*Kroumatograph No. 3"* (2017): Installation. May Santa Barbara 1st Thursday event and (in collaboration with Barbareño) Re-Habituation, 2017 End of the Year Show, Media Arts and Technology, UCSB. Studio F, SBCAST (Santa Barbara, CA).

"To Eleusis, To Tanayan" (2017): Performance in collaboration with Zachary Rosen, Timothy Wood, and Alan Macy. Re-Habituation, 2017 End of the Year Show, Media Arts and Technology, UCSB. CNSI Building, UCSB (Santa Barbara, CA).

"ο της αποστηρίξεως ορχηθμός (The Dance of the Fulcrum)" and *"Kroumatograph No. 2"* (2016): Performance, Installation in collaboration with Maud Watel-Kazak and Timothy Wood. White Noise, 2016 End of the Year Show, Media Arts and Technology, UCSB. CNSI Building, UCSB (Santa Barbara, CA).

"κρουματογραφή (Kroumatograph)" (2016): Installation. SBCAST inaugural event, the March Santa Barbara 1st Thursday event, and the "Dance Anywhere" event in

collaboration with the Santa Barbara Centre for Aerial Dance for their “Floor to Air Festival.” Studio A, SBCAST (Santa Barbara, CA).

“Trans-Sensory Music” (2015)*:* Performance. Open Sources, the 2015 End of the Year Show, Media Arts and Technology, UCSB. CNSI Building, UCSB (Santa Barbara, CA).

“La Galerie d’Ondes” (2015): Installation in collaboration with Bob Lamp. Dionys’hum, inaugural event of the new building of the Maison des Sciences de l’Homme, Paris Nord (La Plaine Saint-Denis, France).

“Vibrotactile Sleeves” (2014): Installation in collaboration with Ryan McGee and Randolph Crowson. 2014 End of the Year Show, Media Arts and Technology, UCSB. CNSI Building, UCSB (Santa Barbara, CA).

“i’m thinking of an object you can find in the metro” (2012)*:* Performance (jury selected), solo composition. Concerts de l’atelier de composition. Institut Cervantes (Paris, France).

“Création Mondiale” (2011): Performance. Solo composition for La Chorale de la Cité Universitaire and small orchestra, conducted by Maestro Italo Marchini. Salon Honnorat, Cité Internationale Universitaire de Paris (Paris, France).

Exhibited Works

“the bad news is that you previously missed the importance of this event”: Installation. 2019–2022. M.A.D.E., the 2019 End of the Year Show, Media Arts and Technology, UCSB. CNSI Building, Hallway, UCSB (Santa Barbara, CA).

“CADUCEUS/KHPYKEION”: Print of 3D sculpture. 2017-2018. Crossings and Boundaries. UCSB Interdisciplinary Humanities Center PLATFORM Gallery (Santa Barbara, CA). 2015. Morphogenesis Workshop. Open Sources, 2015 End of the Year Show, Media Arts and Technology, UCSB. CNSI Building, UCSB (Santa Barbara, CA).

Demonstrations

2018 (March 27) “*A Vibrotactile ‘Musical Sculpture’ in VR Exploring Apparent Motion Illusions of Frequency Beating and Changing Phase":* Demonstrations at the 2018 IEEE Haptics Symposium (March 25–28, 2018) in San Francisco, California.

Archives

Committee on Media and Performance Art Funds. The Museum of Modern Art, New York. Photography work of *Huddle* (Simone Forti, 1961), performed at Cal Earth (2018), led by brooke smiley.

ABSTRACT

Computational Paideia through the New Media Arts:

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by

Alexis Story Crawshaw

Paideia, a Classical ancient Greek notion of education, encompassed both holistic formal instruction and art (particularly poetry) as means to develop cultural values and understanding. This dissertation examines how the new media arts—as a transdisciplinary and computational field—can be leveraged to fulfill a contemporary notion of *paideia* in both its practice and instruction, demonstrated through respective artistic and pedagogical proofs-of-concept. Specifically, we analyze the ways in which the computational platform can facilitate the creation and readability of causal relationships across information to embody value, meaning, and holistic thought. We examine how we design affordances—formal qualities that constrain an object's possible uses by an agent—for guiding participant behavior (observed or enacted) and interpreting meaning as part of experiential learning. We will achieve this through artistic installations and objects. We discuss pedagogical strategies with a cross-disciplinary conceptual framework to support holistic thinking through digital design-based learning. We compare these new efforts toward paideia with ancient Greek media and approaches.

Toward imparting values, the cybernetic nature of physical computing and other interactive systems offer a means to model or to incentivize (and thus train for) certain kinds of participant actions and behaviors. We present an original body of performance and installation work designed to cultivate the values of social cooperation and attention to nuance.

Toward shaping meaning, we propose that complex non-verbal ideas may be communicated by strategic formal design that 1) follows “natural [somatic] mappings” or culturally established associations and/or 2) explicitly defies them, directing attention through “strangeness.” To this end, through a theoretical framework and artistic proofs-of-concept, we explore how computation facilitates abstraction and metaphor via operations of mapping, analysis, and execution.

Lastly, to promote trans-paradigmatic thinking, media arts education and practice through fictional worldmaking can provide a means for organizing complex knowledge and systems. We discuss conceptual framework contributions within the THEMAS (STEAM + creative Humanities) pedagogical model (as originally conceptualized by Marcos Novak).

In these ways, building upon ancient roots, this research both informs the field of media arts and technology and informs education through design strategies for (artistic) experiential and making-based learning.

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1. INTRODUCTION

1.1 OVERVIEW

In ancient Greece, art was seen as serving a critical civic function, promoting cultural values and philosophical reflection about them. Given this purpose, their notion of education encompassed artistic encounters and knowledge. On the more instructive side of education, the collection of subject areas (including music and athletic training) were viewed as performing complementary roles in a common task of shaping character.

As such, artistic study and its practical instruction (through music, in conjunction with other subjects) was not necessarily pursued merely for art's own sake but rather with a greater common purpose in mind: to form the ideal citizen.

In contemporary art practice, art education, and general education—at least in the United States—such a longer view is not an explicitly, culturally-shared understanding or motivation. Within U.S. public education, motivations of civic, ethical, and philosophical inquiry do not presently shape artistic education nor a common vision of how individual disciplines of knowledge might work in concert—let alone how these areas might meaningfully interrelate at all. The arts alone are under-valorized and underfunded in comparison to the highly promoted STEM (Sciences, Technologies, Engineering, Mathematics) fields. While certain arts education groups and efforts may stress such greater cultural goals in part or in whole, these objectives are not common knowledge, nor are they systemically codified.

In our present society, we are in no less of a need than the ancient Greeks for critical reflection about our cultural values and understandings. With the electronic and digital ages, technological advances and their exponential rates of evolution have infiltrated and mediated nearly every aspect of our lives in ever increasing degrees and in ever-changing manners. This has never been more immediately clear than for those who were able to work remotely during the pandemic. Our smartphones alone are effectively handheld limbs. Through many lenses, the human experience is in high flux and we are not well-enough philosophically equipped to steer the change, let alone parse how we are changing in real time.

Yet with electronic and digital technologies, also comes the potential for powerful tools with which to probe, measure, and shape such change and ourselves. Technological advances in the recent decade have helped increase real-time speeds, portability, and immersion. Trackable virtual reality software is now commercially available and relatively affordable. Open-source modeling and animating platforms like Blender[1] facilitate rapid prototyping and the production of virtual environments and assets. Wearable physical computing systems—portable sensors and egocentric displays—help create immersive virtual experiences and explore the notion of *avatarchitecture* (Novak, 2002) with novel sensoria and embodiments. Never before in history have we possessed such profoundly self-analytical means at our fingertips. Importantly, we find such tools in use in

[1] Accessed 03/18/2022: https://www.blender.org/

contemporary art practice within the field of the new media arts (NMA), also termed here media arts and technology (MAT).

In addition to this upgrade in technology, since the Classical period, philosophical inquiry has bifurcated into numerous fields, research methodologies have become more codified within them, and across these various approaches to knowledge-building, we have come to reflect more on the very nature of learning and of creativity, insofar as the latter serves the creation of new knowledge.

Since the ancient Greeks, we now possess greater technological means and intellectual understandings with which to evaluate who we are and to realize changes (after envisioning who we want to be).

In our own present time, how might our contemporary digital tools combined with contemporary understandings of learning and cognition elevate such pursuits of cultural exploration in the new media arts? How can the field of the new media arts with its current or new tools and philosophies promote the cultural aims of paideia more efficaciously (for what ends)? What advantages might these tools and concepts confer to artists beyond the media and approaches available to the ancient Greeks and others since?

This entails an incorporation of aspects of the humanities into the new media arts. We define humanities as a cluster of disciplines that encompass the study of collective human activities (i.e. culture) including the disciplines of philosophy, politics, history, language/linguistics, literature, religion, anthropology, among other areas. As a word, “humanities” centers the human. However, we encourage a more abstracted approach to the notion of the human and the humanities—that of

intelligent agents and their collective activities—a framing which might be more useful from a research standpoint and in coming years as technological advances challenge the boundaries of what is “human” (e.g. artificial intelligence and transhumanism—the latter with respect to technologically extended sensoria, cloud consciousness, extended lives, and bionic Ship of Theseus problems).

This focus on the humanities takes a separate path than the prevailing scholarship of the digital humanities, which tends to be more data-driven and focused on the analysis of existing works. The aim here, in contrast, is more creative and collaborative, closer in spirit to the practices of critical making and speculative design, which both encourage reflections on society through making.

The term paideia references an ancient Greek approach to and concept of education, which—starting in the classical period—included both cultural learning and formal instruction. It entailed an awareness of the role of art, specifically poetry, in shaping and “confirming” the character of the individual and societal collective (Ford, 2002). It included an idea of artists/poets as teachers. In this period, paideia was also characterized by a holistic multi-disciplinary approach to instruction, which included music.

Within the philosophy of art, there is an argument for how art itself inherently entails experiential learning on the esthesic/audience side and practice-based research on the poietic/creating side. The contemporary philosopher Alva Noë defines art (in its true sense) as a “strange tool”: a philosophical pursuit aimed at bringing aspects of the human experience and our notions of reality into relief (Noë, 2015). By this definition, a kind of learning and research is necessary to (true) Art

itself, an idea that also aligns with the ethos of paideia. We should add that this aim of art to diverge from the known and familiar also necessitates creativity.

The practice-led research and research-led practice methodologies that characterize contemporary arts research reinforce the notion of knowledge-building through art—knowledge-building that reaches outside of artistic practice itself (Smith & Dean, 2009).

The (digital) new media arts are a contemporary form of artistic practice which entails the computational platform as part of its realization. Examples of its praxis include virtual environments, data representation, multisensory algorithmic expression, and the modeling and fabrication of objects.

Returning to our previous question, given this contemporary art practice, how can we aspire to a contemporary version of paideia? How should we proceed?

The cognitive sciences along with information theory/aesthetics inform our understanding of the processes of learning and creative thinking. With paideia, we are interested specifically in how these insights may be applied to art that promotes cultural learning (values and meaning) and in disciplinarily holistic art education that promotes creative thinking in developing future culture-shapers/makers.

Additionally, an examination of computational approaches to learning and their limitations insofar as human cognition is concerned might benefit both a shaping of human education through art, but also inform efforts of those wishing to imbue AI with more human-like qualities.

Given the state-of-the-art research, how might we better leverage this knowledge through the digital platform to achieve a modern notion of paideia?

Through this knowledge and the unique advantages of digital tools, how might the media arts be uniquely poised to effectively develop and transmit cultural values and meanings? How might media arts education be especially suited to promote holistic thinking in this context?

This dissertation highlights the unique and creative ways that the computational platform can construct and aid in the interpretation of value and meaning and can promote holistic thinking. Within an artistic context and through objects and installations, this investigation centers around the conscious design of affordances—how the formal properties of mediated objects including information systems shape probabilities of human action. To operationalize holistic thinking, this investigation also includes transdisciplinary pedagogical strategies and frameworks within a creative computational and design approach.

In order to construct this new research and pedagogical model, we are tying together humanities with the new media arts (computer science + the arts), cognitive science, education, and the classics.

1.2 MOTIVATION

The ancient Greeks understood the importance of art (especially literature) and formal instruction in developing cultural values and understandings through the idea of *paideia*. Their notion of education was rooted around a civic purpose. Since the Classical period of ancient Greece, and in modern times, education and the nature of learning have become major areas of research, providing insights that confirm the ancient Greek notion that cultural objects and activities profoundly shape our values and meanings.

Contemporary theories of learning reinforce situated understandings of mind. The mind is not just in the head but extends to its context, which includes the body, culture, and physical surroundings as well as how these elements interconnect. In particular, the cognitive sciences, through a number of complementary theories, point to a view that consciousness is constructed through transactions with the world around us. This especially entails our embodied engagement with artifacts (human-made media). It is useful to understand artifacts in terms of the idea of affordance.

Artifacts are conceptual and material cognitive entities defined by their affordances. The term affordance describes how formal features facilitate or constrain the particular actions of a given person or agent. Affordances are determined by the situated factors of body, culture, and environment. Through these factors, artifacts possess different sets of probability weights for actions, including thought. Moreover, artifacts are initially shaped by and reencountered within different social-historical contexts, which in turn impact our thinking and acting.

Artifacts include tools for interaction with the physical world directly (such as hammers or telescopes), tools for representing the world (through language and action scripts, like the sequence of actions that shape a trip to the grocery store), and self-contained systems for complex analysis of the world (such as artistic works which are arguably necessarily allegorical to the world, whether to abstract or concrete ideas).

These connections imply that authorship over our artifacts and environments gives us authorship over our minds. As such, the idea of a kind of cultural literacy becomes important to both read and write these relationships, through critical analysis and creative design.

Toward this end, we are interested in the exploration of non-verbal cultural learning through computational art. In this way, a framework of cultural learning may also provide a valuable entry point for incorporating the humanities into the new media arts. There's a promising role for art and computational platform to probe this relationship between ourselves and our situated existence, and how these relationships lead to what we value (i.e. how we prioritize certain action outcomes) and how we create meaning (create relevant—i.e. situated—relationships among concepts). This will help us better refine and operationalize definitions of value and meaning for computational and philosophical exploration via art.

1.3 PROBLEM STATEMENT AND RESEARCH QUESTIONS

Artifacts (of all disciplines) are value-laden and the “fundamental constituents of culture” (Cole, 1996; Katz, 2011).

Without critical cultural literacy education (to interpret and make artifacts), we become vulnerable to values and meanings set by others (intentionally or unintentionally) perhaps toward non-beneficial ends. These ends may include monetization or the creation of other asymmetries of power and control, for example by means of advertising or propaganda. We may also be more susceptible to memetic social contagion, including misinformation that threatens our quality of life or our very survival.

Emerging educational trends such as STEM and STEAM, do not substantially or systematically address the transdisciplinarity of their parts, much less the humanities and its related transdisciplinary relevance.

The field of the digital humanities has many definitions, some of which do not presently meet this need in the (digital) new media arts.

Information aesthetics, situated activity/affordance theory, and conceptual metaphor/blending are all active research areas that can connect cultural learning, creativity, and design, yet they have not yet been cohesively integrated theoretically and practically within (digital) new media arts.

This leads us to several research questions:

How can we fashion our artworks more deliberately as design tools to help bring about the society we desire?

How can both the affordances of the computational platform and contemporary understandings of learning and creativity facilitate paideia—specifically, the development of cultural values and meaning through artistic works and holistic instruction?

How might a humanistic framing of digital art practice inform educational reform efforts, particularly those seeking to bridge STEAM with the humanities?

In a holistic educational framework, all knowledge is inherently present, but not all ideas can be emphasized equally: are there certain fundamental notions and approaches that can help better organize collective knowledge and practices with cultural learning in mind?

1.4 RATIONALE

Our argument and rationale for this research is that the new media arts, in uniting arts and computation, possess unique potential for probing and exploring cultural learning. We see this in Alva Noë's definition of art, which defines it as a philosophical pursuit bringing experience/reality into relief via "strangeness" (Noë, 2015). Its definition implies learning, research, and creativity. As a practice-based field, we can exercise both the analysis and making components required for cultural literacy, and have the creativity to design related experiments and prototypes.

Through human-designed computation, we can create strange situatedness via causal relationships in interactive systems and data mapping.

We can tailor paideia to our contemporary mediated thought and aims. These means allow us to explore paideia in ways that were certainly unavailable to the ancient Greeks and that will be more suitable for our times and goals. Their paideia came at a time when thought would have been largely shaped by oration and to some extent, textual literacy (as well as their other media). Now we are moving from textual literacy into more complex systems and patterns of thought with computational and coding literacies. We can also use these modern approaches to adapt paideia to the multicultural and diverse qualities of our societies, exploring the rich heterogeneities of our respective experiences and to promote inclusivity, equality, and equity across these collectives. This approach may help us unyoke ourselves from the anchoring biases of our current world that uphold systemic injustices toward better visions of our imaginations.

1.5 CONTRIBUTIONS

Our proposed contributions can be organized by disciplinary area, although these contributions and disciplines overlap in many respects. These areas include the new media arts (or media arts and technology), classics, education, and the cognitive sciences. It should be noted here that the cognitive sciences and education overlap in the area termed the learning sciences.

We advance the application, theory, and pedagogy of the new media arts; the application and theory of the classics; the application, theory, and design of education; and the application, theory, and pedagogy of the cognitive sciences. We will address further nuance of these points in Chapter 3.

1.6 THEORETICAL FOCUS

To respond to our research questions, we need to better understand how cultural learning and learning in general take place. Additionally, we need to address how cultural making as part of a cultural literacy might be expanded and better supported through such principles of learning and new technologies. As such, for our literature review, we've looked at theories of learning and creativity across our above disciplinary and cross-disciplinary areas, taking into account relatedly, theories of communication and meaning.

Given this overview and across these different areas, four key themes keep reemerging. These themes are as follows: situated mediated action, conceptual structure, balance of familiar/unfamiliar, and compression through strangeness.

Situated Mediated Action (with situatedness referring to our interlacing contexts of environment, embodiment, and culture)

We learn through our actions and feedback from the world around us. For example, these interactions are fundamentally shaped by the affordances of our physical environment (natural and human-made) and the ways they meet the morphology of our human bodies, which includes our sensory windows and their expansion/extension onto the world, how we process this information and construct a world-model, and how we can kinaesthetically engage and transform our environments. Our cultural tools extend and modulate our bodies in further ways. For example, the umvelts of a tall person with blindness and a cane or a short person with a robotic, prosthetic arm will differ. Cultural rituals and cultural everyday

experiences further constrain the range of possible movements into more socially desirable ones, for example ones emphasizing balance or stillness.

Conceptual Structure

Abstract concepts possess structure and formal relationships which anchor back to concrete and situated ideas or possess structures created from blending other abstract ideas. These structures facilitate mediated metaphor. Our everyday experiences and habits bootstrap abstract thinking. For example, George Lakoff and Mark Johnson demonstrate how language is replete with relative spatial metaphors and mappings that tie into experiential associations (Lakoff & Johnson, 1980). For example, in English at least, concepts with positive valence are ascribed "up" metaphors versus negative ones which are "down," which might tie into healthful, energetic human body states like standing up versus ill or deceased states where standing is not possible. A society of super-intelligent fish with air bladders, where energy is needed to remain below the surface might map their metaphors inversely, where good is down and bad is up.

Balance of Familiar/Unfamiliar

Next, there is balance between the familiar and the unfamiliar. In learning, we want to go from what is already known to what we do not yet know. It's about turning the unfamiliar into the familiar and it is an ongoing process. The familiar is situated—the context we are starting from defines what is familiar to us: what is ground to the figure of the new. We can think about this in terms of music. If we

listen to music that is too complex, we might not understand what's going on and find it unlistenable. If it's too repetitive, it might be boring. With music that challenges us a little bit at a time with still enough familiar context to hold onto, we can train our ears to recognize increasingly complex structures and patterns.

Compression through Strangeness (including fiction and counterfactuals)

Lastly, and relatedly, strange examples help compression and pattern-recognition. Especially by creating fictional variables and transpositions, we can reveal common structure through an abstraction. Fiction and counterfactuals (i.e. alternate possibilities) can also help with creating significant unfamiliarity toward this end. Weirdness provokes insight about common abstracted parameters. This approach is found in art, fiction, as well scientific and philosophical thought experiments. Mark Turner speaks about how Marcel Duchamp's "Nude Descending a Staircase" helps reveal a common spatiotemporal structural trajectory through a set of instances that could not actually co-occur in time (Turner, 2006). The well-known trolley problem in philosophy creates a dilemma of potential future realities, whether or not to take action to redirect a trolley that might otherwise hit five people to hit just one person on a second track. This scenario helps us to create an abstraction of how we make ethical decisions and measure stakes. It provides us with principles that can be tested in new situated situations.

Promising Features

These themes hold many promising features as candidates for transdisciplinary fundamentals as part of cultural learning.

Firstly, they each reoccur across many diverse disciplines by means of different methodological approaches. These reinforced patterns lend to their transdisciplinary robustness.

Secondly, these theories can all connect back to situatedness in different ways and through this, they can connect to culture.

Thirdly, these ideas can serve as theoretical tools to help interpret ancient paideia praxis and to develop original new media arts paideia praxis.

1.7 OUTLINE

The organization of the subsequent chapters are as follows:

Chapter 2 will provide a comprehensive literature review in five key parts. 1) The first explores the background of paideia in ancient Greece and its defining features of value, meaning, and holistic thought. 2) From there, we trace contemporary ideas around learning and creativity (including theories of communication and meaning) across the cognitive sciences, education, and media arts and technology. 3) We then look at the new media arts, discussing current intersections with the humanities as well as looking at relevant practice and practitioners with respect to our key learning and creativity thematic areas. 4) The following section briefly reframes the literature review through each thematic lens for added clarity and insight. 5) Lastly, we revisit ancient Greek paideia through our themes, which serve as new analytical lenses.

Chapter 3 discusses our methodological approaches, operationalizing the exploration of each of our four thematic points.

Chapter 4 provides an analysis of our artistic and pedagogical prototypes in terms of how our learning and creativity themes along with the affordances of computational platform advance paideia: value, meaning, and holistic thought. In our artistic prototypes, we explore how computation helps explore value and meaning through our themes. In the second part, we explore the cultivation of holistic thought through pedagogical contributions made to the THEMAS pedagogical model and within the Mediated Worlds THEMAS courses at UC Santa Barbara.

Chapter 5 presents design theory formalized from our prototypes, applying our themes to meaning and holistic thought. We also discuss the application of this design theory within an original Special Topics THEMAS class (E)Utopian Design Tools.

Lastly, we close with our conclusion and future works, examining the extent to which we've addressed our research questions and addressing next steps.

2. BACKGROUND

As our introduction has stated, our aim is to articulate a new theory and practice for cultural learning in the spirit of paideia. In order to do so, there are several key areas to first contextualize. It will be important to understand how to identify and then abstract the key features of this ancient approach, while adapting and tailoring them to our own present times and cultural priorities. For such a contemporary transposition, we'll need to acquaint ourselves with contemporary understandings of learning and the extent to which our present artistic practice and tools (specifically computation) already serve these ends. As a part of this undertaking, in recalling our research questions, we're also trying to look at relevant disciplines to identify fundamental cross-disciplinary trends that can inform the content and operational structure of a new holistic pedagogy. In addition to classics, these disciplines include the cognitive sciences, education, and the new media arts (as the confluence of computer science and art). Given our goals and towards the integration of these disciplines, we're led to several key background questions:

- What are the defining features of ancient paideia and how did artistic knowledge and artistic production contribute to their notion of learning?
- What is the state of art in how learning and original knowledge generation take place? (And what contemporary disciplines are relevant to such an inquiry?)
- In what ways are the humanities and cultural learning, specifically, already present in contemporary art practice?
- What are some prominent cross-threads across these areas?
- To evaluate if these cross-threads can help us operationalize a contemporary paideia: can we analyze ancient Greek paideia praxis through such cross-threads? Does this analysis help explain any strengths of their approach?

This background chapter consists of five key parts aimed at addressing each of these five sets of questions.

In the first section, we will begin with a general framing of paideia in its historical context, i.e. the classics. We will review the particularities that characterized this ancient version and its historical operationalization so that we may successfully abstract its key themes and features.

To follow, the second section consists of state-of-the-art of theories of learning and creativity. We include creativity as it is an integral mechanism of both novel knowledge generation and learning-by-making. Under this umbrella of learning and creativity, we will look at closely related notions of communication, information, and meaning. Our main disciplinary lenses for this inquiry will be the cognitive sciences, education, and the new media arts. In this second part, we will also briefly address other related and relevant theories, including the philosophies of STEM disciplines.

Our rationale for those particular main disciplinary foci is as follows. We include the disciplinary cluster of the cognitive sciences as it is centrally occupied with the study of the mind (which includes learning and creativity). Even though education is already included within the scope of the cognitive sciences (with overlap as the learning sciences), we take additional space to address it, as the discipline itself is concerned with the operationalization of learning. The new media arts (which unites computer science with the arts) is included for several reasons. As a whole, it is important to examine as it is the discipline from which we are conducting this investigation. Secondly, its components have strong intersections with our areas of inquiry. Computer science (another discipline with overlap in the

cognitive sciences) is rooted in questions of learning through communication, as well as artificial intelligence. Arts and creativity are highly correlated, as are ideas around communication, meaning-making, and cultural production. Additionally, the arts are a fundamental ingredient of ancient paideia.

Also, in this second section, as we proceed, we'll highlight emergent thematic trends (the same as evoked in our introduction: situated action, conceptual structure, balance of familiar v. unfamiliar, and compression through strangeness).

Thirdly, we'll focus on important intersections of cultural learning with the new media arts, looking both at 1) previous attempts to integrate the humanities and 2) key practice and practitioners towards a notion of computational paideia.

In the fourth part, we'll reexamine our literature review through the lenses of our four thematic foci (situated action, conceptual structure, balance of familiar v. unfamiliar, and compression through strangeness) for added clarity and synthesis.

Finally, we apply our thematic framework to analyze ancient Greek praxis to examine to what extent these ideas implicitly (or even explicitly) contributed to and supported their notion of paideia.

2.1 ANCIENT GREEK PAIDEIA

We begin our examination of learning and creativity through the discipline of the classics, looking at ancient Greece, particularly in the Classical period.

The ancient Greek notion of education—paideia—was ultimately concerned with the development of the ideal citizen, functioning as part of the city or polis (Ford, 2002).

As it was stressed in the introduction, this conception of education included both art and formal instruction (including creative instruction through music).

Generally speaking, our survey of paideia demonstrates the creation of value, meaning, and holistic thought to be its defining features. These values and meanings often involved action that was embodied and/or culturally situated (e.g. through dance, athletic instruction, ceremonial participation, poetry-making, mythical rewriting). We also see familiar cultural knowledge made strange in some way to create meaning, particularly through mythical rewriting in theater and philosophical dialogue (which we'll discuss further in Section 2.5).

There was an emphasis on promoting cultural values through ethical and civic art and formal instruction. Both art practice and instruction promoted holistic thought and holistic skills in conjunction with the cultivation of such cultural values: artistic practice was multidisciplinary and formal instruction was also multidisciplinary, as we will soon discuss. Additionally, civic instruction and research (through philosophy) entailed practical application and the act of mythical reinterpretation, using myth as a common cultural basis and language with which to create new meaning.

Concerning art, art practice was multidisciplinary, especially within the theater, where music, dance, and poetry were integrally combined in tragic and comedic works alike. Additionally, theatrical performances were couched within civic structures for ethical and civic instruction, where theater festivals served as an occasion for “elaborate symbolic play on themes of proper and improper civic behavior” (Winkler, 1985). The plays leveraged common cultural knowledge (myths) to create meaning, often speaking to themes around civic life and duty (Burian, 1997; Winkler, 1985).

Within art, and in the works of Aristophanes and Plato especially, there is a strong recognition of the capacity of poetry and its formal construction to impart or reinforce cultural values. For example, Aristophanes in his comedic play *The Frogs* (Aristophanes, ed. 2002) weighs the merits of artistic representation of idealized behavior versus that of verisimilitude, as embodied by the respective works and formal choices of tragedians Aeschylus and Euripides, in a fantastical fictional scenario. Within the play itself, the idea that poetry possess the capacity to instruct and inform values is a major explicit focus.

Regarding formal instruction, multidisciplinary subject areas served a collective aim promoting ethical and civic ideas (De Romilly, 1992; Ford, 2002).

Through Plato in particular, it is apparent that the subjects of formal instruction for children were seen as being complementary in forming character. Generally speaking, in Classical Greece, there were but three principal disciplines. These included just gymnastics (athletic training) and music at first, and later, by the end of the fifth century, also grammar (study of reading and writing, particularly with

respect to the poets) (De Romilly, 1992; Ford, 2002). It was this latter component that served as the closest contender to an intellectual education (for a younger age group) (De Romilly, 1992). Additionally, much of the literature of the time (poetry, theater) was sung with music—it is important to understand these works as—effectively—lyrics and librettos. The musical context for these texts was central: these poetic works and "speeches" more generally (Plato, trans. 1968, Book II) were categorized under the notion of music, and not the other way around.

Plato's dialogue *The Republic* exemplifies the ethos of paideia through an educational proposal of mutually dependent disciplines. In his dialogue, the rationale for educational design starts and derives from the desired characteristics and traits of the citizenry. Such desired qualities include that they be a lover of learning, a philosopher, a guardian of the city, moderate, and strong, among other traits (Plato, trans. 1968, 376c). He states that the chief aim of gymnastic and music is not in developing the body and mind, respectively, but the "soul" or character together. For him, it was important to start with poetry to attend to this "soul," which in his view, would help the child better appreciate the value of caring for the body through gymnastic. In effect, training in music would be more likely to encourage an appreciation for moderation that would lead one to gymnastic, but not the other way around.

In his arguments, Plato advocates not only for the censorship (for both youths and adults) of poetic content depicting immoderate behaviors but also of specific formal musical parameters (modes and rhythms) with affiliations to emotional states that he feels do not suit the ideal character of citizens (specifically with a view to the

fulfillment of military duties). Critically, he does not interpret these affiliations as culturally specific but rather as inherent qualities of the parameters themselves. Also importantly, he views the practices of gymnastic and music as necessary to counterbalance one another. He fears music alone would lead to weakness and apprehension of military service, but gymnastic would encourage a more spirited and courageous character. Likewise, musical sensibility is needed to temper gymnastic so as to prevent citizens from becoming too cruel, uncouth, and intellectually incurious.

Furthermore, for the training and development of ideal rulers, Plato advocates for the additional disciplines of the “mathematical sciences” (of arithmetic, geometry, and astronomy) and of dialectic. The mathematical disciplines serve the functional purpose of sensitizing the mind toward “abstract truths” and “true being,” priming it for the study of dialectic/philosophy, which concerns true understanding and is “the science which defines and explains the essence or being of each nature, which distinguishes and abstracts the good, and is ready to do battle against all opponents in the cause of good.”

As such, Plato’s collective conception of the disciplines of music, gymnastic, mathematical science, and dialectic is of a set of somewhat sequenced and yet complementary and interdependent tools for shaping character and pursuing the notion of “truth” and the “good.” His own Academy would have provided him an institutional context within which to realize such a model, although, given its famous inscription proclaiming that knowledge of geometry was requisite for entry, it seems to have been intended for later study concentrating on dialectic/philosophy.

Beyond the pair of music and gymnastic, as scholar Andrew Ford points out (Ford, 2002), with the addition pedagogical addition of grammar, knowledge of the poets increasingly came to serve a social function. With growing literacy, poetical knowledge and education gained social currency, signaling one's status. This then eventually helped fuel the demand and industry for "sophists." Also during this time, poets were increasingly seen as been teachers critical to civic character, although music/choral instructors, philosophers, and poets themselves were the entities largely promoting this narrative.

Apart from these areas, as scholar De Romilly indicates (De Romilly, 1992), more vocational training, including work in medicine, would have been considered to be separate from formal instruction in gymnastics, music, and grammar. Such training took place outside these disciplines with community experts in a more apprenticeship-based model. Again, there was no "systematic intellectual education."

However, following the end of the Persian wars in 479 BC, numbers of men began to travel across Greece to Athens, offering their services as instructors, calling themselves sophists after the word for wisdom (Ford, 2002).

De Romilly (De Romilly, 1992) discusses how sophists offered formal instruction to older students as a kind of "techné of citizenry." Their intended age group would have been students who had already completed their education in the three core disciplines. The sophists proposed fundamental notions of knowledge through oration including rhetoric, reasoning, and decision-making. Although they

encouraged (eventual) practical application in public democratic forums such as assemblies, initial instruction was initially more passive.

The formats of such teachings included lectures and speeches for hypothetical cases (De Romilly, 1992), including presented demonstrations such as Gorgias's famous *Encomium of Helen* (discussed later in Section 2.4.1), which involved myth and greater cultural knowledge (Gorgias, trans. 1993). Later, Isocrates, within his own academy (set up around 392 BC (Norlin, 2016)) introduced more practical exercises, with students taking a more active and participative role in their own education. This included a procedural approach to student-led rhetorical analysis: first reasoning through the purpose of a discourse in its whole and parts before breaking down how rhetorical devices enable these purposes (Isocrates, ed. 2016b). In his work, he is emphatic that learners must be receptive in order for learning to take place (Isocrates, ed. 2016a).

Philosophers employed similar tactics of rhetoric to the sophists. One key difference is that they were ultimately concerned in applying these skills to seek out universal truths (De Romilly, 1992). Plato notably characterized sophists in a negative light in dialogues such as *Gorgias*, suggesting sophists exercised rhetoric as an art of persuasion for its own sake, preoccupied with honing the craft at the disservice of the content and Truth, more generally (Plato, ed. 2012b). As part of this stance, philosophers were opposed to the idea of charging fees, as instruction was not their end—instead aiming at a task closer to communal/collective research through reasoning and discourse.

In the later approach to sophistry with Isocrates, and inherent within the discursive approach of philosophy at the time, knowledge and learning entailed action and participation from the intended learners. Notably with philosophy, the philosophers here are positioning themselves as fellow learners with their interlocutors, although they may possess greater expertise. And within both groups, there is still a common aim of civic instruction and ethical behavior.

Across these diverse instantiations of paideia, value, meaning, and holistic thought emerge as its reoccurring and characteristic features. Themes of action, the body, cultural context, and cultural familiarity all support these aspects. We'll continue to explore these trends in the following sections.

2.2 LEARNING AND CREATIVITY

This section is a cross-disciplinary overview of theories related to learning and knowledge generation (through creativity), especially encompassing ideas around communication, information, and meaning-making. As mentioned previously, we have chosen to investigate these notions with a particular focus on the cognitive sciences (as the study of the mind), education (as the operationalizing of learning), and—under new media arts—computer science (for communication, information, and meaning) and arts (for meaning-making through creative cultural production). Other notable related areas such as semiotics, the philosophy of science, and media theory will be briefly evoked. From this overview, we are on the lookout for key thematic trends that offer promise as cross-disciplinary threads, and we propose the four areas mentioned previously (situated mediated action, conceptual structure, balance of familiar/unfamiliar, and compression through strangeness, especially through fiction and counterfactuals).

2.2.1 COGNITIVE SCIENCES

Across the cognitive sciences and the intersecting disciplines under its collective umbrella, theories of situated action and conceptual structure have been two strong emergent themes. It is important to note that the field of cognitive sciences itself did not come about until around the 1970s with the first Cognitive Science Society meeting transpiring at UC San Diego in 1979 (*UCSD Cognitive Science: History*, 2015). Its related disciplines, however, have longer histories that we'll reach into here.

SITUATED MEDIATED ACTION

A number of theories have advanced the idea that human action is key to the consideration of how consciousness and learning occur and develop. The consideration of action is particularly important to consider in relation to its context of occurrence, or its situatedness. Such contextualizing factors include one's surroundings, one's body, other people, and one's history of learning as impacted by past experiences with others and the long cultural histories baked into the world around us (e.g. architecture, language, etc.).

Cultural Psychology and Cultural Historical Activity Theory

Broadly treated, the areas of cultural psychology and cultural-historical activity theory (CHAT)—branches of psychology (and other social sciences with an interdisciplinary orientation to the cognitive sciences)—have been, arguably, the main and explicit theoretical drivers for the consideration of human action as a key foundational component of human thought and learning. These ideas, informed by a collection of Soviet philosophers and thinkers in the 1920s and 30s, were first formalized in the English-speaking world (with some interpretative liberties based on the ideas of the original Soviet thinkers) via Michael Cole and James Wertsch, who— separately from one another—had studied in Russia in the 60s and 70s, respectively (van der Veer & Yasnitsky, 2016).

Wertsch, in his 1991 book *Voices of the Mind* (Wertsch, 1991), looks first at the work of Lev Vygotsky and later, Mikhail Bakhtin.

Vygotsky's theories stressed the social foundations of learning and development, as tied to action (as interpreted by Wertsch), and in particular, as mediated by technical and psychological (e.g. language) tools. In his view, knowledge develops first socially (focusing on dyadic exchanges) before it can occur intrapersonally (Cole & Engeström, 2007). While Vygotsky's views tend to focus on verbal mediation in learning tasks, Wertsch cites from a number of cross-cultural studies (with children) that sometimes show stronger performance where non-verbal communication strategies and actions are at work, e.g. using visual arranging approaches associated with wayfinding given a culture and environment where desert wayfinding is a part of daily living.

In his analysis of Vygotsky and mediation, Wertsch also speaks of the "unintended effects" that arise from using a given mediational means (with all its cultural, historical, and institutional baggage) in a new localized context, shaping the setting in an undesirable way. He gives the example of the QWERTY keyboard, initially engineered to slow down typing speed so as to avoid certain failures particular to fast typing on mechanical typewriters. Modern users are typically unaware of this history, perhaps mistakenly assuming that the keyboard's configuration would be engineered for efficiency. The inherited design has not been consciously conceived of for the action of efficient typing in its present context. As such, to parse this through another of our themes, there is an inappropriate (and imbalanced) retention of the familiar into an unfamiliar scenario where creative reconsideration of context is likely needed.

As a part of this larger discussion of mediated consequences, Wertsch speaks of “semiotic potentials”:

> The view of how mediational means emerge in response to various sociocultural forces has several implications. Most important, it implies that mediational means have a predisposition to be used more easily for certain purposes than for others, and it implies that this predisposition may not be based on ideal or maximally efficient forms of individual mental action. In the case of language, this is not to assert that certain concepts of forms of reasoning are made impossible by the use of particular expressions…it does mean, however, that certain patterns of speaking or thinking are easier, or come to be viewed as more appropriate in a specific setting than others (Wertsch, 1991, p.38).

This view emphasizes how our tools (particularly language in this context) have probabilistic bearings on our action and thinking. Importantly, these weightings have a social-historical origin. As we’ll see in our upcoming treatment of James Gibson and Donald Norman, this notion of “semiotic potentials” describes something akin to verbal affordances. The idea also shares resonance with computer science notions of event-linked probability weightings in stochastic information models like Markov chains.

Like Vygotsky, Bakhtin’s work, also stresses social importance. In his particular approach, Bakhtin frames the individual as a multi-voiced (social-historical) process. The individual learns through artifacts, which carry social-historical information. The structures around us, including scripts and schemas, derive from the history of others before us. Our language and speech mannerisms are acquired through interaction with or exposure to others. As he argues, when we speak or act, there is always more than one person “doing the talking.” Thusly, we are in effect an amalgam of (imitated) familiar sources. This view offers a distributed take on authorship in a way that shares commonalities with ideas we’ll soon discuss: meme theory and intertextuality.

In Michael Cole's own 1996 synthesis of the cultural-historically minded Soviet thinkers and others, and speaking from the related field of cultural psychology, he proposes that artifacts are simultaneously ideal (conceptual) and material, and contextually situated with multidirectional consequences (Cole, 1996). Human action itself is understood with respect to mediational means. These means or artifacts are ideal insofar as material is shaped by past interactions and informs future interactions. Like Wertsch, there is the stress that the activity of previous generations is accumulated in the human-made environment.

As with Wertsch also, Cole discusses the artifacts of schemas and scripts, stressing their conceptual and material nature. Schemas are (citing Jean Mandler) "knowledge structures in which the parts relate to one another and the whole in a patterned fashion." Scripts, a kind of schema, are sequences of causal events with actors (in social roles) using certain artifacts. As such, schemas and scripts provide a framework of familiarity by which to parse complex structures and events as more minor permutations (functioning inside these rules) or to register more major deviations (functioning outside the rules).

As part of his discussion, Cole builds off a 1973 taxonomy of artifacts by Marc Wartofsky. He proposes a three-tiered conceptualization of artifacts:

- primary artifacts, which manipulate the world directly, serving the production of other artifacts (or for Cole, social life) (e.g. a hammer but also words);
- secondary artifacts, which are "representations of primary artifacts and of modes of action using primary artifacts" (e.g. cultural conventions, schemas like sonata form); and
- tertiary artifacts, which are self-contained imaginary worlds with their own sets of rules and conventions, which in turn serve as a tool for seeing the "actual" world in a new light (e.g. particular artistic works).

This latter category in particular helps support our notion of compression through strangeness through an idea of insight through fiction.

For Cole, artifacts are situated mediators of action and this situatedness is fundamental. He reviews different conceptual models for exploring this nuanced relationship between context and mediated action. In defining context, he moves away from the more prevalent nested metaphor of “that which surrounds and contains,” returning to its etymology as “that which weaves together,” moving toward a view of context as activity systems. This inter-relational view holds that contexts are emergent among individuals, mediating artifacts, rules, community, and how actions are divided within that community. Here, context is a unit of culture, objects and context are emergent together, and action is a part of context, not its by-product. Culture, in turn, is a system of artifacts (necessarily in context) and the mind is a process of mediated action (via artifacts) within a social collective, shaping environment and context.

In terms of the broader application of these ideas, Cole evokes these ideas with connections to education, also stressing learning as a co-created social process through mediated action. Also notably for us, human-computer interaction (HCI) researchers Bonnie Nardi and Victor Kaptelinin cross both the cognitive sciences and computer sciences—they and their collaborators have explicitly applied CHAT to HCI (Kaptelinin & Nardi, 2012). We’ll discuss their work shortly in our upcoming section Affordance Theory.

Situatedness

With Cole and other CHAT theorists, social context is particularly paramount in the understanding of mediated action and the mind. In fact, a significant number of historically recent theories support the notion that the mind extends beyond the brain: that it is couched and shaped not just by a physical body but by its active participation in its surroundings, including other people, the cumulative environment of (human-made) artifacts, and the natural physical world. From such perspectives, these theories paint a coherent picture of consciousness as being situated.

The Cartesian mind-body dichotomy has been extensively challenged in the cognitive sciences, which have promoted a more embodied mind view in recent years since the late 20th century. With their seminal text *The Embodied Mind*, co-authors Varela, Thompson, and Rosch proposed a consideration of the body in the making of the mind and consciousness (Varela et al., 1991). Antonio Damasio's work carries this idea forward with a neuroscientific methodology of case studies, exploring how consciousness arises from a sensing of self, specifically one that transpires from a process of sensation through the various senses, an "emotional" response resulting in a chemical shift, an awareness of this chemical state change from homeostasis, and a resulting "feeling" about this change (Damasio, 1999). This idea is further echoed in Douglas Hofstader's *I Am a Strange Loop* (Hofstadter, 2007), looking at how the layered feedback loops of consciousness can contribute to a sense of self awareness. His scope also points outside the body, toward a more social and supra-individualistic view of consciousness, where those who know us best function as part of this conscious ecosystem. More recently and relatedly,

David Eagleman has investigated the “livewiring” plasticity of our brains using his Neurosensory Vest with complex tactile stimulation patterns, exploring how cognition emerges with new sensoria (Eagleman, 2020).

Within cultural psychology and cultural-historical activity theory (CHAT), we have already seen support for social views of consciousness as well as how the cultural environment itself generates much of this embodied process (Cole, 1996; Cole & Engeström, 2007; Wertsch, 1991). In addition to these theories, we see further arguments for an extended and distributed view of the mind with respect to our surrounding environment (natural or cultural) in the 1998 work of Andy Clark and David Chalmers together (Clark & Chalmers, 1998) and then with Jack Loomis in 1974 (Loomis, 1974), respectively. Clark and Chalmers advance a theory of the extended mind, looking at the role of mediating tools, and pointing out the difficulties in specifying where the mind begins with respect to the environment. Loomis, highlighting the inherent naïve realism of our experience with the external world, illustrates with compelling examples how the boundaries between our phenomenal constructs of the body, external environment, and internal sense of mind are tenuous at best.

As we’ll see next, affordance theory offers a further framework for conceptualizing the close situated relationship that emerges between an agent and an environment.

Affordance Theory

From psychology also comes the crucial notion of affordance as introduced by James Gibson (Gibson, 1979) and developed by Donald Norman (Norman, 2013) and others like Bonnie Nardi and Victor Kaptelinin (Kaptelinin & Nardi, 2012). They show how the opportunities and limitations of our situatedness make certain actions more or less probable. On one level, the idea of affordances is critical to understanding non-verbal communication in our natural and cultural environments and how we learn to interact successfully with cultural objects. On another level, affordance design is about the design of human action, and thus carries extraordinary weight for shaping value and meaning in the mediated way we learn and experience the world.

Introducing the idea of affordance within his book *The Ecological Approach to Visual Perception*, Gibson's notion offers an avenue to conceptualize the connections between body and the physical environment, where form and features constrain possible actions, and these constraints hold value (Gibson, 1979). He advances that:

> … if there is information in light for the perception of surfaces, is there information for the perception of what they afford? Perhaps the composition and layout of surfaces constitute what they afford. If so, to perceive them is to perceive what they afford. This is a radical hypothesis, for it implies that the "values" and "meanings" of things in the environment can be directly perceived. Moreover, it would explain the sense in which values and meanings are external to the perceiver.

In his discussion, he qualifies that the perception of affordances is distinct from the classification of a given object. "Affordances are properties taken with reference to the observer. They are neither physical nor phenomenal." They are a construct that entails an observer and the environment: for example, the extent to

which a surface confers the ability for the observer to sit given their particular size and embodiment. In his inclusive conceptualization, affordances are manifest with respect to physical objects (e.g. substance, surfaces), other people, human behavior, and human artifacts, among other possibilities. In terms of the values affordances hold, for Gibson, these values are objective: affordances can be beneficial or harmful with respect to a given subject, but not in a subjective interpretive sense (in terms of how they personally may feel about it). Here, affordance is a constant property, always capable of being perceived but not contingent upon perception: it does not change according to an observer's need. However, an observer can take action to modulate "shapes and substances" in the environment to change affordances. As such, the notion of action through making becomes important here. On another note, according to Gibson, "the central question for the theory of affordances is not whether they exist and are real but whether information is available in ambient light for perceiving them." This idea, although likely intended in a literal sense, is also interesting to consider in a more figurative sense, as not all affordances need be visible. In this broader sense of light, one might also recall Plato's allegorical sun in the Allegory of the Cave (Plato, trans. 1968). In complex/systemic and/or non-visual contexts, for the conditions of perceivability and readability to be met, we need a way to shine the light of literacy on such affordances: through other senses (extended by technology) and knowledge. The computational platform, in the way that it can augment our senses and thought, offers promise in generating such light.

Donald Norman, taking a psychological approach to design, reframes Gibson's definition of affordance and brings his notion into the realm of human tools especially in HCI with embodied interface design (Norman, 2013). For him, there are affordances which facilitate actions and anti-affordances which hinder. He views indications of an object's functionalities not as affordances themselves but as "signifiers."[2]

Using these ideas, he advocates for human-centered design (HCD) that accounts for human cognition in the design of affordances and their signifiers. As a part of this proposal, he argues for a consideration of natural-body mappings in creating effective affordances: the conceptual structure should be intuitive with our embodiment. For example, it's more intuitive to move an element to the left or right as opposed to up and down to steer a transportation device to the left or right respectively. This point creates a strong link between situated embodied (mediated) action and conceptual structure. The structure is essential for reducing unwanted actions and making desired ones more probable. Towards HCD, Norman also stresses the importance of feedback to signal and confirm that an action has been successfully executed. As part of his justification for feedback, he breaks down actions into a seven-step process, which is as follows: developing a goal, planning action, specifying the action sequence, performing said action sequence, perceiving the state of the world, interpreting the perception, and comparing the outcome with the goal. This added redundancy of feedback helps with these last three stages of evaluation and further reduces uncertainty (especially in an informational theory

[2] Other scholars like Kaptelinin and Nardi tend to regroup affordances and anti-affordances simply as affordances and signifiers as a kind of affordance: learning affordances.

sense). For Norman, it's critical to note that emotion is also key to this action sequence for both executional and evaluative steps: he considers reflective emotion important for informing planning and comparison, behavioral (learned) emotions key to specifying and interpretation, and visceral (instinctive and conditioned) emotions critical for performing and perceiving. Insofar as art and artistic design can stimulate and stir emotions, art has capacity to impact actions and affordance in such contexts.

Researchers Bonnie Nardi and Victor Kaptelinin have built on Norman's HCI work with affordances, and finding limitations with Gibson's original approach for HCI, reframed affordances through the lens of CHAT (Kaptelinin & Nardi, 2012). They identify the key aspects of Gibson's affordances as being a relational property, directly perceived, independent of agent needs, same across natural and cultural environments, and ultimately preoccupied with perception over affordances proper. While other HCI researchers have been in agreement on the first property, they have deviated on agreement with respect to the other points.

In regrounding affordances through CHAT, the authors better account for humans in a cultural environment, acting in a cultural context; the relational emergence of affordances with respect to actors, mediated means/tools, and a (cultural) environment; how tool switching provides different capabilities; how learning can contribute to the perceptual identification of affordances (they need not be immediately perceived); and how affordances can be influenced by situational needs.

Surveying the literature, they nuance different varieties and properties of affordances: visible, hidden, false affordances; nested and sequential affordances; a distinction between the utility (capabilities) and usability (information communicating these capabilities) of an object; and degrees of affordance (its difficulty). With their CHAT framing, they are able to add *instrumental technology affordances* divided into *handling* and *effecter* affordances (which might be indirectly mapped in an HCI context), *aggregation affordances* where different components (analog or electronic) are modularly combined to create different affordance sets (e.g. smartphone+headphones=personal music player), and *learning affordances* (as opposed to Norman's signifiers) acting as Wartofsky's secondary artifacts, representing how primary artifacts should be employed.

This work by Kaptelinin and Nardi is essential for unifying affordance (particularly the role of mediated structure and design) with the situated mediated action of CHAT. Through the connection with HCI in creating and modulating affordances, we begin to see the potentially powerful role that computing (and physical computing) can have in the consideration of human action and cultural context.

CONCEPTUAL MEDIATION + TRANSFER

Conceptual Structure

In their work, George Lakoff and Mark Johnson have examined how many abstract concepts, including philosophy, are conceptually structured by metaphors,

often ones with an embodied or spatial basis (Kimmel, 2013; Lakoff & Johnson, 1980).

In their book *Metaphors We Live By* (Lakoff & Johnson, 1980), they show how these metaphors are necessarily partial with respect to their sources. They borrow from certain select properties of a given source but not all. The authors give an example of the conceptualization of theories and how architectural metaphors of the exterior and shell of a building frame this notion (case in point), but not ideas around the interior parts and rooms. Considering this partial nature of metaphor derivation, the authors highlight three levels of creating increasing metaphoric novelty: 1. by providing unusual detail about the commonly used source parts, 2. by using the unused parts of the source as a structuring metaphor, or 3. by finding a completely new source paradigm by which to structure an idea.

Relatedly, the author James Geary (Geary, 2011), writing on poet Ralph Waldo Emerson's view of language and etymology as fossil poetry, speaks to how, over generations, a new metaphor may—like a volcano—go from active/novel to dormant/cliché to extinct/invisible (and fundamentally structuring). It goes from consciously unfamiliar to consciously familiar to unconsciously familiar.

Across these authors, we see that while metaphors are ever present in our daily lives, it takes unfamiliar conceptual restructuring with respect to our culturally situated structures to help us appreciate new information about a given concept.

In contrast to the work of Lakoff and Johnson, Giles Fauconnier and Mark Turner propose a more generalized mechanism: *conceptual blending* (Fauconnier & Turner, 2002). They propose this idea as a fundamental building block of thought

and imagination. In their model, new concepts are structured through the blending of multiple input sources. Like the partial selection stressed by Lakoff and Johnson, in this model, select aspects of various input sources are brought together to create a new composite "blend." Critically, this blending achieves a compression of ideas. We briefly outline some of blending's generative principles below.[3]

Toward such compressions, they observe that the selected input components typically follow certain vital relationships with one another, which are as follows: change, identity, time, space, cause-effect, part-whole, representation, role, analogy, disanalogy, property, similarity, category, intentionality, and uniqueness. Concerning such connections, they recognize *mirror integration networks* where input features share organizational frames and *double scope integration networks* where inputs have conflicting organizational frames (Fauconnier & Turner, 2002; Turner, 2006).[4] Especially for the latter case, the blend may have an emergent organizational structure which is not present in the inputs.

Additionally, in order to achieve a successful blend, they stress that compression should aim to "achieve human scale." For example, this could be with spatial and temporal scales that are easier to conceptualize—compressing an event transpiring over several decades into an event of several minutes' duration (e.g. a metaphor such as "life is a sonata" invites structural comparisons at a more

[3] The generative principles of conceptual blending that Fauconnier and Turner explain in their book are so rich, that any overview we could provide here would not do full justice to their model. We recommend consulting the source text and examples directly for a more complete understanding. The most critical takeaways for our purposes are that there is a kind of feature extraction at work between conceptual sources, and that certain kinds of fundamental relationships may exist between connected features (i.e. their vital relationships).

[4] *Single-scope integration networks* also exist but differentiating these from the mirror and double scope versions is a more complex undertaking in the context of this brief overview.

manageable scale, at least for a musician familiar with sonatas). To this end of achieving human scale, they propose the principles that a blend should “compress what is diffuse, obtain global insight, strengthen vital relations, come up with a story, go from Many to One.” Furthermore, they argue that one should be able to unpack the parts from this synthesis. Their discussion includes looking at material objects as conceptual anchors: for example, the clock face uses a circular spatial metaphor to compress one full (relative) rotation of the sun into two rotations of the small hour hand, also building off of our understanding of the day as being cyclic. A later article (Turner, 2006) goes into the inherent compression of art contingent upon blending, where certain realities may map some kinds of rules and causalities to an emergent reality but not others (e.g. Turner gives the example of the children’s book *Harold and the Purple Crayon* which features a blend of spatial reality and a world a of drawing where a character can draw a light-emitting moon but needs to draw a ladder first to climb up high enough, with a compressed scale of distance). Related to this idea, counterfactuals and the unreal are also shaped by blending and link back to the real through certain conditions (Fauconnier & Turner, 2002). These include “if, then” and “what if” constructions but they are also implied in more modest statements like negations: e.g. “I didn’t go to the store” implies a possible reality where “I did go to the store.”

The theory of conceptual blending shows how new concepts may be created from existing ideas through simple vital structural relationships (that are relatable from our situated experience of the world). Moreover, this theory provides a formal operation by which the unfamiliar can tether to the familiar to create novelty that is

comprehensible. *Double scope blending* where the blend creates a novel structure provides a potential means to assess degrees of creativity with respect to deviating from the familiar. The emphasis on “achieving human scale” shows how an understanding of human situatedness is critical to designing new concepts to be more easily comprehensible. (This idea will be important to recall in our discussion of information aesthetics.) Furthermore, counterfactuals can reveal themselves as a permutation around a common set of rules with the real. This holds potential for gaining insight into the input source of the real world. Counterfactuals, while compressions themselves, may also serve the understanding and compression of abstract pattern and rules.

Meme Theory

Meme theory, originating in biology, has enriched cultural theory in the cognitive sciences. It unites ideas of the familiar with conceptual mediation and shows how, through imitation, the familiar propagates itself into new contexts.

The biologist Richard Dawkins coined the term of meme in the context of his book *The Selfish Gene* (Dawkins, 1976). This text presents a gene-centric view of human existence and evolution, whereby we as humans are mere vessels for genes, which act in their own selfish, propagational interests. The substrate of DNA code acts as the unit of selection for genes, but to challenge the notion of the gene as the only means of natural selection, he introduced the notion of the meme as unit of cultural inheritance Dawkins frames the meme as “anything that spreads by

imitation," including internet memes, and the idea of the backwards baseball cap (Science Insider, 2015).

Picking up on this concept, the cognitivist Daniel Dennett explores the meme in the context of cultural evolution, where memes, as mediated concepts (in any medium), spread in their own (ignorant) interest (Dennett, 2001). The consequences of this propagation can be of mutualistic, commensal, or parasitic rapport to its human hosts. Given an individual's history with certain memes and resulting structure of their minds, they become a "loci of interaction" where certain minds serve as more or less optimal "meme nests" for retaining and ultimately propagating a new given meme. Applying Darwinian notions, he proposes a cultural natural selection (e.g. ships that don't sink might exist long enough to be copied), unconscious selection (the unconscious introduction of variation), methodical selection (meme-breeding, intentional introduction of variation), and memetic engineering. In the last two categories of memetic breeding and engineering, individuals actively create variations on familiar structures (e.g. Bach reworking musical works with an established fitness). However, even for these cases, Dennett is skeptical of intention and ideas of authorship, as for him, intention is shaped by meme and the desire for identification with one's memes is also a meme.

In Dennett's meme theory like in Gibson's affordances, some ideas hold beneficial or harmful consequences, and in this way, these memes hold value. We also see how we might conceptualize the introduction of the unfamiliar to the familiar in terms of agents, and how agents are structured by the history of their exposure to culturally mediated structures. As such, there seems to be significant

promise within this theory for an integration with CHAT, cultural situatedness, and conceptual blending.

Separately, meme theory has found another valuable integration: the theorist Paul Marsden proposes that the sociologically recognized and documented phenomenon of social contagion provides an empirical evidentiary basis for memes, while memes provide a needed theoretical framework for understanding social contagion (Marsden, 1998).

SYNTHESIS

Ryan Dewey and Michael Kimmel have applied and/or synthesized many of these ideas together in ways interesting to our investigation.

The artist and theorist Ryan Dewey outlined a practical guide for how to practice art as a kind of cognitive engineering in his 2018 *Hack the Experience* (Dewey, 2018). In his approach, he combines notions of conceptual structuring, embodiment, and affordances among other ideas to inform the design of artistic installations, directing attention in intentional and desired ways.

Reviewing cognitive linguistics, cognitive psychology, and cognitive anthropology, Michael Kimmel has done particularly interesting work in connecting notions of embodiment, culture and conceptual structure (Kimmel, 2013). Relevant to our own creative practice, he has also applied this work with dyads in somatic learning, specifically tango—looking at joint improvisational creativity (Kimmel, n.d.).

In his writing, he illustrates how learning through both special designed events (rituals) and everyday experience in a culture can reinforce value in an embodied

way (e.g. the value of balance in Anlo-Ewe Ghanian culture permeates everyday actions in various scenarios, gaining a significance beyond other cultures). In this way, cultural conventions have an embodied basis connected to action scripts. Within his discussions, he also highlights the capacity of cultural objects for cognitive offloading, with a recognition of affordances as a part of this process.

He emphasizes that his theoretical synthesis aims to both identify cognitive universals and account for culturally situated specifics. As part of this, we seem to possess some simple near-universal conceptual embodiments (e.g. the future is in front of us/the is past behind us). We can combine such near-universals to create culturally-specific conceptual structure (e.g. demonic possession as combining ideas of body as container and intrusion across a boundary). He points out that we are not a tabula rasa: there are some fundamentals in the toolbox of universal processes guiding conceptual variation (e.g. schemas, scripts, metaphor, blending, affect, somatic marking) and in what concepts are made of (e.g. 5-6 core emotions, spatial references, certain near-universal metaphors). These ingredients allow for rich emergent permutations in cultural context. Also, in defining the causal relationship between concepts and embodiment, he points to bi-directional influence. As Lakoff and Johnson point out, conceptual understanding can scaffold to more fundamental embodied schemas (projection), but also new ideas and concepts can alter somatic experience and schemas in a process he terms retrojection (e.g. using the concept of flowing water to inform a new kind of movement in learning a dance).

Such a comprehensive of view of cultural conceptual embodiment offers rich opportunities for creative artistic exploration and profound insight on the nature of learning and creativity with respect to culturally situated concepts.

2.2.2 EDUCATION

Modern Education Paradigms

Examining student-centered learning environments (SCLE), educational scholars (Land et al., 2012) have looked at the gradual abandonment of a unidirectional transmissive approach (e.g. lecture formats) for more constructivist and situated approaches, where students co-create knowledge with their peers and instructors through discourse and meaningful common tasks. They stress more recent research that highlights the importance of metacognition—reflection and feedback about their learning activities—for efficacious learning. They also explore the use of digital tools including virtual worldmaking to create such learning scenarios.

There are several approaches that can support this new angle. In their review of techniques, they highlight the importance of cultivating multiple perspectives.

They identify project-based learning as one kind of SCLE approach. The authors also promote iterative learning processes where students are guided to create own problem-solving strategies to challenges, with opportunities for social exchanges to compare strategies and for reflection to evaluate and refine their work. This may culminate in a final outcome or artifact that is shared. As a part of situated learning, they also advocate for *authentic practice*, using professional real-

world methods with domain-specific knowledge and professional practitioners in meaningful contexts (albeit with some simplification and making more tacit processes explicit). Virtual worldmaking tools for designing new aspects of a society are also discussed, but these 2012 tools are much less bottom-up than some techniques we'll discuss in our own research.

Media Arts Pedagogy

At the university level, such advocated strategies to learning are already built into the design of new media arts programs (or are already necessary to research at the graduate level). As such, both the new media arts field and graduate study models might inform more general education for younger groups to create effective SCLEs.

The Media Arts and Technology Graduate Program at UC Santa Barbara, founded in 1999 by JoAnn Kuchera-Morin (the director of this present dissertation), creates a multiple perspective learning environment through its transdisciplinarity—uniting the arts, music, computer science, and electrical engineering at its inception (but encompassing many additional areas since). Learning by making and student-led research projects are particular to the field, and the graduate environment fosters further opportunities for constructivist and situated learning through social research collaborations with colleagues and professors/lab directors. Authentic practice is also facilitated in multiple areas as students are coming in with a given level of expertise in a particular field and are encouraged to hybridize in company with peers and instructors with expertise in various complementary practices.

The Media Arts and Practice program at USC is another but later example of an institutionalized SCLE in the new media arts. It has used the metaphor of worldbuilding in service of ideating a non-linear curricular structure for their undergraduate major, realized for the moment at a smaller scale in their 2-semester introductory Superstudio course (Willis & Anderson, 2013). Taking a student-led approach encouraging communal and civic engagement within and outside the institution, the design also encourages thinking through making and abides by a constructivist model, where learning occurs in a social context. Following the self-driven inclinations of their research interests, they are given freedom to seek out a variety of resources and experiences with faculty. (These faculty represent different "zones of expertise.") To this end, they are provided a kind of departmental-specific currency to pool together to request specialized faculty meeting, workshops, guest lectures, screenings, field trips, and other opportunities.

2.2.3 NEW MEDIA ARTS: COMPUTER SCIENCE + ART

This section surveys learning and creativity in the fields that comprise the new media arts: computer science and art. Through computer science, we'll follow the impacts of information theory down through to theories of meaning in information aesthetics and artificial intelligence, and then trace information theory's relevant impacts on systems thinking with cybernetics, physical computing, and human-computer interaction. Through art, we'll look at relevant areas of criticism, art philosophy, and aesthetics.

COMPUTER SCIENCE

As a key component of the new media arts, computer science, from its early days, has offered insights into modeling culture and representing communication and learning processes. Starting with Claude Shannon's formalization of information, we'll look at how this theory has informed pursuits of meaning, learning, and creativity via information aesthetics and artificial intelligence and then look at how it has informed systems theory, and the relevant development of experiential models.

Information Theory

Claude Shannon in his seminal text *A Mathematical Theory of Communication* (Shannon & Weaver, 1949) created a formalized, mathematical definition for information (*H*) as entropy or uncertainty. Through this definition, we see that information increases with uncertainty and randomness, while it decreases with certainty and regularity. Specifically, as a measure of uncertainty, it can increase with both the number of possible choices and when there's more equally distributed randomness/probability among those choices.

Information is measurable in the unit of the bit— the number of binary states to describe some entity (Shannon & Weaver, 1949).

A helpful illustration of the bit is in signal sampling of sound with quantification. When sampling the height of a wave, the number of bits determine the resolution, specifically the relative tolerance of measurement. For example, an 8-bit resolution will divide the full potential height into 2^8 (i.e. 256) possible positions, whereby the

actual height will be rounded into one of these positions, describable with 8 binary states. This compression (down from 256) is possible as we can proceed with binary states of the coarsest resolution: effectively starting by asking “is the height position in the top half or bottom half of all possible positions?” and continuing with the same question applied to the localized half until we stop at 8 inquiries of precision total (or more if using a higher resolution). In this way the 256 possible states can be partitioned to belong to more generalizable classes: being in the overall top/bottom half, etc. As such, through this description, we see a connection between the bit and pattern compression/abstraction which will be important for our future explorations.

Probability distributions among choices is also a key idea. As mentioned earlier, whether probability is more evenly or asymmetrically distributed will impact the resulting measure of information—with more evenness, and thus uncertainty, increasing H.

Information can also be causal. Processes like Markov chains create probability weightings contingent on information that proceeds a given state. From this notion comes predicative typing, among other applications. For example, in the English language, there’s a high probability (and less uncertainty) that given the letter “q,” the letter “u” will proceed it. Information may increase for the choices following more versatile letters like “t.”

In this way, we can make a connection between information/uncertainty and context. Conventions of what is familiar or unfamiliar impact the measure of information and how probability distributions are modeled.

It is critical to stress here that Shannonian information is independent of content or meaning, although others have since sought to apply his information theory toward more semantic ends, which we will now discuss.

MEANING

Towards Information Aesthetics

In the very forward to Shannon's text, Warren Weaver ventures that although information is independent of meaning, some quantified definition of meaning would likely be some function of information (i.e. where meaning=$f(H)$) (Shannon & Weaver, 1949).

A potential connection between meaning and information is immediately made more concrete when considering the common game of *20 Questions*. This game is effectively a semantic information game that operates by the principle that most things can be identified with 20 bits of information. For the uninitiated, the game's premise consists of at least two players where one person decides on a given and secret "person, place, or thing" and the other person must guess the other person's entity in 20 yes/no questions or less.

The interest of this game is in the framing and sequence of the questions. Starting with questions that are too specific are unlikely to yield a correct or approximate answer in 20 questions (i.e. around 2^{20}=1,048,576 possibilities). Rather, it is more advantageous to proceed from the most common classes: general, equal categorical bifurcations into which we might compress any object of the previously defined class. For example, asking if a thing is animate

(vs. inanimate) will be a more productive starting question than asking if the person is thinking of a goldfish specifically. Dividing all known things into an animate/inanimate category will give a better distribution of possibilities than a goldfish/non-goldfish distinction, which is more like 1: (2^{20}-1).

Such games have already been programmed into software and handheld devices, where the computer, acting as the guesser, proceeds from more generalizable classes into more specific ones, appropriate to the previously determined class.

Game play aside, practitioners and theorists in the area of information aesthetics have sought to use Shannon's information theory to quantify more traditionally qualitative notions in the realm of art.

Back in 1933, mathematician George Birkhoff had advanced a formalization of aesthetic measure as some function of the ratio of order and complexity (Douchová, 2015). He defined complexity (*C*) as a measure of the attention demanded by a given object (i.e. the number of units requiring attention, e.g. the number of notes in a musical phrase), and defined order (*O*) as a measure of the resulting feeling from the consecration of attention, be it negative or positive. Later, the theorist Abraham Moles proposed a reformulation of this function as multiplication, and redefined its elements in terms of information theory. Here, *O* was low *H* redundancy and certainty, and *C* was high *H* incompressibility and uncertainty (Douchová, 2015).

In his work, Moles explores the idea of semantic and "esthetic" information (Moles, 1966). In his conception of information aesthetics, he presents a methodology for quantifying (sensory) information in a work, by analyzing its

medium in terms of its formal degrees of freedom (e.g. frequency, amplitude) and the number of sensory bits which are present.

Moles terms such collections of sensory bits and possible sensory states *repertoires*. He bounds these spaces at one end by a *detection threshold* (where the parameter becomes perceivable) and at the other end by a *saturation threshold* (where the parameter reaches another extreme of sensory inutility—for example pain at about 120 dB in the case of sonic, auditory amplitude). These states can then be sub-divided into difference thresholds corresponding to our just-noticeable-differences (JNDs), or the amount of measurable change in a physical parameter for us to perceptually register a difference. These subdivisions across a given range then become the number of bits to define that sensorial degree of freedom. In this way, Moles proposes a means for quantifying sensory information. These degrees of freedom can define multi-dimensional creative space for one given creative medium or many in multimedia works.

Another important idea in his writing in that of the paradox between that which we deem banal v. original and that which we deem comprehensible v. incomprehensible. We appreciate what is uncertain enough to be original and yet certain enough to still be comprehensible. Periodicity also comes into play here, offering regularity. This appreciative coefficient or sweet spot as described here is subjective, contingent upon the experience and education of the subject. His writings also evoke human action in the context of the strange and unfamiliar, stating that if a message is certain it cannot modify behavior but an unexpected event can modify behavior.

Artificial Intelligence

In the area of artificial intelligence, Jurgen Schmidhuber, a pioneer of deep learning, has created a mathematical model for interestingness (and other concepts) that reinforces this balance noted by Moles and the feeling described by Birkhoff (Schmidhuber, 1997, 2007, 2009). He describes his model as one providing a theory for subjective beauty, novelty, surprise, interestingness, attention, curiosity, creativity, art, science, music, jokes, and discovery. He frames interestingness as a measure of pattern compression, specifically the first derivative of a learning algorithm, measuring the difference of bits as a process of pattern recognition (Schmidhuber, 1997, 2007, 2009, 2012).

This model reinforces the importance of context and familiarity: previous information sculpts what is deemed as relatively new. Additionally, this back-log of knowledge provides the means to recognize patterns as soon as new information creates enough of a picture of heretofore unforeseen regularity across the old data and this new data. For him, art plays a critical role here for such learning:

> Good observer-dependent art deepens the observer's insights about this world or possible worlds, unveiling previously unknown regularities in compressible data, connecting previously disconnected patterns in an initially surprising way that makes the combination of these patterns subjectively more compressible (art as an eye-opener), and eventually becomes known and less interesting (Schmidhuber, 2009).

This anchors our theme of significant strangeness as being key to (new) compression.

Also in the area of AI, Zachariah Neemeh highlights some important bridges with ideas of cultural and affordances (Neemeh, 2019). Generally, the application of affordance in AI helps to offload some of the computation on the environment, reducing the need for planning representations and allowing for a tighter sense-

action coupling. However, cultural affordances pose some challenges. While natural affordances are contingent on the “informational structure of the environment,” and cultural ones are contingent upon acculturation and may entail memory (e.g. knowing how to open a drawer in non-deviant ways or that a mailbox operates within a greater social structure). Some relevant approaches entail programmed representations of the mediating objects, applying rules on top of the natural affordances (held by the agents). However, with unsupervised learning (learning through violations) and supervised learning (imitation following observation of human guidance/demonstration), such representation can be avoided. As such, learning transpires via habit—here, familiar situated action.

On the subject of creativity in AI, cognitivist Margaret Boden has worked on formalizing creativity for the purposes of AI computational creativity (Boden, 2009). She defines creativity in terms of novelty, surprise, and value. Setting aside value, she defines novelty social-historically (whether an idea is new only to the individual or if it is historically novel to all) and focuses on surprise in terms of operations of familiar/unfamiliar elements or rules. She recognizes three kinds of creative surprise: combinatorial (combining familiar elements in an unfamiliar way), exploratory (permutations within a familiar set of rules), and transformational creativity (changing or altering a familiar rule to create an unfamiliar space for exploration). In addition to the obvious resonance with our third theme of familiar/unfamiliar balance, there seem to be some parallels with conceptual blending. Of further value here, the transformational category provides a useful formal mechanism for deriving counterfactuals and what-ifs.

SYSTEMS

Cybernetics and Physical Computing

The area of cybernetics and the modern practice of physical computing that derives from it situate the human body and computational tools within an environmental information flow. These information models are systems consisting of sensing, processing, and actuating levels, with feedback.

Around the same time as Shannon, Norbert Weiner was formulating his similar theory of cybernetics (Weiner, 1948). Creating a parallel between living entities and automata machines, he notes that both have the capacity for creating flows of information via sensing receptors (that take in information from the outside world), effectors (that act upon the world), with a mediating control system. Making a comparison to learning, Weiner explains that this control mechanism may contain a memory of past sensory data, and this memory may impact or change rules governing its behavior. Furthermore, output may be fed back into the system, impacting its behavior as a whole.

Writing decades later, Dan O'Sullivan and Tom Igoe (O'Sullivan & Igoe, 2004), identify a similar three-part approach to define physical computing practice in a handbook. This process entails input, output, and processing, the latter part involving programming to coordinate the output decisions of the machine based on a given input. O'Sullivan and Igoe present their handbook in the spirit of democratizing computer-making, particularly toward the creation of systems that contend with the parts of the human body and the physical environment that the desktop computer neglects (e.g. the sensing of temperature, the triggering of music

depending on certain bodily movements). The intended audience of their book explicitly includes artists. Given this framing, the authors offer a computational means for greater embodied and environmentally situatedness in digital art practice.

Human-Computer Interaction (HCI)

Within the field of human-computer interaction, there is an acknowledgement of three distinct waves or trends in research approaches and preoccupations (Filimowicz & Tzankova, 2018). The jump from the second to third wave is of particular interest to our research. The second wave may be said to concern information flow and transfer reminiscent of a more Weiner-informed cybernetic model. This framework concerns itself more with workplace contexts. To some extent, for Bødker (Bødker, 2015), it might also account for “situated action, distributed cognition, and activity theory.” However, the third wave more explicitly operates within a context of culturally and embodied situated action, examining values and meaning outside the workplace in ubiquitous computing and also including in artistic scenarios. We situate this present dissertation and its practice within this wave.

ART

Criticism

Art theory and criticism (from across all the arts) provide us with several useful notions for parsing meaning relevant to our pursuit of learning and creativity.

A group of these ideas provide us with ways of understanding how familiar elements may be sourced and mapped to new, unfamiliar, scenarios.

To begin, the music cognitive theorist Leonard B. Meyer (Meyer, 1956) makes a key distinction between meaning that sits outside the context of a given work (or generally here, artifact) and is thus *extratextual*, and meaning that emerges from formal relations inside the work/artifact itself, and is said to be *intratextual*. The connections between these two ideas may come to appear more shared and ambiguous as we continue, but they are a helpful starting point, nevertheless.

Another related and relevant term from art and literary theory is that of *intertextuality* (Miola, 2004; Taschian, 2017). Like the notion of extratextuality, intertextuality refers to meaning in a work borrowed from outside itself. The key distinction here is that the intertextual source is another work (human-made artifact) as opposed to anything. As such we might say that intertextuality is a sub-class of extratextuality.

For example, to better illustrate these differences, an extratextual source could be birdsong (e.g. the “Lever du jour” dawn chorus in Maurice Ravel’s *Daphnis et Chlöé*) whereas an intertextual source might be a literary work (e.g. the use of Homer’s *The Odyssey* in James Joyce’s *Ulysses*). For further clarification, we refer to a target work as a *hypertext* and the source material as a *hypotext* (Taschian, 2017*)*.

Intertextual mappings can occur in a variety of ways. A hypotext can range from the broad to the specific (Miola, 2004): it can pertain to a whole genre (e.g. film noir), cultural schema (e.g. sonata form), the œuvre of a particular artist (e.g.

Beethoven's harmonic language), a particular period of an artist (e.g. Picasso's Blue Period), or a specific work (e.g. Gaudi's La Sagrada Familia). The intertextual element can be extracted from the hypotext in whole or in part (including abstraction), and mapped to the whole or part of the hypertext (Miola, 2004).

These mappings then create a dialogue between the source and target, where an assumed or desirable familiarity with the source creates some anchoring for some new commentary or reflection created by the unfamiliar target transposition. The use of a hypotext also necessitates prior cultural knowledge for understanding to transpire.

Another interesting notion related to meaning comes from a theory of fiction. The film theorist Edward Branigan, in writing on fiction (specifically cinematic), describes it as an allegorical open function, whereby a fictive element may symbolically map to any elements of a constrained set of real ideas/objects (Branigan, 1992). In this way, in remembering Shannon, fiction must have a degree of uncertainty and information through its extratextuality and related connotations.

On the same subject of cinematic narrative, it's worth evoking an interview with director Terry Gilliam that echoes this same very notion (*Terry Gilliam Criticizes Spielberg and Schindler's List*, 2009). In comparing Stanley Kubrick's *2001: A Space Odyssey* to Stephen Spielberg's *Schindler's List*, he praises the former for inviting critical contemplation through its mystery and condemns the latter for proposing a reductive, unquestioning hero's narrative in the context of the holocaust—which itself is a failing of humankind. For Gilliam, Spielberg's egregiousness transpires on two accounts (which we can parse through our greater

theoretical understandings): for a lack of information/uncertainty (which impedes active meaning-making on the part of the audience), and for an inappropriate conceptual mapping that undermines the cultural lesson to be gained from an historical atrocity.

Elsewhere in art criticism, object-agency theory provides some important resonances with mediated action and CHAT, especially the views of culture as defined by Cole. For Alfred Gell, art is a “system of action” and culture manifests through social interactions which take place through actions by agents (Gell, 1998). An agent is “one who has the capacity to initiate causal events in his/her vicinity” due to their intentions. Art objects act as social agents, specifically secondary agents: where a primary agent has offloaded/distributed agency. Art objects are simultaneous causal products (an index of their maker) and materials that provoke interpretation, affecting others in a social context.

Philosophy

As mentioned in the introduction, the philosopher Alva Noë has explored the idea of art as a strange tool and philosophical practice (Noë, 2015). In his view, technology is a precondition for art but with a subversion of function. He contrasts art with design: “design organizes and enables; art subverts,” “art is bad design on purpose.” Confusion and a degree of uncertainty is requisite to confound the viewer and motivate them to interpretive action to parse its meaning. This view is interesting to consider with respect to the notion of affordance and our balance of familiar and unfamiliar. Here, the object must evoke familiar affordances (and be

aware of situatedness), but with enough unfamiliarity to provoke a sense of strangeness with respect to our situatedness, leading one to seek compression.

Grounding his ideas in a survey of philosophical literature, Noë critiques Plato for his proposals of censorship but accepts his recognition of the power of art. He finds support in Aristotle's *Poetics* for the idea of using art as a thought experiment and philosophical practice to explore the true nature of things. Martin Heidegger also acknowledges philosophical role of art to bring things we have taken for granted into focus—art doesn't just show structure of world but makes it, revealing its functions. Furthermore, art brings oddness into what we take to be familiar and, in the process, offers insight into our thinking process and how we ascribe value. In John Dewey, we find the view that living and experiencing is meaning-making, which gives art a certain power as experience making. For Noë, art is not about the object but the action of experiencing the object. These views are also coherent with ideas from CHAT and object-agency theory.

Aesthetics

In his book *Formalized Music* and particularly within his chapter "Symbolic Music," composer Iannis Xenakis explores how the intratextuality of formal relationships gives meaning (Xenakis, 1992). For Xenakis, repetition is a tautology of existence/non-existence toward the modulation of time. Ontologies arise from the interrelationships of three or more elements, with asymmetries providing relational differentials: e.g. short intervals and long intervals. As such, meaning can be created from the network of formal relationships alone.

The composer Curtis Roads, citing Gérard Grisey (Roads, 2015), reinforces a similar point in discussing electroacoustic music that might operate outside of traditional musical schema—e.g. outside Western tonality, with synthesized timbres (beyond traditional analog instruments), with microrhythms. For such music, within the exposition, the rules of the work can be formally presented and developed from there. As such, familiarity does not need to rely on cultural familiarity with extramusical schemata but can be created intratextually with the repetition of formal relationships, building a new framework from which to create and contextualize unfamiliar deviations.

2.2.4 OTHER RELEVANT THEORIES

Here we would like to briefly evoke several other theories of learning and creativity as they pertain to meaning, interpretation, and knowledge-building in other disciplines that hold some relevance to our present inquiry. These areas include philosophies both of communication and STEM, with semiotics (in linguistics and art), media theory (a philosophy of technology), engineering ethics (a philosophy of engineering), the philosophy of scientific practice, symmetry (with respect to mathematics and science), and others.

Semiotics

The field of semiotics (particularly through linguistics) has concerned itself with theories of meaning and is interesting to consider with respect to conceptual structure particularly. Its origins arguably begin with Plato's dialogue *Cratylus*,

where the relationship between a given word to represent an object and the object itself are considered (Plato, ed. 2012a). Plato views the naming of things as a kind of cutting or discretizing of reality. For him, names can be true or false, more or less apt (if not objectively "correct"), found only by those who are capable of distinguishing true properties (in this case philosophers or gods). Relatedly, ontology is also explored in this discussion: the assertion is made that if one thing resembles another in every respect, it would be the thing itself. This seems to acknowledge the inherent partial nature of names, which finds resonance with Lakoff and Johnson's work on metaphor millennia later.

Also much later, in the first decade of the 20th century, Ferdinand de Saussure formalizes this idea between the word and object with the terms of signifier and signified, claiming an arbitrary rapport between the two that serves to "construct reality" rather than represent or categorize it as it is (Chandler, 2002; de Saussure, 1971). Later scholarship (Chandler, 2002) is critical of the notion of pure arbitrariness: while labels may be ontologically arbitrary, they may not be so from an intralinguistic socio-historical perspective (e.g. compound words). Additionally, autological qualities including onomatopoeia may create more or less intuitive extralinguistic tethers. We might evoke here the famous kiki-bouba example from psychology that explores cross-modal auditory-visual mappings between the words *kiki* and *bouba* and a spiky or rounded shape. There is an inclination to map kiki to the spiky shape and bouba to the rounded form due to the sharp sonic amplitude attacks of the former and more gradual amplitude attacks of the latter—such word and object pairings share defining formal qualities for a more apt embodiment.

Bridging semiotics with criticism, the writing of Roland Barthes is also worth evoking here. For the interpretation of text, he evokes five kinds of codes in his book *S/Z* (Barthes, 1970), codes which have also been used in interpretation in the visual arts (Taschian, 2017). These categories connect to the themes we have seen previously. They include the hermeneutic code (the questions present in a scene, especially those that contribute to suspense), the semic code (the use of signifiers without the signified, providing an extended connotative space), the symbolic code (the kinds of formal juxtapositions present which delineate different degrees of freedom and create symbolic meaning), the action code (breaking down a scene in terms of the actions and consequences they imply as part of a sequence of events), and the cultural code (the types—e.g. physiological, scientific, historical—of background cultural knowledge evoked, which may be necessary to parse a scene) (Barthes, 1970; Taschian, 2017). Across these categories, we find resonances of action (action code), cultural situatedness (semic and cultural codes), conceptual structure (symbolic code), the importance of the unfamiliar/strange (hermeneutic code), and the use of contrast toward the end of bringing common parameters to the fore (symbolic code).

Media Theory

Marshall McLuhan's media theory unites ideas of embodied and cultural situatedness with affordance and action (McLuhan, 1964). He frames technology as extensions of the human with important ramifications for the mind: "any extension whether of skin, hand, or foot, affects the whole psychic and social complex." His

famous utterance of the “medium is the message” underscores how the formal qualities (or affordances) of a kind of technology rearranges both personal and social life at large scales, shaping individual and collective actions (including thought). Also, with respect to quantifying action, he distinguishes between hot media (low in participation) and cold media (high in participation). For cold media, due to the need for audience completion and the range of their possible contributions, in an information theory sense, we might say that the latter carries more uncertainty and potential for unfamiliarity.

The media theorist Bret Victor emphasizes the capacity for technology to not only extend our sensory and actuating abilities but to “think unthinkable thoughts” (Victor, 2013). He gives the example of the invention of algebraic notation and how creating *x* to symbolize a value was a springboard for thinking of new substitutions: *x* as a vector or a matrix or other structure, etc. As such, we see how the introduction of new technologies creates a faciliatory ladder for transformational creativity and what-if thinking.

Engineering Ethics

The area of engineering ethics is significant to this discussion as it has addressed the role of the maker—the engineering professional—as a moral agent, also examining the extent to which the products of the engineer’s craft are vessels of moral ontologies.

As an area of study, engineering ethics has gained ground since the O-ring incident with the Challenger disaster (when engineers prioritized loyalty to their

company over the greater wellbeing of the people involved) (C. E. Harris et al., 2005) but also earlier, particularly as a response to the events of WWII. The horrors of the Holocaust, the material institutional structures that enabled it, and the proceedings of the Nuremburg trials that followed all provoked a wave of philosophical reflection about the ethical role of engineers. Here, there were gas chambers and high-capacity crematory ovens tailored to enact and accommodate genocide on a certain massive scale. This express purpose governed the form of these spaces and objects, and someone had to conceive of their design and implement it. Albert Speer, who served as an architect and headed the industrial system of Germany under the Nazi regime, had claimed value neutrality in his own defense, but to others, like scholar Eric Katz, it was clear that his projects, like all technological artifacts, were inescapably value-laden (Katz, 2011).

In a 2011 article, Katz points to scholarship arguing that one's technical profession of engineer or architect necessitates acting in the welfare of others, and insofar as one does not act accordingly, one is a failed professional (Katz, 2011). Furthermore, he argues that the acts of making and of using cannot be ethically separated: one cannot simultaneously claim to produce items to benefit society and then claim the items are neutral until engaged by an end-user. The capabilities of technologies are written into their form, as thusly, it is the maker's professional duty to preoccupy themselves with questions of ethics, specifically the material design of values (with respect to embodied "political, ethical, social, and cultural norms and ideologies").

Related research in recent years has increasingly focused on the design of computational systems, including algorithms in ubiquitous computing. Such work can help us reexamine ideas around disability (including neurodiversity), reframing such notions in terms of ubiquitous technical bias and the paucity of adequate inclusive technologies.

In an article, the technological philosopher Helen Nissenbaum discusses how values may be embodied within computational system design, looking at issues such as bias and user autonomy (Nissenbaum, 2001). She defines a biased system as a system that unfairly and structurally benefits one group at the expense of another. She also distinguishes technical bias (emerging from particular formal constraints) from preexisting (societal) bias and emergent bias (the “result of contextual shift”). She encourages control as one means to enable user-autonomy.

This work effectively describes the affordances of computational systems and the extent to which a user might be able to create some authorship over such structural features, emphasizing how such affordances carry value through the implications and consequences for others.

Such ideas connect also to inclusive design, a topic we’ll discuss as a part of the new media arts.

Music Cognition

In describing the basic psychological and neurological underpinnings of musical appreciation and emotional response, music cognitivist Daniel Levitin points to anticipation with respect to an acquired cultural schema and corresponding

dopamine releases in the neural accumbens (Levitin, 2006). This response relates to how a musical work can provoke surprise with respect to a given memory framework (to what locally came before and more general features of the genre, style, etc.). Repetition enters this as well. In these ways, this description of music cognition corresponds with our theme around the balance of the familiar and unfamiliar—how surprise is contingent on a given context— and how this context is culturally situated.

Philosophy of Science

The philosophy of science offers some interesting insight on our notions of familiar and unfamiliar as well as how strangeness can leverage compression. Thomas Kuhn defines the cycle of scientific knowledge through revolutions, which he characterizes as paradigmatic changes (Kuhn, 1962). An accepted paradigm sets up hypotheses and research questions within an established framework of rules (here we might think of Boden's exploratory creative permutations). Anomalies in the results help to provoke a reconsideration of the rules, leading to the search for a new set of rules to encompass the previous results and anomalies. This may entail questioning the premises upon which previous research questions were based. A new paradigm demonstrates fitness to overtake the previous if it fits the anomalies and previous research better, successfully predicts new kinds of phenomena that the other model cannot predict, and/or provides a simpler, compressed synthesis. Once accepted, this paradigm become the new exploratory framework (which is incommensurate with the previous model). Here anomalies,

strangeness, lead to compression through a reconsideration of conceptual structure that also evokes Boden's transformational creativity of rule changing.

Also importantly, Kuhn takes the position that the trajectory of science doesn't aim at a singular truth, but is strongly contingent upon former knowledge and its constraints. This sentiment resonates with the idea of cultural situatedness and the constraining affordances of social-historically established conceptual structure.

Symmetry

The mathematical concept of symmetry is also useful to consider within our investigation. Symmetry itself may be defined as a kind of transformation without change. The composer JoAnn Kuchera-Morin defines art itself in terms of symmetry as the "making and breaking of symmetry," [5] which we may relate back to our point about the balance of the familiar and unfamiliar.

In a series of written lectures, the mathematician Hermann Weyl presents different kinds of symmetries, moving from bilateral/reflected symmetry, eventually to crystals and more mathematical abstractions (Weyl, 1952). In verbally defining asymmetry, he points out that "seldom is asymmetry merely the absence of symmetry. Even in asymmetric design one feels symmetry as the norm from which one deviates under the influence of forces of non-formal character." This assertion further reinforces our ground/figure notion of the familiar and unfamiliar. Across his writings, he presents mathematical formalizations of symmetry in terms of groups. For example, mathematical groups of similarities (or automorphisms) undergo

[5] (J. Kuchera-Morin, personal communications, 2014–2021)

translations like congruent transformations, where elements are repeated together elsewhere in specific, varying ways.

Speaking speculatively, the mathematical formalization of kinds of familiarities as found in symmetry seems to offer promise for information aesthetic efforts to qualify the balance between familiar and unfamiliar. In future work, we would like to explore this potential in collaboration with mathematicians and related experts.

It's also worth noting that symmetry has become a valuable methodological tool for making scientific discoveries and thus growing human knowledge. As Frank Wilczek has pointed out, it has been scientifically expedient to first theoretically identify potential physical symmetries and then scout out their potential manifestations in the world (Wilczek, 2015).

2.3 NEW MEDIA ARTS INTERSECTIONS

This section serves as a state-of-the-art for the areas and practices within the new media arts that already contend with the humanities and related ideas around cultural learning. We'll first look at previous efforts in the new media arts to integrate aspects of the humanities and then highlight key practitioners whose work might fit within a notion of computational paideia. The aim here is to provide context for our own attempts to engage paideia through our original artistic and pedagogical practice (discussed in Chapter 4).

2.3.1 THE HUMAN IN NEW MEDIA ARTS

In the new media arts proper and in the disciplines and practices that it comprises, we find various integrations and intersections with the humanities. We will explore some of these approaches here, with a particular focus on fiction, the use of art within social or political contexts, application of the humanities to the arts, and the use of NMA as a humanities analytical tool.

FICTION

We find the practice of fiction not only in literature and cinema but also in design, non-verbal art, and immersive experiences like games. Perhaps less obviously at first glance, we also find it in philosophy, science, and mathematics to validate or build knowledge. Across these diverse disciplinary manifestations, we can engineer fiction for purposes beyond mere entertainment as a tool serving ends of actual cultural ideation and action.

Speculative Design

In the chapter entitled “A Methodological Playground: Fictional Worlds and Thought Experiments” of their book *Speculative Everything*, Anthony Dunne and Fiona Raby call for a new kind of approach to design based on the practice of speculation (Dunne & Raby, 2013). They characterize such a practice of speculation in design as “designing for how things could be”; designing “for reflection, critique, provocation, and inspiration”; using the story-making potential of design in contexts outside of industry “toward more social ends that address the citizen”; and as a means to “unsettle the present rather than predict the future.” In this definition of speculative design, its very articulation implies a kind of paideia, in serving the citizen ultimately as an object of critical reflection ultimately concerned with their betterment. The authors evoke several extant practices that might serve the purposes of this speculative approach, including fictional worlds and thought experiments through different disciplinary lenses.

In their couching and breakdown of fictional worlds practice, they cite from philosophy, political science, literary theory, fine art, game design (although stressing their aims of advancing ideology over simple entertainment), and science, also with focus on utopias/dystopias and idea-led narratives. In worldmaking, they encourage a bottom-up approach with a focus on the society:

> Rather than thinking about architecture, products, and the environment, we start with laws, ethics, political systems, social beliefs, values, fears, and hopes, and how these can be translated into material expressions, embodied in material culture, becoming little bits of another world that function as synecdoches.

In this way, the authors echo the idea from CHAT, that design objects may carry information beyond themselves in the values, meanings, and other ideas about the hypothetical society that derived it.

In their couching of thought experiments, they contextualize their history both within “fields where it is possible to precisely define limits and rules, such as mathematics, science (particularly physics), and philosophy (especially ethics) to test ideas, refute theories, challenge limits, or explore potential refutations,” and within art and literature as well. Under the category of thought experiments, they list counterfactual thought experiments and what-ifs, distinguishing between the two thusly: for them, the former entails the consequences of altering some aspect of a past event (e.g. think Philip K. Dick’s *Man in the High Castle*) whereas the latter is more “forward looking” and encompasses more fantastical scenarios focused on the pursuit of a particular idea.

Both approaches support the theme of compression through strangeness, hitting at the common essence as manifest in the actual world so as to motivate synthesis and reflection followed hopefully by action.

Design Fiction

In close relationship with Dunne and Raby’s notions, Stuart Candy calls for exploring possible worlds and futures through experiential design and experiential futures beyond language (Candy, 2010). Specifically, he views his design fiction approach as the confluence of future studies, politics (theory and activism), and design.

Implying alternative worlds through designed objects, he emphasizes the need to explore the possibility space of our future reality in a hyperdimensional manner. His preoccupation is that of a kind of paideia: “it is about developing the requisite tools to steer ourselves, and our communities, towards preferred futures.” In terms of non-verbal mediations, such explorations may entail the full spectrum of sensory experience and serve as synecdoches or compressions of their own realities. In the consideration around the development and consequences of such objects, he ties in ethics and their “sociocultural implications.” As such value and mediated situatedness come into play.

Virtual Worldbuilding/Worldmaking

Alex McDowell defines worldbuilding as generating “a container for narrative, or for multiple narratives” (Willis & Anderson, 2013). Marcos Novak, also approaching worldmaking as a derivation source for countless narratives also defines worlds in terms of boundaries.[6]

Fictional world ideation and creation can serve not just science-fiction narratives in literature, cinema, and games, but also other artistic applications as well as holistic pedagogical models. A growing number of media artists have used immersive technologies to explore worldmaking. As leading theoreticians and practitioners on the subjects, McDowell and Novak have also separately developed pedagogical frameworks for learning through world generating approaches at USC and USCB, respectively. Other worldmaking practitioners include many alumni and

[6] (M. Novak, personal communications, 2014–2021)

current students in UCSB's MAT Program, including Mark-David Hosale, Haru Ji, Graham Wakefield, Timothy Wood, and Weidi Zhang, to list just a few.

Futurisms

Through the movements of Afrofuturism and Indigenous Futurism, historically marginalized groups have leveraged the practice of futuristic worldmaking including as a means to explore desired futures outside the oppression of present societal narratives. Speculative design and design fiction practices provide avenues to exercise such futurism making practice.

ART/DESIGN IN SOCIAL CONTEXT

Critical Making/Critical Design

The conceptual-material practices of critical making and critical design integrate critical thinking with action-based practice and the production of concept-embodied objects. Critical making is similar to critical design, but critical design can be said to be more concerned with the final product rather than the production process of making itself within critical making (Farahi, 2021b). This work ties together situated action with conceptual structure.

Authors Ratto and Hertz propose critical making as the interdisciplinary glue for STEAM-type educational pedagogies, with making serving as a "non-disciplinary middle ground" (Ratto & Hertz, 2019). The authors identify three practices that unite material and concept in a critical way: critical design (after Dunne and Raby: a practice that principally critiques commercial uses of design), critical technical

practice (which tries to bridge different technical disciplinary mindsets), and reflective design (which intends to provoke user reflection).

They define their critical making practice in terms of “opening up the hidden assumptions and values associated with modern sociotechnical life.” The “critical” aspect of critical making refers directly to critical thinking. This criticality is explicitly concerned with the values inherent in disciplinary boundaries and practices with “the overt goal ‘to liberate human beings from the circumstances that enslave them.’” They ground the making aspect of critical making in maker- and hackerspace practice, also asserting that making necessitates technological skill.

Although critical making places greater emphasis on the process itself of making (as we mentioned earlier), Ratto and Hertz advance the idea as an umbrella term for general critical material-conceptual practices across fields and disciplines. As such, critical design would be a child practice of critical making.

In his own pedagogical practice, Hertz adopts a five-step methodology from reflective design, whereby assumptions and metaphors within a discipline are identified, assessed for occlusions, inverted, and then the inversion is built and shared. This conceptualization of metaphor connects with the arguments of Lakoff and Johnson that metaphor is inherently partial with respect to its source with both used and unused parts. Furthermore, consistent with the theory of Noë, their approach also supports defamiliarization as an aim: making strange.

This work also connects back to CHAT and related pedagogical theory as well as learning through making. Here and elsewhere, Ratto connects critical making

within the history of constructivist educational theories, which includes Vygotsky, a founding CHAT theorist.

In a further synthesis to our previously discussed theories, authors Dourish et al. have specifically explored the use of HCI as a critical technical practice, citing CHAT in their theoretical grounding (Dourish et al., 2004).

Relatedly, with respect to media arts and technology practice, Angus Forbes proposes a methodological theme of provocation, which includes the capacity of media arts to challenge of the status quo (Forbes, 2015). This also leaves room for the media arts to tie into the intersection of art and activism, our next theme.

Artivism

The convergence of art and activism is a topic too large to treat in any great detail here. The term of artivism itself connects to Chicano/a art practice in the late 1990s, including in digital mural art making practices in Los Angeles led by Judy Baca (Sandoval & Latorre, 2008). The idea of using art as a form of activism or more broadly as political commentary reaches back further, to ancient times. In more contemporary consciousness, the protest art and music associated with numerous 1960s countercultural movements come readily to mind.

Human-Centered Design

Human-centered design (HCD) is the design approach that design cognition specialist Donald Norman advances in his research. We've already looked at this through affordance theory with natural-body mappings and emotional design, but

his approach also emphasizes the importance of considering the limitations of how the human mind already operates in the optimization of design rather than starting from some view of how the mind should work (Norman, 2013). This is an important consideration even in learning systems that try to change how we think: if the design does not contend with one's starting point and scaffold understanding from there, it might be harder to achieve desired progress.

Inclusive Design

Designer Regine Gilbert has offered strategies for operationalizing accessibility within inclusive design (Gilbert, 2019). She advocates for a reflective process that includes a consideration of one's social lenses (inherited, developed, and behavioral), and a consideration of the opposite by entertaining what evidence would prove an assumption wrong. Her research in this area is also grounded in the work of Donald Norman. As such, her work contends with the myopia of one's cultural situatedness and how such shortcomings bear on affordances. Her strategies promote counterfactual thinking to shift perspective out of one's situated vantage point.

APPLIED TO ART

As we evoked earlier, Ryan Dewey has applied ideas from conceptual blending, and human-centered design, and embodiment to inform a cognitive engineering approach to the design of artistic installations (Dewey, 2018).

ANALYSIS

The digital humanities mostly focus on digital analysis of “cultural heritage datasets,” consisting predominantly of text, investigating trends across multiple works using data representations usually visual in nature (Jänicke et al., 2015). One might describe the digital humanities as a methodology as well as a collective and collaborative approach to knowledge building (Kirschenbaum, 2010). While this area can be extraordinarily insightful for analyzing certain kinds of cultural situatedness and memes as evidenced in data repositories, alone, it lacks a holistic framework for the consideration of human action.

DATA REPRESENTATION

Here, it’s also critical to recognize new media arts approaches to data representation, which can occur via different sensory modalities (e.g. visualization, sonification, haptification). The forging of conceptual structure is central to the mapping process inherent in such work, and often the goal is a compression to bring salient information and patterns to the fore.

The work of JoAnn Kuchera-Morin in conjunction with her AlloSphere Research Facility is a pioneering and fascinating illustration of such a process. The formal design of the lab-instrument is key to such an end.

Kuchera Morin’s AlloSphere is 3-story diameter, 360° immersive spherical multi-modal projection environment, housing 26 projectors and a 54.1 channel speaker system (*The AlloSphere Research Facility*, n.d.). The space features a bridge that runs through middle of the sphere, on the second floor. The artifact that

is the AlloSphere is interesting to note for the substantial creative leap away from the rectangular caves that preceded it. It's cylindrical form—particularly the lower visual field it affords (Kim, 2021)— brings an immersive continuity that is critical to the research of the lab. Working with experts in such areas as quantum physics, material science, and mathematics, among other areas, their work aims to create immersive, experiential, and more intuitive compressions of complex data that speed up time to discovery.[7] An example of this is in how a collaboration with a material scientist team, scientists were able to acquire an intuition for nuances in the data via sonification. After repeated immersive exposure to their synthesized and compressed data, they began developing a sensibility for desirable or undesirable results including bugs in the code[8]: it became familiar and situated. Interesting anomalies are also represented and may help to advance the conceptual framing of their research.

On a related note, conceptual blending and AI may soon help data visualization. Coral Featherstone is investigating the potential to encode input spaces and conceptual spaces computationally by creating databases of predefined relationships between concepts via text (Featherstone & van der Poel, 2017). She discusses the potential of AI in discovering conceptual trends in datasets, toward the end of generating appropriate and insightful visual metaphor. For the time being, she stresses that humans are better than AI at creating these visualizations.

[7] (J. Kuchera-Morin, personal communications, August, 2021)

[8] (J. Kuchera-Morin, personal communications, August, 2021)

2.3.2 RELATED PRACTICE

3rd Wave HCI

Thecla Schiphorst's work has incorporated physical computing systems including wearable sensors and external interactive soft objects for touching (Schiphorst, 2009; Schiphorst & Andersen, 2004). Her work explicitly couches itself within the practices of somatics, affordances, human-computer-interaction, and activity theory (through the work of Bonnie Nardi). Many of her pieces focus on a single gesture and the affordances that that particular action creates. As a part of this work, she introduces opportunities for participating subjects to reflect on their embodied experiences, which happens to promote the notion of metacognition as found in education—a key element of impactful situated learning environments.

Behnaz Farahi's projects entail interactive wearable physical computing systems concerned with exploring social interactions. Her work explicitly engages critical making through contemporary understandings in neuroscience, cognitive philosophy, computational design, among other areas (Farahi, 2021a, 2021b). Using facial tracking technologies, she has created garments that respond to the gaze of another (*Caress of the Gaze*, 2015) and the interpreted emotion of another (*Iridescence*, 2019).

Timothy Wood (2021) engages in a practice he terms *embodied worldmaking* that explores the use of computational tools within HCI and virtual worldmaking to explore embodied connections to environment (Wood, 2021). These works cultivate somatic sensitization and learning as well as sensibility to one's surroundings,

promoting ecological values. Many of his projects engage such ideas through full-body tracking and audiovisual feedback within immersive environments.

Jiayue Cecelia Wu terms her artistic practice *embodied sonic meditation*, which considers embodiment and cultural affordances within the design of gestural sonic music grounded in the tradition of Tibetan sonic meditation (Wu, 2021). She designs versatile affordances for both intuitive sonic gestural control as well as for audience interpretation. As part of this work, in her installation *Resonance of the Heart*, she uses Buddhist Mudra hand gestures to map to audiovisual parameters with respect to Buddhabrot fractals.

Somatic Movement/Dance

Somatic specialist Bonnie Bainbridge Cohen has developed the Body-Mind Centering approach to movement practice, which serves dance (Cohen, 2019). This model yokes conceptual structure to embodiment from a biological and anatomical perspective. Evolutional and developmental trajectories of the human body to inform movement patterns, with a consideration for the conceptual significance of the origins of such gestures. Sensorially, this process is concerned more with first-person kinaesthesia (the feeling of the body in movement) than how the body might visually appear to a third-person viewer.

Formal Metaphors

Composer Iannis Xenakis leverages mathematics to realize complex conceptual structure and philosophical reflection about Plato's *The Republic* in his

1978 electronic piece “La Legende D’Eer.” As Marcos Novak points out, he uses stochastic laws and a Lorenz attractor as a metaphor for Plato’s “Myth of Er,” where souls (under many cycles of transmigration) vacillate unpredictably between just and unjust lives until they learn philosophy (Novak, 2014). Xenakis interprets this precarious variation as a stochastic law and bookends his work with extratextual associations to cicada song (a creature with strong associations to music and death in Greek myth).

As previously evoked, Ryan Dewey explicitly uses conceptual blending to inform design and interaction metaphors in his cognitive engineering design model and works in the context of installation art (Dewey, 2018).

Speculative Design Fiction

As mentioned earlier, Stuart Candy’s work engages speculative design fiction with an eye to political imagination. One relevant project is a future ideation card game entitled The Thing from the Future (Situation Lab, n.d.). The combination of different kinds of prompts given by different card types provokes the imaginative descriptions for hypothetical objects from different points in different hypothetical futures. Prompts include the kind of future arc, terrain/context, the form of the object, and mood. As such, there is opportunity for speculative design in an environmentally situated way, with a consideration of form, and thus—potentially—affordance as well.

Information Aesthetics

Artist Philip Galanter has explored ideas from information aesthetics in his artistic practice (Galanter, 2013). He has developed an audiovisual creative platform called XEPA which features a network of intelligent light tube displays that vary spatiotemporally in color across their length and produce sound. The tubes function socially with respect to one another, communicating via data radio to adjust their behavior to better suit the theme or "mood" of the others. This platform is explicitly optimized to test informational aesthetic concepts of Moles' repertoire space and ideas of balance between originality and banality.

Virtual Game Ethical Decision-Making

Virtual game play has also explored ethical decision making and causal consequences. Pakorn Tancharoen's "Ethics Game" explores such ideas with respect to Buddhist ideals which provides scenarios to exercise these values, rewarding points for adherence to said values, and deductions for violations (abgal, 2007; Sherriff, 2007).

2.4 THEMES IN FOCUS

In this section, we'd like to briefly reframe aspects our literature review in terms of our four key themes in order to more clearly see the rich multi-pronged support for these notions across the disciplines we are uniting: new media arts (computer science + arts), the cognitive sciences, education, and classics.

2.4.1 SITUATED MEDIATED ACTION

The importance of learning through action, specifically situated mediated action, has been both an implicit and explicit gravitational trend in both antiquity and the present.

Shifts from Unidirectional Information Transfer to More Multidirectional Active Approaches

Across Classical Greece, modern education paradigms, and computer science (specifically human-computer interaction), we can observe a general trend whereby unidirectional information transfer models are abandoned in favor of more multidirectional approaches with active, participatory components.

In Classical Greece, we see this trend transpire across sophistical formal instruction. Earlier sophists presented their teachings in more lecture-based contexts and presented demonstrations of their skill for analysis (De Romilly, 1992).[9]

[9] (F. Dunn, personal communications, August, 2021)

A famous example of the latter is Gorgias's text *The Encomium of Helen* (Gorgias, trans. 1993). To advertise the capacities of rhetorical persuasion, this text undertakes the task of arguing in defense of one of the most universally condemned mythological figures, Helen, who is attributed with instigating the Trojan War (as a Hellenic queen leaving her home with a Trojan prince). Correspondingly, the text itself argues that Helen is blameless as she was deprived of agency through compulsion via either emotion, rhetoric, physical force, or divine design. As such, through its content and structure, this text, informs about and models rhetoric, but as an object of study.

With sophistry being considered the "techné of citizenry," the instruction was intended for later application in civic spheres such as assemblies, but application did not feature as an emphasized component of the instructional process until later with Isocrates (De Romilly, 1992).[10]

Isocrates, who eventually founded his own academy, advocated for practical exercises as part of sophistic instruction. In so doing, the active contributions of the pupils became part of the learning process (De Romilly, 1992).[11]

In more modern education paradigms of the 20th century, educational scholars (Land et al., 2012) describe a general move away from more transmissive approaches (where students absorb or take in lecture from an instructor) towards more constructivist and situated learning approaches (with student-centered learning environments where knowledge is collectively and socially co-created).

[10] Ibid.

[11] Ibid.

This pivot was instigated by activity theories coming from Soviet thinkers like Lev Vygotsky and the constructivist work of French educational scholar Jean Piaget.

More recently, Land et al. have stressed the added importance of having students engage in metacognitive reflection (i.e. feedback) with respect to their constructivist and situated learning experiences and they have detailed the way in which digital tools (including virtual gameplay and worldmaking) have supported such learning environments (Land et al., 2012).

Lastly, within computer science and human-computer interaction research-practice, we see activity theory integrated within second-wave HCI but in a more unidirectional information transfer model, and a focus on problems pertaining to the workplace.

However, in the present third-wave of HCI, we see the integration of situated action, and how this contributes to meaning-making. Additionally, contexts of application have extended beyond the workplace to include artistic contexts, which includes new media art praxis.

Fields

Action and situated mediated action theories have been advanced and supported through a myriad of research areas, particularly including the following foci:

- cultural-historical activity theory
- cultural psychology
- affordance theory
- embodied mind theory
- extended mind/distributed consciousness theories
- education: through constructivism and situativity

- human-centered design
- cybernetics
- object-agency theory

2.4.2 CONCEPTUAL STRUCTURE

Formal (Mediated) Structures as Carriers of Value and Meaning + Value and Meaning as Being Formally Mediated/Structured

As with the ancient roots of action, the idea that externalized formal structures can embody certain values and meanings is also an ancient concept.

This notion was explored in Classical Greek philosophy of art and art proper, for example with Plato's philosophic dialogue *The Republic* (Plato, trans. 1968) and Aristophanes' comedic play *The Frogs* (Aristophanes, ed. 2002). *The Republic* reviews the moral character of certain musical modes and rhythms and in *The Frogs*, through parody, formal musical elements of the tragic poets Aeschylus and Euripides are contrasted and evaluated for their social value, with those of Aeschylus embodying ideal values and those of Euripides embodying the value of being true-to-life, in all its grittiness.

This idea also carries over into many other disciplines and fields looking at the formal conceptual qualities of human artifacts and environments including perceptual psychology and human-centered design (with affordance theory), anthropology and art (with object-agency theory), engineering ethics (with the notion of value-ladenness), biology and cognitive science philosophy (with meme theory), and cognitive linguistics (with conceptual metaphor and blending), among others.

Like Plato, many of these connected theorists (Dennett, 2001; Gibson, 1979; Katz, 2011) explicitly discuss how such conceptual structures can be beneficial or harmful to humans. Cognitivist Daniel Dennett goes so far as to present an evolutionary model by which ideas (acting in their own structural interests) may be mutualistic, neutral, or parasitic with respect to the human.

To varying degrees, these modern theories couch their ideas with respect to agents and back to their situated actions, as shaped by the contextual factors of embodiment, social/cultural schemata, and the physical environment.

2.4.3 BALANCE OF FAMILIAR AND UNFAMILIAR

The balance of the familiar and unfamiliar is a key mechanism to learning echoed throughout numerous areas.

The familiar is contingent upon our situatedness and prior experience: our body, our learned cultural knowledge, our known natural environment. As a consequence, what is determined to be unfamiliar is also defined and measured in terms of what is familiar and situated.

This balance is explicitly explored in information theory/aesthetics and creative computation, and it's also necessary for parsing conceptual blending, meme theory, intra/extra/intertextuality, scientific revolutions, symmetry, music cognition, and the strangeness of art in Noë's philosophical approach.

2.4.4 COMPRESSION THROUGH STRANGENESS

Within several theories and practices, we find the idea that significant strangeness (especially through fiction and counterfactuals) can lead to pattern compression (or the recognition of a previously unrecognized aspect of situatedness). These include Wartofsky's tertiary artifacts of contrasting worlds, conceptual blending, Schmidhuber's theories of interestingness, Boden's transformational creativity, Kuhn's anomalies and resulting paradigm shifts, Noë's idea of art as a strange tool, and in fiction practices including speculative design, critical design, design fiction, and futurism.

Also, while patterns may be eventually delineated by large sample sizes acquired unconsciously through experience or consciously by systematic effort, patterns may be more economically brought into focus with the help of one powerful strange example which changes enough variables to force a recognition of a critical common property.

2.5 PAIDEIA REVISITED: AN ANALYSIS

Given our detailed survey and defined themes, it is now possible to revisit our contemplation of Classical Greece to see how these trends might elucidate paideia at work in ancient media forms and works. For the most part, we will concentrate on two particularly illustrative areas: Greek theater (including its contextualizing festival rituals) and philosophical dialogue.

Before diving into this analysis, it's also worth briefly evoking several correspondences between our modern theories and ideas expressed in ancient philosophy. Plato uses metaphors, of shaping the body and of culture as an environment, as part of his argument for the role of art with respect to character (Ford, 2002). This approach brings to mind ideas of situatedness and conceptual structure. Another resonance is found in Aristotle's interpretive framework of the four causes (Aristotle, ed. 2013b, ed. 2013a). For him, all objects have a material cause (what it's made out of), an efficient cause (who brought it about), a formal cause (what form or kind of object it is), and a final cause (its purpose). This framework ties together form with purpose in a way that could be said to anticipate later affordance theory and ideas of value-ladenness. Yet another correspondence comes from Aristotle in his *Nicomachean Ethics* when he states that "…moral or ethical virtue is the product of habit (ethos), and has indeed derived its name, with a slight variation of form, from that word" (Aristotle, trans. 1926, Book II). Ethics are performed, they are actions that take a similar structure through many iterations over time. This pattern of behavior brings to mind Kimmel's points about the connections of concepts and actions (Kimmel, 2013).

Concerning our interpretation of ancient media, we'll look at examples through our themes.

2.5.1 SITUATED MEDIATED ACTION

The notion of action manifests in different aspects of ancient Greek theater, including the plot, the chorus, and the audience.

The medium of ancient Greek tragic theater entails observed causalities of actions. This perspective of theater was explicit to the ancient Greeks themselves. As Aristotle points out in his *Poetics*, "tragedy is the imitation of an action," and

> …most important of all is the structure of the incidents. For tragedy is an imitation, not of men, but of an action and of life, and life consists in action, and its end is a mode of action, not a quality. Now character determines men's qualities, but it is by their actions that they are happy or the reverse…without action there cannot be a tragedy. (Aristotle, ed. 2013c, Book VI).

Here, action incidents are construed as units of life and tragedy is preoccupied with their representation. Relatedly, for Aristotle, plot, the structure for such actions, is paramount and the "soul of tragedy" (Aristotle, ed. 2013c, Book VI). Moreover, its structure must be complete: with a beginning, middle, and end, where each subsequent part is a consequence of the preceding part (Aristotle, ed. 2013c, Book VII). Within this plot, simulations of poor actions arising from "error or frailty" (Aristotle, ed. 2013c, Book XIII) may unfold for the audience to bear witness in a cautionary way. It's also interesting to note that he emphasizes scaling the length of the action to "be easily embraced by the memory" (Aristotle, ed. 2013c, Book VII). In this way, the medium is situated with respect to human embodied limits.

The chorus too is a vehicle for action in two related ways. On one hand, the chorus as a character is the representation of the audience. In another sense, the

chorus, as comprised of ephebes (young men coming of age as active citizens), served as a training ground for civic life, performing as the representation of the audience, and as such, in the role of members of the citizenry.

The mechanism of the chorus in Greek tragedy serves as an avatar of the audience of sorts, often voicing the moralizing thoughts, questions, and concerns of the audience (or at least an ideal audience). A straightforward example is found in Euripides' *Medea*, where the chorus empathizes with Medea when her husband Jason wrongs her, but when she voices her plans to exact revenge on him through the murder of her own children, the chorus admonishes her and urges her not to go through with her plans (Euripides, trans. 2008, 790–813). Here, the chorus is a tempering voice, albeit one not ultimately heeded. Author David Wiles explores this perspective as well, examining the roles of the chorus both as a "surrogate spectator" and the "voice of myth" (Wiles, 2000). Concerning this first point, he points to ideas of the chorus as an "ideal spectator" (after Schlegel), as an "intermediary between the audience and the actors," and how this is reinforced in how the audience must observe a smaller group engaged in an act of watching an event. In this sense, watching acquires an active quality, one that can be performed. This brings to mind McLuhan's distinction of "cold media." With respect to the latter point about myth, the chorus is also the avatar of the greater culture: they "embody the collective wisdom of the community" in evoking a shared and familiar corpus of knowledge, evoking relevant myths for steering interpretation (Wiles, 2000). This ties into cultural situatedness and also notions of the extended mind where the chorus is an externalization of collective memory. Classicist John Winkler also

reinforces this notion of the chorus as an intermediary. He first stresses that the main characters, played by men and full citizens, bear the "responsibility of correct social action" and that the chorus, played by young men who are "citizens-in-training," are implicated in the actions but not responsible (Winkler, 1985). There is then a "vector of attention from the watchful (though not personally responsible) chorus to the actor." Furthermore,

> …the events and characters portrayed in tragedy are meant to be contemplated as lessons by young citizens (or rather by the entire polis from the vantage point of the young citizen), and therefore makes the watchful scrutiny of the chorus structurally important as a still center from which the tragic turbulence is surveyed and evaluated (Winkler, 1985).

Here, this interstitial role performs the act of both watching and of critical social analysis, important for paideia and the development of values.

Related to this point, the chorus also served a greater civic purpose within the community for the very training of these young men who comprised it, known as ephebes, as they entered into public life as citizens. Specifically, ephebes were young men in military training of about eighteen to twenty years of age, in a transitionary and formative phase as citizens-in-training (Winkler, 1985). Winkler argues that the very origins of the spring dramatic festival, the City Dionysia, and of the early tragic art form were centered around this group: they were the not only the choral performers, but the audience was organized in such a way to reflect their transition into civic life (as we'll soon discuss in more detail), and the scripts themselves were largely about young men coming of age. As such, connecting to situated mediated action, the chorus served as a vehicle for these young men to perform citizenship and to perform moral contemplation and evaluation—to first ventriloquize and then eventually embody the collective social consciousness and

conscience. In these ways too, the theater was an interactive mechanism, a rite-of-passage in which its citizen spectators would have likely participated at some point. This first-hand participation would have also conferred dramatic literacy of the medium itself, which would have been valuable for understanding theatrical intertextual meaning in plays such as Aristophanes' comedy *The Frogs* (Griffith, 2013).

Connecting to our previous points, the audience itself can be considered as a character within the plays. In addition to the ways in which the chorus serves as an interface to the main action onstage, the seating arrangement of the audience strongly evoked civic and militaristic associations, with an arrangement similar to actual full-citizen assemblies (Winkler, 1985). The theater even served as the venue for some such meetings (Winkler, 1985). This arrangement, recalling the structure and forum for active civic engagement, serves its own performative role, anchoring the audience to the action on stage as they, couched in the ritual of the larger festival, perform their greater societal roles. The audience is on hand to act out their civic position as part of the larger ceremony. The specifics of their seating arrangement connect the idea of situated action to our next theme of conceptual structure.

2.5.2 CONCEPTUAL STRUCTURE

We will discuss some interesting manifestations of conceptual structure in Greek media, examining three examples: the theater audience through its well-

structured seating arrangement, the formal intertextuality in Aristophanes' comedic play *The Frogs*, and the use of stichometry in Plato's dialogues.

As we've already discussed a bit, there was a civic importance in the experience of theater-going itself as couched within larger festivals. (These festivals, including Rural Dionysia, Lenaia, and City Dionysia, celebrated Dionysus (Winkler, 1985)). The ritual and organization around theater-going invites parallels to the modern artistic installation. Here, we find militaristic and other civic metaphors, many of them spatial and pertaining to the seating arrangement (Winkler, 1985). The audience participants would have included (voting) citizens from the ten Attic tribes, and of these tribes, a special council or Boulé comprised of fifty representatives from each of the ten tribes (Winkler, 1985). This number informs the number of chorus participants (ten competing groups—a group from each tribe—of fifty). The auditorium was divided into thirteen vertical wedges, with spaces for the ephebes and esteemed Boulé seated in the center, non-citizens at the edges, and for each tribe in the other wedges (with some adjustments in later years when the number of tribes increased) (Winkler, 1985). The representation of the various tribes, occupying different vertical wedges of the seating area reinforces the notion of democracy, a weighting of equal importance in these groups coming together. It also reinforces notions of military might: presenting a "unified front" against enemies (Winkler, 1985). The seating also integrates the youngest generation into the fold, celebrating this integration in giving them a privileged place of seating with the council members. Additionally, spatial proximity to the stage within each wedge was a sign of esteem (Winkler, 1985). For Winkler,

> …the entire audience is organized in a way that demonstrates its corporate manliness as a polis to be reckoned with, comprising individuals who are both vigilant to assert excellence against other members of the city (tribe versus tribe) and ready to follow legitimate authority against external threats (cadet soldiers and Council).

In these ways, conceptual metaphor is a key part of theater ritual, rooted in their civic values. The meditated ratios and spatial placement of the citizens in the auditorium communicate democratic and honor-based values about governance. Furthermore, they place value on the institutionalization of citizenship, where formal parallels and equivalencies are established between both its newest members and highest leaders, speaking to the life cycle of the civic body.

Another example of conceptual metaphor as part of paideia can be found in the intertextuality of *The Frogs* by Aristophanes (Aristophanes, ed. 2002). As mentioned earlier, the comic (fictional) plot involves a contest between the tragic playwrights Aeschylus and Euripides, where they respectively mock the formal properties of the other's work. These formal parameters include diction, the length of qualifiers, metric rhythm, cultural metric associations, among other aspects. Critically, these parameters are not merely spoken about, but they are formally manifest and reproduced in the play's performance itself (i.e. they are acted and thus also tie into our theme of action). For example, both characters parody different predictable qualities in the other's choice of meter. The character of Aeschylus mocks the composition of Euripides' meter, which provides him the space to tack on a silly expression like "lost his oil bottle" to the end of his phrases (Aristophanes, ed. 2002, 1198–1248). Euripides in turn mocks the lyrical patterns in Aeschylus' meter inserting an absurd phrase at regular intervals (Aristophanes, ed. 2002, 1261–1297). The variety of mocked qualities are also culturally situated: Aeschylus' and

Euripides' styles are associated with high and low social registers, respectively. For example, Aeschylus' lengthy qualifiers and regular meter evoke the medium of epic poetry, its divine and demi-god characters, and its culturally associated grandeur (Griffith, 2013). On the other hand, Euripides employs mixed meters, with a style evoking ordinary speech (Griffith, 2013). These situated conceptual structures served to reinforce the social values that each tragic poet represented: the ideal versus the real and true. And, importantly for paideia, this contest is couched in a narrative exploring the cultural and ethical merits of each approach, seeking to identify which is most needed by and beneficial to society. (Ultimately, Aristophanes, through the character of Dionysus selects Aeschylus.)

A last example of conceptual structure is in the mathematical and macrostructural partitioning of Plato's dialogues, through an approach known as stichometry, or the measuring "of syllables in a line or lines in a stanza" (Kennedy, 2010). J.B. Kennedy, surveying Plato's dialogues and their respective number of lines, argues that many adhere to a twelve-part structure, which could be linked to the importance of number twelve in Pythagorean musical theory. Advancing that the dialogues are organized like a scale, with certain ratios having a consonant or dissonant relationship to the twelfth note, he identifies harmonic/disharmonic subject matter at the corresponding critical intervallic points in *The Symposium* (e.g. if 4/12ths is harmonious, the text might reference harmony or subject matter with strong harmonious cultural associations, like the god Apollo). These points are also significant to the greater dialogue: "Plato used this musical scale as an outline, pegging key concepts and turns in the argument to steps in the scale." He also finds

references to justice at the halfway points in numerous dialogues, an apparent pun on half and justice, citing Aristotle: "'dikaios is so-named because it is [cutting] in half (dicha).'" This also recalls the notions of balance as a part of the understanding of justice in Plato's *Republic*. In these ways, the dialogues' mathematical structuring and the structure's situated associations to extratextual ideas imbue these works with greater meaning. Their cultural mathematical and musical associations allow the text to embody the very philosophical ideas that the dialogues' subject matter often communicates: notions of order, measure, and balance.

2.5.3 STRANGENESS + FICTION

Lastly, our theme of strangeness that leads to compression is manifest in the way Greek myth is used and rewritten in cultural practice. We'll also see intersections with our notion of the balance of the familiar and unfamiliar. We will briefly discuss two examples: intertextual remixing in tragedy and Plato's use of novel genealogies and myth, looking at *The Symposium*.

Burian argues for tragedies as being fundamentally intertextual, relying on familiarity with cultural conventions in myth to be able to conform to them or subvert them, thereby directing the attention of the audience. In this way, plays operate within a "system of tragic discourse," and tragic poets serve as active mythmakers, without notions of orthodoxy (Burian, 1997). Where the plot deviates in new plays from the history of known versions, even in minor ways, is where the attention is

intended to be focused and where meaning is derived. As Marcos Novak states, it's "the difference that makes a difference."[12]

Plato also uses strange mythical rewriting as a philosophizing, meaning-making tool in his dialogues. In *The Symposium*, Plato, through the character of Diotima, redefines the genealogy of Eros, the Greek god associated with erotic love (Plato, ed. 2012c). The dialogue features a dinner party where the guests deliver speeches about Eros, often with the purpose to communicate some new idea about the domain he represents. To advance his idea that love concerns the pursuit of beauty and wisdom rather than some notion of lustful attraction, Plato reframes Eros' parentage away from other culturally familiar versions where he is the son of Aphrodite, goddess of beauty (noting two different genealogical versions of Aphrodite herself, through Pausanias). Rather, through Diotima, he asserts that Eros is a daimon (between the divine and mortal) and a child of Poverty and Plenty, conceived on the birthday of Aphrodite. His parentage positions the notion of love as being between two extremes:

> …he is never in want and never in wealth; and, further, he is in a mean between ignorance and knowledge. The truth of the matter is this: No god is a philosopher or seeker after wisdom, for he is wise already; nor does any man who is wise seek after wisdom. Neither do the ignorant seek after wisdom. For herein is the evil of ignorance, that he who is neither good nor wise is nevertheless satisfied with himself: he has no desire for that of which he feels no want.

The strangeness of this mythical rewriting (and great deviation from known versions) not only provokes compression about the ontology of love but also provides compression about the greater societal purpose of genealogy in myth as a philosophical mechanism for exploring ontologies of all kinds.

[12] (M. Novak, personal communications, 2014–2021)

2.5.4 REMARKS

In sum, our extracted themes help to demonstrate how the communication of value and meaning is operationalized in ancient Greek media: these themes, strategically leveraged, are critical engines behind paideia.

3. METHODS

In our last chapter, we isolated four key themes for learning and creativity: situated mediated action, conceptual structure, balance of familiar and unfamiliar, and compression through strangeness. In this chapter, we first detail our methods and contributions by discipline and then discuss the ways that our four key themes inform our methods. We will preface our thematic methods with an overview as to how these themes are fundamentally integrated with one another.

3.1 METHODS BY DISCIPLINE

We can categorize our methods and proposed contributions by key disciplinary areas: the new media arts (or media arts and technology), classics, education, and the cognitive sciences. While the following points may seem manifold, the picture is in fact much simpler, with overlapping interconnections. As a general trend, our research applies these fields to one another in novel ways, advancing their theory and pedagogy through such cross-pollination.

3.1.1 NEW MEDIA ARTS

Learning by doing (i.e. action) is inherent to new media arts (NMA) methodology. As part of the feedback loop of research-led practice and practice-led research (Smith & Dean, 2009), beginning with practice (which invites the strange and unfamiliar) often leads to theoretical formalization (i.e. compression), which can then inform pedagogy.

Practice:

We create original NMA artworks. Our prototypes serve to generate research questions (after Forbes (Forbes, 2015)) leading to the development of original theory.

Application:

We apply NMA as a model to shape a holistic pedagogical approach, serving education/the learning sciences.

The practice of NMA helps to explore human experience in a way that advances cognitive science research.

Theory:

We initiate the creation of original theory via NMA practice.

We develop the theory of the field by integrating in cognitive science and aspects of the humanities to new media practice.

Pedagogy:

We advance NMA pedagogy through a formalization of transdisciplinary fundamentals. This includes our four themes, theory developed from these themes, and integrating these themes within a context of learning by doing.

3.1.2 CLASSICS

Application:

We apply the framework of paideia (through the ancient Greeks' choices in cultural output and formal instruction) to guide a contemporary transposition through new digital media practice.

Theory:

We develop classical theory by analyzing ancient Greek media and their approach of paideia through the lens of a new theoretical framework consisting of our four themes (as we've done in Section 2.5).

This new framework also allows for more meaningful intertextual exploration of Greek media through original, contemporary artistic practice, serving analysis non-verbally through new mediated objects.

3.1.3 EDUCATION

Application:

We apply educational theories based on the learning sciences and analyses of situated activity to shape and inform how we approach the creation of interactive digital media artistic experiences.

Aspects of educational theory can inform NMA practice in ways that are not presently explicit. Furthermore, metacognition and pedagogical development itself can serve as part of the NMA research process.

Theory:

We develop educational theory by proposing a new model for holistic education, at least at undergraduate general education level.

Design:

We develop educational design through the addition of artistic practice. Furthermore, we serve educational design and tools by integrating affect and the compelling beauty of careful design, thus creating objects of greater emotional appeal and investment. Additionally, an art-led approach to learning helps to promote the kinds of strangeness that provokes insight and compression.

3.1.4 COGNITIVE SCIENCE

Application:

We apply the cognitive sciences as an analytical tool, aiding the interpretation of ancient paideia praxis as well as the interpretation and assessment of contemporary prototypes.

Additionally, we apply the cognitive sciences as a design tool, informing design decisions in the spirit of cognitive engineering (Dewey, 2018).

Theory:

Our development of deliverables (in the form of artworks and pedagogy) inform cognitive science theory via the notions of art as generator of research

questions (Forbes, 2015) and art as philosophical praxis regarding human experience (Noë, 2015). This is accomplished via the strangeness that art confers.

Moreover, our pedagogical model promotes cognitive science research.

Pedagogy:

Our novel pedagogical model promotes cognitive science education through a transdisciplinary and creative practical lens.

3.2 METHODS BY THEME

3.2.1 HOW THE THEMES TIE TOGETHER

Following our literature survey of learning and creativity, not only have we been able to tease out our four themes, but we can also start to see the ways in which these themes are integrally interwoven. Here, we'll address these interconnections more explicitly and systematically. For simplicity, we designate our themes by letter thusly:

A: Situated Mediated Action

B: Conceptual Structure

C: Balance of Familiar/Unfamiliar

D: Compression through Strangeness

We'll discuss their overlaps by pairings (AB, BC, AC, CD, AD, BD), which should gradually and cumulatively help us in understanding their triadic relationships among the themes (ABC, ACD, BCD), and full integrative rapport (ABCD).

A

To begin, we'll review the inherent integrality of our first theme: situated mediated action, starting with action and situatedness before accumulating mediation.

Our actions are shaped by our situatedness (i.e. context) and situatedness arises from our actions. The (direct or mediated) interactions between the embodied self and the environment—natural, cultural (of artifacts), or social (of others)—shapes what actions we can or are likely to perform in new situations. The

accumulated history of our actions further shapes these probabilities, and these situated weightings are constantly updating if not changing at deeper levels given new experiences. As a reminder, Cole defines context as activity systems, with action as a part of context, not its by-product (Cole, 1996). In these ways, action and situatedness are co-dependent.

Mediation is also a key part of this co-dependency. Culture, a system of artifacts (after Cole), is necessarily comprised of mediations, and these mediations/artifacts shape our situated actions with the natural environment and others (e.g. through language). For Cole too, context/situatedness is a unit of culture (/artifact system), and objects/artifacts and context/situatedness are emergent together. Kaptelinin and Nardi's re-grounded notion of affordance encapsulates these ideas (Kaptelinin & Nardi, 2012).

AB

Conceptual structure integrates into situated action through culture and mediation.

Through Kimmel especially, we see a fundamental connection between the situatedness of embodied and cultural actions and conceptual structure (Kimmel, 2013).

Many concepts have an embodied basis: embodiment appears to inform most if not all near-universal building blocks and guides more cultural-specific conceptual compounds. Culturally-specific everyday and ceremonial actions can provide concepts with an embodied basis. Moreover, the formal design of a given

mediation/artifact encodes concepts through cognitive offloading and through the notion of affordance: its relationship to a given agent and their situatedness.

BC

Conceptual structure through metaphor and conceptual blending relies on anchoring to familiar ideas to build new concepts, borrowing parts of familiar input sources in the process, and building upon their formal relationships (e.g. in time, in space, etc.).

Additionally, familiar concepts, in their mediated forms, propagate into new contexts with or without formal variation as we see with meme theory and intertextuality. The unfamiliarity of the new context along with any formal variations will impact their meaning.

AC+ABC

Situatedness itself is the basis of what is familiar and thus determines the relative measure of what is unfamiliar. Estimating the right balance for a particular objective (e.g. intuitive design on the more familiar versus question-provoking art on the more unfamiliar) is contingent upon a consideration of situatedness for the intended audiences.

As such, 1) given this tight relationship between familiarity and situatedness, and 2) given that conceptual structure is built out of relationships to more familiar ideas and experiences, the mechanisms of conceptual structure entail both situated mediated action and balance of the familiar and unfamiliar.

CD

The balance of the familiar and unfamiliar is critical for facilitating our fourth theme of compression through significant strangeness. Significance here is defined by this balance.

Strangeness is defined in terms of unfamiliarity. Given something above a certain threshold of unfamiliar, it may register as strange, and this can help us tap into the bank of familiarity/situatedness and provoke recognition of heretofore unconscious trends. This newly recognized commonality, linking previously unconnected ideas, allows for compression through such a common structure.

Fiction and counterfactuals invite the hunt for one or several pivot points with respect to the familiar and known of the factual world. As fiction deviates from the familiar, the more perhaps it invites greater levels of abstraction in the mind's pursuit to identify possible commonalities and pattern. Remembering Branigan's idea of fiction as an open function (Branigan, 1992), there needs to be some degree of the familiar to provide traction so that a fictional entity can't just mean anything but is directed in its scope of possibilities.

It's also important to recall here that Western abstract art and music in the 20th century was catalyzed from an exposure to outside cultural ideas, e.g. Claude Debussy encountering the Javanese gamelan (Haladyna, 2006). These differences in musical approaches helped launch an exploration into the building blocks of musical structure that informs international musical research-practice to this day.

Additionally, what is now strange later becomes part of the model of familiar, even if is more improbable within the memory bank of familiar items.

AD+ACD

As situatedness determines familiarity (and thus unfamiliarity), this too bridges situated mediated action into compression through strangeness.

BD+BCD+ABD+ABCD

The compressions that result from our fourth theme will possess formal qualities, creating conceptual structure. As a reminder from Fauconnier and Turner, conceptual blends are themselves compressions (Fauconnier & Turner, 2002).

These transdisciplinary themes all support a new approach to cultural literacy given their connection back to situatedness, which may support their application to the cultivation of paideia (with respect to values, meaning, and holistic thought).

3.2.2 METHODS FROM OUR THEMES

As we have seen, our learning and creative themes are profoundly inter-related, and this more integrative view starts to inform a more general and cohesive picture of how learning and creativity do indeed transpire.

How might this insight inform media arts theory, practice, and pedagogy? And what can the computational platform afford us?

Our mission now is to 1) explore ways in which the computational platform can leverage this view of learning and creativity in new media arts research-practice and pedagogy, and 2) develop our themes within a new supportive design theory for facilitating these practical approaches toward cultural literacy. Additionally, we want

to accomplish these aims with a mind to promoting value, meaning, and holistic thought.

First, we will indicate our hypotheses for learning given our themes. After, we will then consider how the computational platform might leverage these ideas, what kind of design theory/steps could support practical application, and/or what proofs-of-concept may be applicable.

KEY THEMATIC TAKEAWAYS

Given our synthesis of themes in the preceding section, we propose that the following aspects are important to cultivate in learning scenarios:

- Learning via action.
- Learning environments that facilitate whole body interaction with others through a variety of tools.
- Strangeness and exploring the space between familiar and unfamiliar via:
    - The ability to make and break mediated action (tool-making for exploring different mediated actions).
    - The ability to make and break situatedness (embodiment, cultural conventions, etc.).
    - The ability to make and break conceptual structure (including multicultural conceptual literacy, and a consideration of transcultural building blocks).
    - The ability to measure and make familiarity and strangeness.

METHODS BY KEY TAKEAWAY

We address **learning via action** through learning-by-making in the practice-led research and pedagogy particular to the new media arts.

We propose that the computational platform affords rapid prototyping and—from desktop models to physical computing systems—the ability to sense different

kinds of input actions and translate them into a variety of output actions in diverse media.

We explore this through physical computing and iterative worldmaking in the Mediated Worlds Course Series, as well as our own physical computing practice. We further stress learning through making with original theory on distinguishing using from making.

We address **whole-body and social interactive environments** through single-user and multi-user movement-based environments.

Here, the computational platform can facilitate interactivity with others through multi-user gestural control with physical computing or through the rendering and projection of spatial media for whole-body navigation.

We explore this potential through our original practice in multi-user installations which engages movement through physical computing and spatial projection requiring kinesis. We create different systems/tools across these works for different insights.

We address **making and breaking mediated action** through the design of affordances with consideration for cultural situatedness.

The computational platform can assist with implementing affordances through rapid prototyping and modeling. To evaluate and discover unintentional affordances, simulations and the use of AI can be useful to this end.

For us, we will propose theory and pedagogy for designing action probabilities and the consideration of culturally situated affordances. This includes worldmaking pedagogy concerning the relationship among agents, their

environments, and tools; artifact production through different disciplinary making mindsets via the THEMAS (STEM+Arts+Humanities) approach; and what-if/what-then causal thinking.

We address the **making and breaking situatedness** through immersive interactive mappings, pattern translation, and situatedness modeling.

The computational platform affords situated play through physical computing in immersive extended realities, creating avatarchitectures (after Novak (Novak, 2002)). It can also facilitate data mapping from cultural sources. Also, it facilitates the modeling and worldmaking of environments and agents.

We explore strange situatedness in our immersive physical computing practice and in worldmaking pedagogy.

We address **making and breaking conceptual structure** through metaphor building strategies and transdisciplinary perspectives.

The computational platform leverages the creation of metaphor and conceptual relationships through data mapping and algorithmic design. Machine learning may also facilitate conceptual generation and design, given formal blending rules and principles.

We explore conceptual structure in original practice in the consideration of metaphor in interactive algorithms and in data mapping decisions. We propose a design theory for creating intertextual data mappings—the transfer of familiar, salient/defining patterns into new scenarios. We also discuss related theory and pedagogy in a worldmaking context, and through the disciplinary lenses of the THEMAS approach.

We address the cultivation of **familiarity and strangeness** through a regrounded information aesthetics, what-if worldmaking, and critical making.

The computational platform can help explore the balance of familiar/unfamiliar with complexity algorithms and create more culturally situated explorations with machine learning and other memory models (or through AI habit training).

We propose theory that advances strategies for assessing and measuring the balance of familiar/unfamiliar from a situated perspective (uniting information aesthetics and situatedness), including analytical tools for assessing the scope of familiarity and of strangeness. We discuss implementations of this theory in original practice and within what-if worldmaking pedagogy. The latter includes the making of both fictional and real-world artifacts along certain THEMAS themes.

METHODS BY KEY THEME

To conclude, we can also synthesize these points and summarize how we propose to advance our themes as follows:

Action/Situated Action/Situated Mediated Action

Through practice and pedagogy, we investigate virtually constrained or incentivized affordances (for virtual or human agents).

We design new/strange situatedness with physical computing systems, particularly in virtual environments, and also in worldmaking with the design of environments and agents.

We discuss our making-based pedagogical approaches.

Conceptual Structure

Our practice and virtual worldmaking pedagogy shows different ways to create conceptual interrelations between information.

We identify computational approaches for intertextuality via steps of mapping, analysis, and execution.

Balance of familiar and unfamiliar

We outline a regrounded design theory of information aesthetics through situatedness.

Strangeness aids in compression/pattern recognition

We use original practice to help cultivate strange perspectives toward new insights for users and for our research alike.

We explore transformational creativity in what-if fictional worldmaking pedagogy.

Within transdisciplinary pedagogy, we use different and interconnected disciplinary conceptual structures to promote both multifaceted and cohesive perspectives of knowledge.

Lastly, all these themes are present in our practical prototypes to varying degrees.

4. PROTOTYPES

This chapter deals with the prototypes that initiated and fed the research process of synthesizing our four key themes of learning and creativity. Our prototypes are our first attempt to explore paideia with our themes-in-progress. These prototypes are artistic and pedagogical. Again, our themes are:

A. Situated mediated action (SMA)

B. Conceptual structure

C. Balance of the familiar and unfamiliar

D. Strangeness that leads to compression (especially via counterfactuals and fiction)[13]

Through both this practice and scholarship, we were able to formalize our themes. Here, in revisiting our prototypes analytically, through the lenses of our now formalized themes, we see how computation and computational systems can help optimize these principles for learning, particularly toward the objective of paideia (through value, meaning, and holistic thought). From these perspectives, we can also better see where we fall short in achieving something akin to paideia and where to direct our energies in future practical iterations of this work. These analyses also serve the development of further theory to optimize our learning themes in paideia practice.

This exchange between theory and practice exemplifies the importance of action through creative making in the learning process, here serving original research and knowledge production. Strangeness in the making was especially key

[13] As with the last chapter, we will use the letters A, B, C, and D as shorthand for our themes.

here too, in provoking the questions that fed this journey of curiosity. Our practice is a case in point for why strangeness and learning-by-doing/acting are necessary to the research-practice cycle characteristic of the new media arts (Forbes, 2015; Smith & Dean, 2009).

The first part of this chapter discusses artistic prototypes and the second part pedagogical ones. Toward the end of paideia, through artistic practice, we have explored some ways computation might leverage value and meaning, and through transdisciplinary pedagogical practice, we have explored some other ways computation can leverage value and meaning within a holistic instructional framework.

4.1 ARTISTIC WORKS

4.1.1 OVERVIEW: TOWARD VALUE AND MEANING

Given our four themes for learning and creativity—situated media action (SMA), conceptual structure, balance of familiarity and unfamiliarity, and compression through strangeness—here, through descriptions of our various prototypes, we explore how computational systems can enrich these ideas in artistic experiences and objects designed for the general public. Specifically, we are interested in how we can bridge these themes to a contemporary approach of paideia: how such systems put our learning themes to work in the service of promoting certain values and/or interpretive meanings.

We can describe value and meaning in terms of our learning themes.

With respect to value, we are interested in how media shapes actions with conceptual structure. In particular, we are interested in how computation mediates certain kinds of actions—designing affordances that prioritize certain kinds of behaviors (observed or directly enacted), and how these actions may be shaped by a given conceptual structure (recall the example of rituals of balance in daily Anlo-Ewe Ghanian culture). In this way, computation creates situatedness through environmental constraints.

Regarding meaning, we are interested in how the use of familiar elements in strange new contexts or conceptual structure can provoke compression. In particular, we are interested in how computation can serve the transposition or transformation of familiar situated information, operations which can provoke new interpretative insights (i.e. compressions) given new formal relationships (i.e. conceptual structure) within a new, strange situatedness.

In these ways, through our prototypes, we are looking at how computation might supercharge our learning themes toward cultural learning, and thus paideia, at least insofar as these works advance a notion of art in shaping social character.

However, as we have discussed earlier, paideia also entails formal instruction in multiple subjects with a common social purpose. The realization of this particular body of new media artworks certainly entails the development and application of holistic knowledge, especially as this work entails space, time, and many senses (and requires knowledge of the different kinds of physical energies that engage them). Teaching others how to make such work would contribute toward the holistic instruction idea of paideia, and insights gained from this practice

inform and help systematize transdisciplinary instruction in a classroom setting (for undergraduate students) within the THEMAS model and related Mediated Worlds series in the following section, Section 4.2. Yet, for now, we concentrate on value and meaning in our original artistic practice.

As these works are merely paideia prototypes, and as they were created before the formalization of our learning themes, there are many shortcomings. We try to highlight these deficiencies as we proceed. The formalization of our learning themes now benefits us in identifying ways in which these works may be improved in promoting certain values or meanings.

We have created around sixteen different yet interrelated studies that leverage our learning themes and computation to generally explore the value of attention to subtlety and nuance via action—specifically, active sensing and/or bodily action. We consider these approaches as examples of sensory listening and calibration, respectively. By sensory listening, we mean the active intake and attention to sensory input, which may be strange or unusual by virtue of the employed sensory modality (e.g. vibrotactile touch) or its sensory parameters (e.g. infrasonic range of audition), or—in many cases—the employed cross-sensory pairing (e.g. gustation and interoceptive vibration). By calibration, we mean that motor action or kinesis is engaged in some capacity that modulates the sensory input in a surprising way. Through the cultivation of attunement to nuance, we are aiming to promote the general ability to pay closer attention to detail and to be more careful in one's actions.

In terms of meaning, many works concern ideas around situatedness and the integrality of our perceived experience of the world. Several works entail intertextual meaning with references to ancient Greek literature and culture.

The prototypes discussed in this section include the following original works: *Vibrotactile Sleeves* (2014), *La Galerie d'Ondes* (2015), *Trans-Sensory Music* (2015), *Caduceus* (2015), *Kroumatograph Series No. 1–4* (2016-2019), *The Dance of the Fulcrum* (2016), *Accords No. 2* (2016), *To Eleusis, To Tanayan* (2017), *Asclepias* (2018), *A Vibrotactile "Musical Sculpture" in VR Exploring Apparent Motion Illusions of Frequency Beating and Changing Phase* (2018), *Superadditive Musical Amuse-Bouches* (2018), and *OrchScape* (from *Moon Moons*) (2019).

Of this body of work and in our assessment, the pieces that are most interesting in terms of demonstrating paideia use algorithmic mappings or body display mappings to play with conceptual structure. The strongest examples of paideia are a set of performances-installation environments conceived of as part of a greater multimedia song cycle entitled *Psychagogy* (or the "leading of souls")—a more age-inclusive notion of pedagogy (the "leading of children"). These works include *Dance of the Fulcrum* (2016); *To Eleusis, To Tanayan* (2017); and *Asclepias* (2018), as well as their related studies. The idea behind *Psychagogy* is to create a collection of works promoting different, yet complementary values, mostly around attention to nuance and respect for the body, others, and environment (and their interconnectivity). Towards this objective, *Dance of the Fulcrum* promotes friendship through the amplification of dyadic interactions; *To Eleusis, To Tanayan* promotes the respect of the "Other" and environment through an amplification of

collective regulation efforts; and *Asclepias* promotes health and bodily listening through the amplification of and interaction with internal phenomena and states. All three entail intertextuality with ancient Greek literature and culture to reinforce these ideas. They also all involve movement professionals who first model interactivity with the environment to prepare visitors for their interactive engagement with the material.

Related studies for *Dance of the Fulcrum* include *Trans-Sensory Music* (2015) and *Caduceus* (2015). *Kroumatograph No. 1* (2016) and its preceding study *La Galerie d'Ondes* (2015) were also integrated into the first presentation of the work as an accompanying installation *Kroumatograph No. 2* (2016), but this integration was not successful and does not feature in a current reworking of the piece. Related studies for *To Eleusis, To Tanayan*, realized after its initial presentation only explore certain technical aspects removed from the collectivist values of the work and include *A Vibrotactile "Musical Sculpture" in VR Exploring Apparent Motion Illusions of Frequency Beating and Changing Phase* (2018) and its adapted implementation in the collective project *<Future::Invisible::Tripping::Machine>* (2017–2018) (not discussed here). Related preparatory practice for *Asclepias* includes aspects of *Accords No. 2* (2016) and *Kroumatograph No. 3* (2017), with major refinements in the subsequent study *Superadditive Musical Amuse-Bouches* (2018). As such, we might bear in mind the following clusters as we work through the artistic prototypes in more or less chronological order:

Vibrotactile Sleeves (2014)

La Galerie d'Ondes (2015)
Kroumatograph Series No. 1–4 (2016-2019)

Trans-Sensory Music (2015)
Caduceus (2015)
The Dance of the Fulcrum (2016)

To Eleusis, To Tanayan (2017)
A Vibrotactile "Musical Sculpture" in VR Exploring Apparent Motion Illusions of Frequency Beating and Changing Phase (2018)

Accords No. 2 (2016)
(*Kroumatograph No.3 v.2* (2017))
Asclepias (2018)
Superadditive Musical Amuse-Bouches (2018)

OrchScape (from *Moon Moons*) (2019)

In this way, some standing-wave works group together, as do the works serving *The Dance of the Fulcrum* (focused on dyadic emergence), the musical sculpture works around *To Eleusis, To Tanayan*, and the cross-modal taste works informing *Asclepias*. *Vibrotactile Sleeves* and *OrchScape* are more independent studies.

It is important to briefly highlight here that certain approaches particular to this body of "computational paideia" work need not be particular to all such future practice of computational paideia.

This work happens to use computation to stimulate or render strange sensory phenomena or strange perceptible effects in order to encourage heightened attention to nuance. As a means to create a new situated sense of place and environment, this work tends to engage multiple senses, including many artistically under-explored senses to bring in the unfamiliar. As a means to engage the body in an immersive way and play with both embodied situatedness and (to some extent) action, these senses tend to include aspects of somatosensation: a

group of corporal senses that include touch, proprioception (sense of orientation), kinaesthesia (sense of movement), haptics (interaction between touch and kinaesthesia), and interoception (sense of internal body states and phenomena) (Crawshaw, 2021). A majority of these works use sound waves to interact with somatosensation via vibrotactility (vibratory touch) and interoceptive sensations of body resonances (e.g. sensations around the chest from low bass frequencies).

Contemporary technology is an integral part of these approaches. Our electronic media (e.g. sensors, displays) permit the engagement of multiple senses and specifically bring attention to our embodied situatedness by engaging under-explored somatic senses and to action through movement. Many of our works engage the somatosensory system via sound diffusion devices and a subset of these works engage movement through spatial tracking. Regarding our sound displays, some works use subwoofers, which can produce low frequencies at amplitudes that affect both hearing and the vibromechanical sensing of corporeal resonance (most frequently and prominently rib cage resonance felt in the chest around 30–80 Hz (Leventhall, 2003)). Many others use tactile actuators, which can engage whole-body vibration when actuating platforms for seating or standing or vibrotactile touch when smaller devices are mounted on the skin.

Our engagement of the body and space (as enabled through computation and electronics) facilitate strange play with the relative corporeal and spatial bases of many conceptual metaphors.

These choices are specific to this approach to paideia. In general, from this practice, interactive multimedia environments with intentional conceptual mappings seem to be useful as a subset of computational paideia practice.

Our four learning themes are already present to varying degrees in new media arts practice, but they may not always be optimized for effective learning or paideia. It is our hope that the details of our practice and pitfalls in this chapter can inform the efforts of new media artists in their own works. Our works merely show how these themes may operate in the new media arts and they illustrate specific ways the computational platform helps explore values and meaning (with paideia in mind), taking this approach in a unique direction.

4.1.2 DESCRIPTIONS OF WORKS

Vibrotactile Sleeves (2014)

Figure 4.1: *Vibrotactile Sleeves* (2014). Photo: Marcos Novak.

The work *Vibrotactile Sleeves* provokes sensory strangeness to promote insight about our embodied situatedness and musical experience. The computational platform allows precise control of space—via sonic panning between audio and tactile wearable displays—to challenge conceptual metaphors relating to the separation of the senses and Cartesian duality. It also promotes a compressed idea of spatial music as an entity beyond hearing, inclusive of tactility.

Description

Vibrotactile Sleeves is an installation for one participant at a time and consists of a spatial multichannel vibrotactile music composition with a connected spatial auditory component. This work was presented as part of the 2014 UC Santa Barbara (UCSB) Media Arts and Technology (MAT) End of Year Show (EOYS).

The installation entails outfitting participants with six wearable tactile actuators (three on each arm at the shoulder, elbow, and wrist) and a pair of headphones. This cross-sensory multichannel platform supports the projection of a brief, two-minute composition with spatial panning across all eight channels (audio and vibrotactile). During this time, participants are blindfolded to help them actively attend to the projected spatial motifs, and rhythmic patterns in an unfamiliar sensory and cross-sensory experience.

With respect to the work's technical development, the electroacoustic piece was developed in AlloLib[14] using the Gamma library. With the assistance of Ryan McGee, we used a distance-based panning approach to create the multichannel

[14] Accessed 03/18/2022: https://github.com/AlloSphere-Research-Group/allolib

environment connecting the two audio channels and six vibrotactile channels. This enabled 3D panning among the actuators and between the audio and vibrotactile sensory realms.

Randolph Crowson of Crowson Technologies provided space, equipment, and other materials for the testing and development of the hardware and its diffusion. The author designed and 3D printed actuator arm mounts for the installation.

Analysis

A:

Vibrotactile Sleeves engages SMA via sensory and cross-sensory listening in a novel medium engaging the body and cultural language of electroacoustic music. It integrates situatedness primarily through embodiment in stimulating the surface of the body and for some, through the cultural paradigm of spatial multichannel electroacoustic music. Although the subjects are stationary, the novelty of the stimuli provokes active attention: sensory listening. The novelty of the multichannel sleeve and headset projection medium help to invite such attention.

B:

The mediated placement of the wearable devices reinforces a familiar vertical metaphor for the senses and for mind/body separation and the strangeness of the continuous panning between the sensory channels helped to challenge these associations. The placement of actuators on the arms and headphones, necessarily over the ears, reinforces an association of hearing as being up in the head and

touch as being lower in the body (even though touch extends to the head as well). If these two areas had remained separate, it might have reinforced a more Cartesian dichotomy between mind and body, but the panning across them helps to draw attention to their continuity.

C:

In addition to the challenge to familiar sensory associations above, the work strikes a balance between the familiar and unfamiliar by blending the (to some) familiar language of spatial electroacoustic works with an unfamiliar sensory modality: touch, specifically, vibrotactility.

D:

The spatial trajectories within an underutilized artistic sensory modality and across this modality to audition invite strangeness, and hopefully a compression and recognition of the stimuli's common property of sound, an appreciation for the ways our body is sensitive to sound, and the musical potential of sound across the other senses upon which it impinges.

Computation:

Software facilitates the designation of complex spatial trajectories in signal processing across multiple channels. The electronics in the display facilitate a bridge between the auditory and tactile modalities.

Values:

This work exercises attention to nuance.

Meaning:

This work resituates familiar conceptual metaphors about the loci of our senses and mind/body separation. Our cross-sensory panning promotes a sense of embodied continuity between hearing and touch, the external environment (via sound) and our body, and mindspace and bodyspace.

***La Galerie d'Ondes* (2015)**

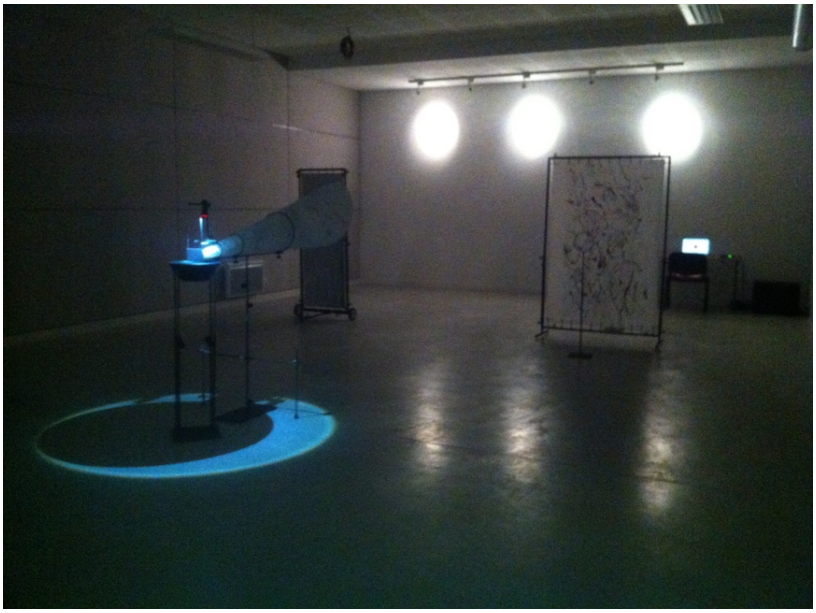

Figure 4.2: *La Galerie d'Ondes* (2015).

In *La Galerie d'Ondes*, computational precision in sound synthesis facilitates a strange spatial acoustic effect that impacts both the surrounding environment and the body (as resonating object), linking the two, promoting compression regarding the connection between embodied and environmental situatedness. Action through movement and the affordances of responsive sculptures help reveal the effect,

reinforcing the concept of listening that is central to the work. In these ways, the work incentivizes careful actions and attention.

Description

La Galerie d'Ondes is an installation consisting of a standing wave sound sculpture-composition and a set of "listening" sculptures by Bob Lamp. Lamp's structures serve to visualize spatial perturbations arising from the sound sculpture, placed strategically at amplitude maxima in the room.

It explores heightened sensory and cross-sensory listening involving audition, haptics (through biomechanic vibration and whole-body movement/kinaesthesia), and vision. The work is also intended to increase sensitivity to low bass frequency and infrasonic perception.

This work was featured as part of Dionys'hum, the inaugural ceremony of events for the new site at Porte de la Chapelle of the Maison des Sciences de l'Homme Paris Nord (Northern Paris Institute of Human Sciences, translation).

The spatiotemporal installation consists of four movements: two alternating "dynamic" movements in which the diffused signal content changes over time and the two other "static" movements in which the diffused content is static in time. In the dynamic movements, the sonic material is mostly in the low frequency range (under 100 Hz). It plays with rhythm through frequency beating (an effect that can produce pulsations at infrasonic rates, <20 Hz) and uses descending glissandi to frequencies in the infrasonic range. The frequency beating and the glissandi serve to guide and sensitize the ear to infrasounds, including those used in the static

movements. The temporally static movements, exploiting standing wave principles, create spatial variations in amplitude across the space, which can still be experienced temporally through self-propelled spatial movement. The presence of sculptures in the space seeds this movement by creating a visual invitation to move across the space in approach for a closer look (given the cultural conventions of gallery spaces). Furthermore, the design choices of the sculptures themselves are intended to invite closer inspection, both in appearance and in function.

Lamp engineered the three sculptures with the intent to amplify sound wave phenomena via a cymatic (sound wave visualization) approach. Their curious construction is in the visual language of measuring instruments. The sculpture “Sensitive Dependence” consists of a mylar membrane with a long needle running through it. The length of the rod permits for amplification of vibrations at its ends and limiter rings restrain these movements and provide a local visual reference for their relative perturbations. Another mylar-membrane-based sculpture “Mirror, Mirror” is on wheels with a handle, serving as a “roving node finder.” Vinyl numbers on the ground along the length of the room create a visual aid for visitors as they displace the interactive sculpture in search of amplitude maxima in the room-scale sound sculpture. The reflective surface of the sculpture aids in highlighting perturbations from sound wave vibrations, acting a bit like a funhouse mirror as it distorts the reflection of the displacer. Lastly, the “Listening Horn” consists of a mylar cone, ending with a membrane attached to a metal stylus dipped into an illuminated pool of oil and graphite powder. These functional affordances for

cymatic listening, were slightly less effective and more subtle than we had hoped, yet functional for all three sculptures all the same.

In terms of the technical development of the sound, we used AlloLib and its Gamma library to develop the musical movements. In addition to existing instruments in the software (including ones with simple sinusoidal waves, tremolo, and vibrato), we adjusted a few simple sinusoidal and vibrato instruments to permit for glissandi between notes. We also created an additive synthesis instrument capable of reading .txt data and converting values into sinusoidal frequencies. We developed this tool in order to create timbres from squid skin data, in collaboration with researcher Amitabh Ghoshal (with the generous help of principal investigator Dan Morse) of the Morse Lab in the Institute for Collaborative Biotechnologies at UCSB.

Analysis

A:

The work engages SMA through a strange sensory and cross-sensory active listening experience with calibration from movement. The sound interacts with architectural affordances of the space to effectively create a spatial instrument that can be “played” and experienced through action. The formal construction of the sculptures amplifies subtle sound phenomena in a visual medium, reinforcing active listening in hearing and somatosensation. The work brings attention to embodiment through chest resonances from low bass frequencies and adds embodied action via full-body movement in the space. The piece also relies on cultural situatedness,

specifically action scripts from art gallery experiences to motivate movement in the space, specifically movement around the sculptures where key parts of the sound sculpture are also located.

B:

Regarding conceptual structure, a few ideas are present within the work. One idea is the play between change over time and change over space, explored through the contrast of static and dynamic musical movements and through the sound sculpture, which must be experienced by spatial movement over time. Another idea is in the action of tuning, present in the sound sculpture (which is tuned to the space), the node finder sculpture, and the timbral use of squid skin data (as squids achieve structural color by expanding and contracting nanoscale folds in their skin to reflect different electromagnetic wavelengths). Listening is another concept, with the sculptures acting as ears.

C:

Visually, this piece evokes gallery spaces and measuring devices (like the gramophone in “Listening Horn”) to anchor into the familiar, but these objects are unfamiliar given their cymatic affordances. Even though the more subtle aspects of the spatial variegation and sensations arising from low frequency waves are unfamiliar to everyday experience, the cymatics provide intersensory reinforcement, to make their perception more certain.

D:

This work hopes to use the strangeness of these cymatic devices, the spatial variations in the sound sculpture, the qualia of low frequency audition, and the

sensations of chest resonance to bring about a compressed notion about sound waves, and the various ways they can impact space and our bodies.

Computation:

Here, computation facilitates and enables the creation of the strange sound phenomena and other sonic effects at the center of the work. The precision of the computational platform allows for an exact calculation of room modes and the generation of exact frequencies tuned to the space. It enables sound synthesis, including from squid data, the creation of glissandi, and other effects like frequency beating between exact intervals.

Values:

This work incentivizes attention to nuance and care in one's actions.

Meaning:

Intertextual connections are evoked in the posted description of the work and these connections guided the conceptual development of the work, but they are neither definitively embodied nor represented in other ways that would be obvious to a naïve viewer. The contrast of the texts *Daphnis and Chloé* by Longus and *The Odyssey* by Homer informed the spatiotemporal tensions of the work, as the first entails a formational journey that happens over time and the other entails a formational journey over spatial distance.

Trans-Sensory Music (2015)

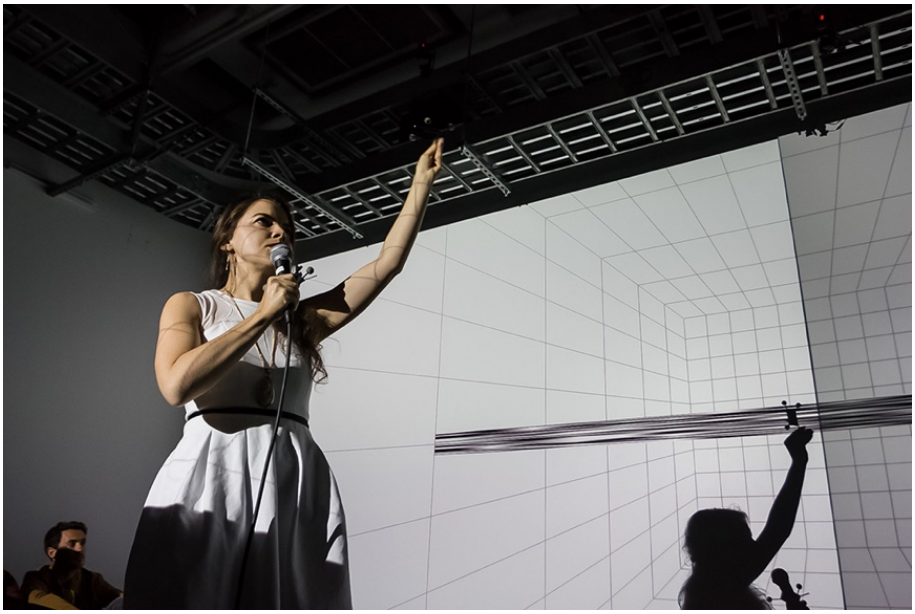

Figure 4.3: *Trans-Sensory Music* (2015). Photo: MAT, UCSB.

By means of computation, *Trans-Sensory Music* provokes sensory strangeness by alternating musical material between audio and tactile display channels. This controlled interchange creates a composite, emergent musical motif, promoting a compressed sense of musicality beyond heard sound alone, bringing attention to cultural, embodied, and environmental situatedness. The structural partitioning of a musical line between two sensory voices also communicates complementarity.

Description

Trans-Sensory Music is a live performed work for voice and audio-tactile electronics. The piece was performed in the MAT transLAB as part of Open Sources, the 2015 UCSB MAT End of Year Show.

The composition explores emergent musical motifs across the senses, borrowing the word *trans-sensory* from the film theorist Michel Chion (Chion, 1994). Chion uses the term with respect to audiovision, the emergent audio-visual interplay in the cinematic arts. Here, we transpose this idea to auditory sound and vibrotactile sound, using 3D spatialization across 16.2 channels for the audio component, and vibrotactile bench seating for conveying a whole-body vibrotactile aspect to the audience. The spatialization of the audio is gesturally controlled with a spatial tracking marker held by the singer (in this case, the author). Some panning also occurs between the audio and vibrotactile elements, creating continuous trans-sensory phantom sources and motifs. However, for the most part, trans-sensory motifs are created via hocketing—the discrete alternation of musical material between two voices—here, between two sensory modalities.

Aesthetically, during the creative process, we made other formal compositional decisions with the intention of stressing the theme of emergence and to facilitate the sensory parsing of vibrotactile sound (an unfamiliar artistic sensory modality to most if not all audience members).

The content largely consists of FM and double-carrier-FM instruments. FM synthesis itself embodies the notion of emergence, where complex phenomena arise from simple rules.

Furthermore, glissandi in double-carrier FM and vibrato instruments are used throughout the work and also in conjunction with audio-tactile panning as a tool to guide the tracking of phantom sources between the senses, with frequency movement serving as metaphor for spatial movement. Spatial movement is also

present between the senses in a more literal, mediated sense. The cross-sensory panning is provided a vertical axis within the performance space itself with the vibrotactile bench planks almost flush to the floor, a set of loudspeakers on the floor (but with speaker cones centered several inches above the planks), and a second set of loudspeakers suspended around the ceiling.

In terms of the content distribution, lower and infrasonic (≤ 20 Hz) frequencies are typically used for the vibrotactile channel and higher frequencies for the auditory channel. There are practical reasons for this, as vibrotactile perception is more salient for frequencies in a lower range of ≤ 250 Hz, with sensitivity reaching into the infrasonic range, whereas pitch perception in audition is higher, around 20–20K Hz (Crawshaw, 2014, 2021). While infrasounds can also be heard, they are experienced as rhythm, and due to the substantial amplitudes (and thus perturbations of air pressure) at which we begin to detect them, they are often experienced with accompanying vibrotactile sensations (Crawshaw, 2014). Also, in everyday experience, our encounters with whole-body vibration are typically at low frequencies with the rumbling of vehicles, and also earthquakes (if living in the Pacific Rim) or other large scale natural phenomena. As such, owing to physics, a given person may be more likely to have an experiential association with lower frequencies in the context of vibrotactile touch than to higher frequencies. Thus, low frequency-vibration, high frequency-hearing algorithmic mappings make for a compelling and intuitive association. (This metaphor is further reinforced spatially in the installation given the lower placement of the vibrotactile benches and higher placement of the speakers within the performance space.) For strangeness, on

occasion, this relationship is subverted: a few cross-sensory panning gestures use the higher tone in the vibrotactile channel.

Additionally, along the lines of our theme of emergence, play with the infrasonic range points to the perceptual emergence of pitch from rhythm.

With respect to the technical development of the work, the electroacoustic element of the composition was mostly realized in AlloLib using the Gamma library (in C++), producing a 2-channel sound file. We programmed panning instrument modules for controlling the content between the audio and vibrotactile channels. These instruments included versions of FM, vibrato, and double-carrier-FM instruments that enabled panning envelopes. Then, with the resulting file and using the ambisonic extension suite Cosm[15] in Max, we spatialized the audio channel from Gamma across the ambisonic 3D 16.2 audio system in the transLAB. The gestural mapping to the sound system was fairly intuitive with some scaling: approaching the speakers with the marker localized the sound source to that area, and raising or lowering the arms localized the sound to the upper or lower rung of speakers, respectively.

The voice element too is subject to gestural control. Acceleration and velocity of the spatial tracker impacts the reverb of the voice. This effect was created in Max[16] by modifying a reverb patch created by F. Myles Sciotto.

This work served as a study for what later became *Dance of the Fulcrum* (2016). It was also initially intended to incorporate two dancers and use the

[15] Accessed 03/18/2022: https://w2.mat.ucsb.edu/cosm/download.html

[16] Accessed 03/18/2022: https://cycling74.com/products/max

Caduceus (2015) sculptures as spatial tracking mounts, but due to time constraints and printing costs, these plans were modified.

Analysis

A:

The performer engages action via gestural control, and these actions control music in the environment, reinforcing a theme of situatedness by linking body to external phenomena. The audience must engage active attention to attune to these causal relationships and appreciate the emergent musical ideas in the work.

B:

The timbral development of the piece and the structural division of a musical motif between two senses reinforce themes of complementarity and emergence.

C:

The cultural familiarity of musical rhythm and audiovisual rhythm in cinema help to anchor the unfamiliar partitioning of a sonic stimulus between the senses of hearing and touch.

D:

This strange musical experience helps promote a common notion of musical motif independent of senses. The strange causality of gesture on a projected sonic experience helps compress body and environment into a situated continuity.

Computation:

Computation leverages the creation of nuanced digital sounds, the pre-composition of complex panning gestures, and real-time spatial tracking to control

the real-time panning and modulation of audio data. Thanks to electronics, these output channels can be divided into both auditory displays (speakers) and somatosensory displays (vibrational benches). The physical placement of these displays in conjunction with panning trajectories can create spatial metaphors.

Values:

This work exercises attention to nuance.

Meaning:

This work emphasizes body-environment situatedness and music as an expressive construct beyond cultural associations with heard sound.

***CADUCEUS* (2015)**

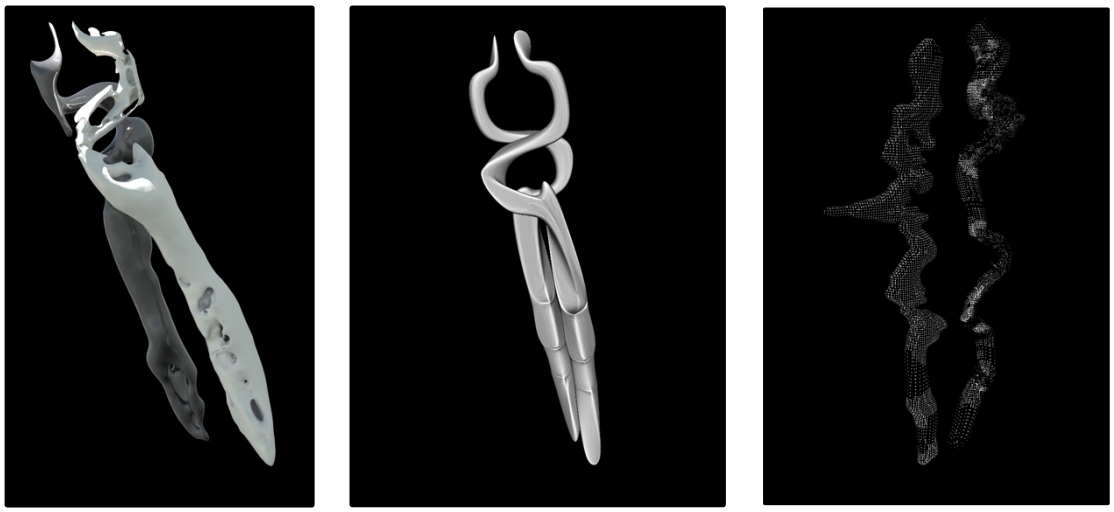

Figure 4.4: (Left) *Caduceus* (2015) final transformed objects; (Middle) Input 1: initial freehand CAD-modeled objects; (Right) Input 2: 3D geometries from an audio signal (relative left) and vibrotactile signal (relative right).

Caduceus, a pair of sculptures, introduces strangeness to the form of Greek god Hermes's staff, a well-known cultural fictional artifact. The strangeness is

mediated with computation, modulating each form with musical data—each one part of a motif in duet. The complementarity of the musical data reinforces a conceptual structure of complementarity between the two parts of the sculpture. The connection to music evokes an intertextual cultural association to the origin story of the caduceus, which, given its specifics, couches this complementarity within a theme of friendship and of the interconnection of space and time.

Description

Caduceus is a pair of sculptural staves derived from original musical data. The two staves evoke the intertwining snakes that comprise the mythological staff of Hermes. A print of these twin sculptures was first exhibited at Open Sources, the 2015 UCSB MAT EOYS, and was later featured as part of the UCSB Interdisciplinary Humanities Center Platform Gallery Exhibition to accompany their Crossings + Boundaries Lecture Series (2017–2018).

These generatively modeled objects are intended to be printed as 18” tall objects with mounted spatial trackers for use in virtual environment experiences.

Initially, the tracking staves had been intended to be used as part of *Trans-Sensory Music*, which was to have two movement artists, but this plan was scraped due to time constraints.

With the mentorship of Jean-Michel Crettaz and Marcos Novak, we developed the meshes for the staves in Mathematica[17] by displacing the vertices of

[17] Accessed 03/18/2022: https://www.wolfram.com/mathematica/

a staff (CAD modeled in FormZ[18]) with music data. The music data derives from the amplitude envelopes of the main hocketed motif between the audio and vibrotactile channels in *Trans-Sensory Music*. We created two amplitude envelopes for our displacement algorithm: one from each channel for each staff. We then remeshed the vertices using a Poisson reconstruction algorithm in the program MeshLab.[19]

Analysis

A:

These sculptures are spatial tracking mount tools intended to be used in whole-body movement between two individuals. They are meant to be integrated into a physical computing system that links social engagement with changes to a virtual environment, playing with situatedness. With respect to cultural situatedness they also can evoke associations with staves from ancient Greek mythology.

B:

Their intertwining forms and rotational symmetry emphasize the idea that they are two parts of one whole object. The temporal music gains a spatial conceptual structure, with amplitude variations over time impacting 3D form over the length of each staff.

[18] Accessed 03/18/2022: http://www.formz.com/

[19] Accessed 03/18/2022: https://www.meshlab.net/

C:

These sculptures use the culturally familiar idea of a caduceus and create and unfamiliar separation of its parts and an unfamiliar modulation of its geometry by music.

D:

This strangeness and its conceptual connections to mythology encourage a resituated reading emphasizing space-time complementarity.

Computation:

Computation enables the rapid modeling of staves and geometrical transformations with musical data.

Values:

This work exercises attention to nuance and its intended active deployment encourages pro-social cooperation and discovery.

Meaning:

The staves' visual interpretation and intended use evoke social complementarity. Our objects are intertextual with ancient Greek literature, specifically the *Homeric Hymn to Hermes* (Homer, trans. 2004), and their strange music-derived design draws out connections in the myth to friendship and the balance of space and time. The caduceus is generally affiliated with Hermes, the messenger god. In the myth, the caduceus (here three branches instead of two snakes) originates as part of a gift exchange between Apollo and a young Hermes as gesture of goodwill following a dispute. The other part of the exchange is Apollo's lyre. This mythological exchange helps establish Hermes as a herald and Apollo as

a god of music. This exchange creates an equivalence between caduceus and lyre and the identity/domains these objects confer on their recipients. Our caduceus, in spatializing temporal data, reinforces the complementarity of these objects: the spatial aspects of travel (in being a messenger) and temporal aspects of music (in lyre playing).

Kroumatograph Series **(2016–2019/ongoing)**

Like *La Galerie d'Ondes*, the *Kroumatograph* series uses the precision of the computational platform to create a strange acoustic effect impacting both environment and the body (as resonating object), promoting compression regarding the situated interconnections between them. The work explores attention to sensory and cross-sensory nuance via low-bass audition and somatosensory corporeal resonance with calibration from actions of whole-body movement in the spaces and of humming.

Description

In the *Kroumatograph* series, using acoustic principles, low frequency waves create a spatially variegated sound sculpture, where different areas of the room contain different rhythmic patterns that can be felt via chest resonance. Attention to spatial movement, body, and rhythm help reveal these nuances.

These works grew out of the *Galerie d'Ondes* installation. In one of its static movements, we incorporated frequency beating and observed that these slight frequency offsets created amplitude maxima and minima in slightly different

locations than our calculated room modes. The *Kroumatograph* series was an attempt to explore this spatial frequency beating phenomena further.

Analysis

A:

In all these works, like with the *Galerie d'Ondes*, SMA is engaged through a strange sensory and cross-sensory active listening experience with calibration from movement. The interaction between sound and architectural affordances generates a spatial sonic instrument that is "playable" via action, specifically whole-body movement. A sense of embodiment is engaged through felt chest resonances from low bass frequencies and this full-body movement.

B:

This work creates a conceptual blend between rhythm and spatial position.

C:

This work makes an unfamiliar combination of familiar elements of rhythm and space (and perhaps also sound art for visitors with cultural knowledge of this kind of artistic practice).

D:

The strangeness of the acoustic phenomenon impacts both space and body, hearing and somatosensation, provoking compressed insight about the common material of sound.

Computation:

Computation enabled the generation of precise frequencies with certain precise relationships to the dimensions of the room to create the nuances of the spatial sonic media.

Value:

This work incentivizes attention to nuance and care in one's actions.

Meaning:

This work explores situatedness through the connection between body and environment (as both are acoustic-sensitive entities).

***Kroumatograph No. 1* (2016)**

Figure 4.5: *Kroumatograph No.1* (2016).

As part of the mise-en-scène (the arrangement of scenery), this version uses analog media to evoke familiar, embodied and culturally situated associations to

either steer attention to the body (and the effects of the sound sculpture), or to cultivate more a positive valence experience given the potentially uncomfortable intensity of the sonic stimulus.

Description

The first iteration of the *Kroumatograph* project, *Kroumatograph No. 1*, began as simply *Kroumatograph*, and it was created upon the invitation of Alan Macy for the inaugural ceremony of the Santa Barbara Center for Art, Science, and Technology (SBCAST). This site-specific work was realized for SBCAST's Studio A. During its extended run, it was further showcased at the March Santa Barbara First Thursday event, and the "Dance Anywhere" event in collaboration with the Santa Barbara Centre for Aerial Dance as part of their "Floor to Air Festival."

The sound sculpture aspect of the work, developed in Max, consists of a set of eighteen temporally static sinusoidal waves, derived from the first three standing wave harmonics for the width and length of the room. For each of these six harmonic nodes, a cluster of three sine waves are finely offset from one another to provoke frequency beating. Given the spatial nodal offsets of these neighboring sine waves from standard standing wave patterns, this produces a series of amplitude pockets across the room, in non-obvious locations, with different polyrhythmic qualities. As these frequencies occur within the typical frequency range for rib cage resonance, these rhythms can be felt in the chest. The polyrhythmic patterns of these felt rhythms change as one moves around the space.

We identified a few factors that help with the perception of these audio-somatic rhythms. In our experimentation, we found that humming a low note accentuated the somatosensory perception of these felt rhythms. Furthermore, we found that the presence of pitched auditory sound also helped the auditory perception of these rhythms, as the pulsations would create an amplitude modulation of the pitched material.

As such, we made a few artistic decisions to take advantage of these findings. At the entrance, instructions written on musical staff paper direct visitors to hum a low note and wander freely in the space. We also accompanied the sound sculpture with an audio track: a reverberant electroacoustic manipulation and granulation sourcing the piano-voice composition in *The Dance of the Fulcrum* (2016). Compositionally, the work served an ambient purpose, with very gradual shifts in harmony and other musical parameters, so as not to introduce competing rhythmic elements. In these ways, we hoped the spatial composition of pulsations could be brought into further relief.

To further support the experience of the sound sculpture, we designed the analog mise-en-scène of the work to draw attention to the body, the spatial nuances of the space, and to promote a positive and calm experience of the high-amplitude, low-frequency waves, which can be potentially uncomfortable for some in certain contexts (Crawshaw, 2014). Visually, we created light-emitting sculptures to evoke viscera: we made them from multiple large strips of Lycra (four-way stretch) and other semi-transparent tissue-like fabric wrapped from metal beams on the ceiling (also wrapping and covering a sink and the subwoofer), internally lit with red LED

lights. Upon the spatial sonic polyrhythmic grid, we superimposed a vector field of thermal, olfactive currents. Three driftwood tripods sculptures and a staff each carry one of four scents, and adjacent thermal sources (e.g. heaters, fans, open doors) propagate them in the room. These currents consist of outdoor-ambient fennel, warm bergamot, cool rose, and indoor-ambient cardamom. This selection created a pleasing collective composition, and with its individual components, we hoped to evoke possible situated associations: the anti-emetic properties of fennel (or calming outdoor walks through California marshes); any soothing tea associations with bergamot (Earl Grey) or cardamom (masala chai); and associations with outdoor garden greenery with rose.

Supplemental Analysis

Computation:

Computation also facilitated the development of the pitched electroacoustic component.

Meaning:

There is an intertextual element in this piece not previously mentioned. The presence of tripods with different scents creates a cultural reference to ancient Greece myth: to Apollo and his Oracle at Delphi (S. L. Harris & Platzner, 2012, p. 235). Tripods were affiliated with the god and the temple there, and vapors were affiliated with the oracular process. In this new space, and in context with the other elements evoking calm, the tripod sculptures bring more of a sense of the sacred: a space for communing with one's surroundings.

Kroumatograph No. 2 **(2016)**

This version attempts to add another layer of interaction via computation: using spatial tracking between two users to incentivize pro-social engagement. It measures for proximity, mirroring, and rate of change (as collective risk taking), and creates strange feedback in the sound sculpture to incentivize these behaviors. In this way these computationally mediated actions bridge social and embodied/environmental situatedness and advance conceptual structures for friendship actions.

Description

We developed the second version of *Kroumatograph* as an installation to follow a performance entitled The *Dance of the Fulcrum* (2016), presented in the transLAB at the UCSB California NanoSystems Institute. We presented this work as part of White Noise, the 2016 UCSB MAT EOYS. There was already an existing pairing with this work, given the audio track accompaniment in the first installation.

We retained several other elements of the first installation in this version. This included encouraging visitors to wander freely and hum a low note.

However, in addition to a necessary tailoring of the room modes to the dimensions of the transLAB, we made some other artistic changes.

Regarding the mise-en-scène and visuals, this set-up lacked the red lighting and the elaborate Lycra sculptures of the first, although there was some set dressing with the fabric as an attempt to evoke bodily tissue. However, this potential

interpretation was not well enough reinforced by other elements in the space. Additionally, we did retain the thermo-scent tripods, with roughly the same olfactive composition, except with heated fennel.

Creatively, the largest experiment was in the introduction of interaction to the work. Specifically, we used a Kinect's tracking data to impact the offsets of the harmonic clusters. The tracking area only covered a limited area of the room. The system we created could be controlled by the interactions of two tracked individuals within this space. We developed algorithmic mappings with the intent to incentivize pro-social behavior. These parameters are detailed in the description to *The Dance of the Fulcrum*. One major issue with this implementation was in the difficulty of causal discoverability. As the sensing input of the system entailed tracked movement and the feedback changes also necessitated physical movement to discover the changed nuances, it was not clear to what extent perceived changes were due to a virtual system or physical acoustic phenomena. Also, the offsets and phenomena were too subtle, especially with the number of people walking around in the room at the same time.

Supplemental Analysis

A/B/Computation/Value/Meaning:

As mentioned, the addition of computational mappings linking dyadic whole-body movement to environmental changes intends to emphasize social-body-environment situatedness and incentivizes pro-social behaviors.

***Kroumatograph No. 3* (2017)**

Figure 4.6: *Kroumatograph No. 3* (2017).

This version contends with our themes in a novel way as it strangely blends the culturally situated structures of a length of sequential musical events in a music score, the sequence of feet in dance notation, and the structure of a path to create a time-based experience of a sound artwork.

Description

The third *Kroumatograph* was a greater departure from the first two versions. It entailed systematic acoustic studies of the space to finely calibrate the spatial composition and a graphic path-based score on the floor to guide the movement of visitors.

This work was site-specific to Studio F at SBCAST and was showcased at both the May Santa Barbara First Thursday Event and Re-Habituation, the 2017 UCSB MAT EOYS.

The development of the sonic content was more rigorous for this version. In a series of preparatory acoustic studies conducted by the author and a research assistant Nicole Boutté, we measured and graphed the spatial amplitude topologies of small and large frequency offsets to calculated room modes. We used this data as a basis to select for an interesting configuration of unique spatial amplitude pockets across the six room modes (comprised of three frequency clusters each), and then, judging by artistic ear/sensation, we made some very minor calibrations to certain frequencies for more compelling polyrhythms.

We decided to create a more time-based experience of the piece and created a movement score for visitors using both directions provided on score paper and a floor-notated path of tape and adhesive shoe graphics. This path was a “first movement” and the score also indicated a second movement of free movement in the space, making one’s one path. The score also encouraged humming a low note, like the other versions.

On the wall, as a visual aid to the spatial sonic effects, we projected the topological graphs of the frequencies employed in our composition, with a video looping through images of the six composite modes.

In contrast to the other versions, the auxiliary mis-en-scene was rather spare, with some spotlights added for ambiance, but with the immersive content, graphic

floor score, and projected topology maps dominating the audiovisual impact of the experience.

However, during its run, we experimented with other sensory additions. The iteration of this work for the EOYS also consisted of a collaboration with Barbareño restaurant, to explore potential cross-sensory impacts of these low-frequencies on the inherently cross-sensory construct of flavor. This motivation for such an exploration is grounded in an extensive body of scientific research demonstrating connections between sound and the chemical senses of olfaction and gustation, particularly where certain sounds can alter which tastes and aromas are more present in a food item possessing complex or ambiguous flavors (Crisinel et al., 2012). At the entrance, visitors received an avocado-based mousse to eat over the course of their experience. In discussions with Co-Owner Jesse Gaddy and then Head Chef Justin Snyder, we decided upon a dish that would have a composite taste—with sweetness, acidity, umami, and saltiness all present—and a variety of haptic taste elements (e.g. the smoothness of the mousse, the crunch of added crystalized basil). We hoped that this variety of elements would help provide more pronounced emergent shifts in flavor given the more subtle (spatially-dependent) shifts in this sound. In this way, we hoped the faceted properties of the dish would serve as amplifying affordances for the sound. In our experience and in the experience of several visitors, flavor was indeed impacted: we found the mouth feel and acidity of the dish shifted in different sonic areas of the installation.

Supplemental Analysis

A:

A specially crafted gastronomic dish acted as a tool to amplify the nuances of the computational content. Visitors deployed this tool through the action of eating.

B/C:

We combined familiar elements of paths and music and ballroom dance notation in an unfamiliar way to guide a temporal, musical experience in a spatial sound sculpture.

Computation:

The computational platform helped us to record and graph data to identify interesting nuance for exploitation and then generate very fine frequency and amplitude adjustments for an optimal artistic effect. We also produced visual aids for visitors from this data.

***Kroumatograph No. 4* (2019)**

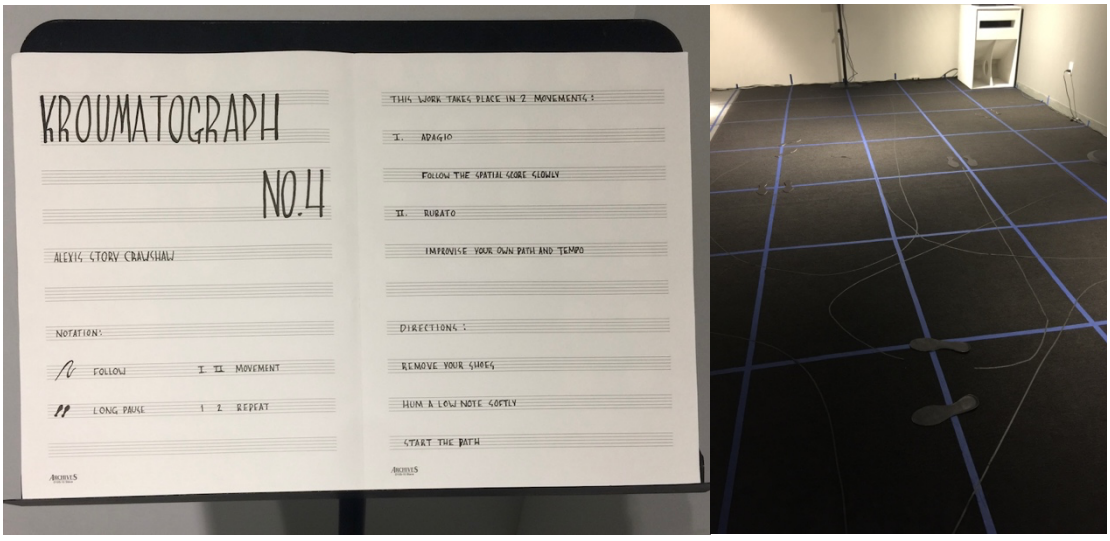

Figure 4.7: *Kroumatograph No. 4* (2019).

This version removes some unfamiliar sensory content from the previous version to bring focus on the more essential sensory strangeness, aiming for a better balance of familiar and unfamiliar.

Description

We presented a fourth version of *Kroumatograph* as part of the combined 2019 International Computer Music Conference and New York City Electroacoustic Music Festival, exhibited in the Fridman Gallery.

This work refined the approach of *Kroumatograph No. 3*, borrowing most of the same elements, with some adjustments. We acoustically tailored the new work to the dimensions of the below-ground space, and due to a quick turnaround for installation, we composed the spatial polyrhthymic offsets in the space exclusively by ear/sensation/movement instead of through measurements and graphs. This work also featured a paper score and floor score dividing the experience into two movements: one following the score and the other indeterminate. One difference was the absence of visual projections on the wall. We believe that the absence of the graphs helped visitors to be more present in the space. We also did not incorporate flavor into this version to leave greater focus on the sonic impacts alone.

Supplemental Analysis

A/C/D:

As such, in comparison to *Kroumatograph No. 3*, aspects of the familiar and unfamiliar/strange were most affected. There were less unfamiliar dimensions to attend to, even if these dimensions reinforce the strangeness. They require an active attention that we felt might shift too much attention away from active sensory listening in the key sonic and kinetic channels.

Dance of the Fulcrum **(2016)**

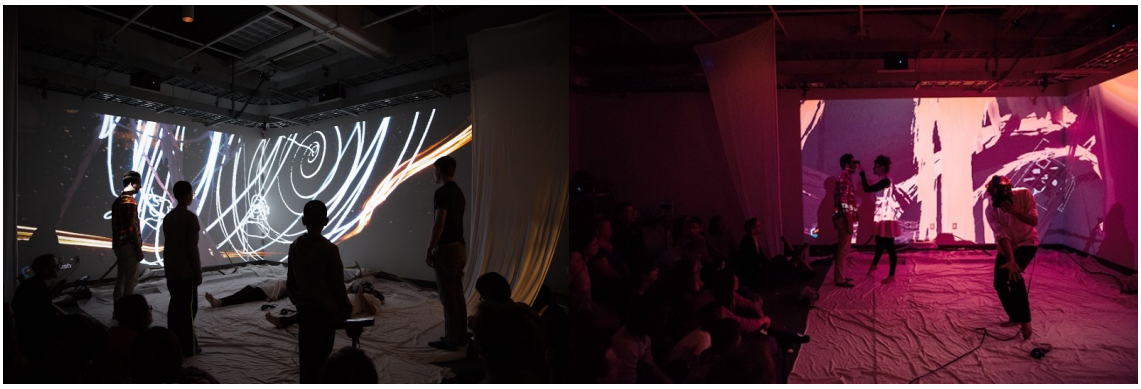

Figure 4.8: *Dance of the Fulcrum* (2016). Photo: Mohit Hingorani.

Like *Kroumatograph No. 2*, this works uses spatial tracking between two users to incentivize pro-social engagement. Creating an intertextual algorithmic metaphor for Aristotle's writings on friendship in his *Nicomachean Ethics* (Aristotle, trans. 1926, Book VIII), it also measures for proximity, mirroring, and rate of change (as collective risk taking), and creates strange sonic feedback to incentivize these behaviors. In this way, these computationally mediated actions also bridge social and embodied/environmental situatedness and advance conceptual structures for

friendship actions. Other elements of the performance and composition use bilateral symmetry and asymmetry to play with conceptual structures of complementarity and balance.

Description

This piece attempted to cultivate philosophical ideas about social values and meanings, through listening and exploring with others. Using concepts from Aristotle's ethical writings on ideal friendship, we created computational conceptual mappings between the spatial movement between two people and changes to auditory parameters to try to incentivize greater social engagement and creative play. Through these mappings, the piece is meant to model a notion of constructive and collaborative friendship.

We presented this performance-based work in the transLAB of the UCSB California NanoSystems Institute (CNSI) as part of White Noise, the 2016 UCSB MAT EOYS. The performance was followed by *Kroumatograph No. 2* as a related installation-based experience. It featured theater artist Maud Watel-Kazak and dance/media artist Timothy Wood. The work was sponsored by a number of UCSB entities: Division of Humanities and Fine Arts, Graduate Division, Interdisciplinary Humanities Center, College of Creative Studies Music Composition, College of Creative Studies Computing, Media Arts and Technology Program, Department of Music, Department of Theater and Dance, and Classics Department.

In terms of its layout and technical aspects, *The Dance of the Fulcrum* (the song/performance portion) consists of three performers (two dancers and one

pianist/vocalist), a stage area, a virtual reality (VR) head-mounted display and hand controller, a piano, a spatial-tracking system, a sound system, and a visual projection. The visuals from the VR display are projected onto the wall behind the stage area and dancers for the audience to see.

In *The Dance of the Fulcrum*, one way that these values are expressed is through a spatially-tracked dance in which the spatial movements of the dancers have the potential to algorithmically generate more or less interesting musical changes to an electronic musical component. These changes depend on the proximity of the dancers, how closely they complement the movements of one another, and how ambitious they are in experimenting with their movements. In this way, through this algorithm, the dancers are musically guided and incentivized to strengthen their bond to one another as well as to strengthen their individual abilities as dancers.

Specifically, the tracked movements impact parameters affecting the reverberance of the piano, which has a contact mic. The processed piano creates an ambient wash, however, the changes to this wash are perhaps too subtle with everything else going on in the performance. These parameters later are reconfigured to affect frequency offsets in the *Kroumatograph No. 2* sound sculpture parameters.

Moving to live piano and voice, Watel-Kazak and Wood choreographed their movements to play with the tracked parameters. A key feature of this performance also entails a narrative using TiltBrush in VR, making and revealing a 3D drawing in real time. For part of the time Watel-Kazak wields the hand controller for drawing

and Wood, wearing the head-mounted display, reveals the results of her drawings with his strategic gaze. This performance also engages audience members, inviting them to stand and have a likeness of them drawn in VR over their face as a virtual mask.

The accompanying composition for voice and piano consists of original lyrics in ancient Greek. As a creative constraint to embody the idea of balance, the chords in the piano are symmetrically mirrored around G#/Ab. Occasional asymmetries are balanced over time. The lyrics speak of complementarities—particularly balances, regulations, and mirroring in nature—through an original myth of the two Greek panopticons: Argos, the many-eyed monster, and Helios, the sun.

Analysis

A:

Action (observed) between two dancers affects changes in the sonic environment. Actions by one dancer while interacting with the other dancer and audience members create a real-time 3D drawing in a projected virtual environment, leaving a mediated trace of past actions and encounters. This drawing is only revealed by the active gaze of the other dancer. These actions create a strong link between social relationships and environment, promoting situatedness.

B:

In the dyadic spatial tracking mapping, proximity structures the concept of social interest, mirroring/imitation structures the concept of social engagement and listening, and rate of change structures the concept of social playfulness and risk-

taking. These conceptual mappings were informed by Aristotle's writings on friendship in his *Nicomachean Ethics*. Mirroring in the dance and music composition reinforce these ideas.

C:

Familiarity and unfamiliarity are balanced here in the use of symmetrical actions and deviations from this symmetry to focus on the concept of regulation and balance.

D:

Strangeness is introduced in the ways dyadic interactions amplify and modulate the visual and sonic virtual environment with the intent to promote insight about the idea of friendship.

Computation:

Computation is necessary to create a visual and sonic virtual environment responsive to spatial tracking, and to create the complex mappings between movement and feedback detailed earlier.

Value:

This work incentivizes attention to nuance, care in one's actions, and pro-social interactions.

Meaning:

The work advances ideas about friendship, informed by Aristotle's *Nicomachean Ethics*, using computational mappings to promote ideas that friendship entails closeness and readiness to listen, listening and learning from one another, and playfulness and risk-tasking for collective growth.

***Accords No. 2* (2016)**

Figure 4.9: *Accords No. 2* (2016).

Accords No. 2 (accord=chord in French) enables strange interactive play between the conceptual structures of musical chords (as related stacks of notes) and olfactive accords (as sets of blended olfactive notes). The grouped concept of musical chords itself is further abstracted away from notes here into any collection of sonic frequencies: including low-frequency rhythms, heard and felt, creating an equivalence between chords and polyrhythms. A computational system mediates this strange conceptual blend, allowing visitors to actively adjust pitches and rhythms to create a cross-sensory "polychord" (a set of multiple chords) with an original drink they also compose. This strange task allows for compression: insight regarding abstract cross-sensory associations, as well as inviting a more abstract

idea about musical chords as being beyond the senses. This complex interaction rewards attention to nuance.

Description

In *Accords No. 2*, participants mix a cordial of different floral waters and syrups, and use a digital interface to tune auditory sounds, vibratory sensations, and room resonances to either match or complement the olfactory and gustatory qualities of their beverage. The unusual request of the task encourages close sensory attention and calibration and encourages abstract thinking to create cross-sensory metaphors.

This work was shown at SBCAST in Studio F and its run included the October AIA Architect Walk event and the October Santa Barbara 1st Thursday event.

The installation plays with cross-sensory ideas around harmony and chords. It is informed by scientific literature on the inherently cross-sensory construct of flavor (Stevenson, 2010) and the connection between pitch and the chemical senses of olfaction and gustation (Crisinel & Spence, 2012; Holt-Hansen, 1968; Seo & Hummel, 2011).

In the space we set up a drink-mixing station and a sound-composing station, with lily-pad-like vibration platforms arranged around the room, including one for feedback at the sound station. A subwoofer in the corner supports the output of low-frequency room modes and two speakers provide auditory output.

The installation creates a novel action script for visitors: the steps are written out onto a sheet of musical staff paper at the entrance and repeated by a live attendant at the drink-mixing station. The steps begin with composing a floral cocktail from a selection of vials. The attendant then adds sparkling mineral water to the mixture. Following this, visitors go to the sound station to “create a cross-modal polychord” with a digital interface: to tune sounds, resonances, and vibrational rhythms to be in cross-sensory consonance or complementary dissonance with their drink. Visitors can also save their sound with an associated number and record their number and drink combination in a logbook back at the mixing counter. Lastly, before leaving, visitors ritually clean their glass with lavender dish soap at a dish-washing station at the entrance/exit.

The mise-en-scène serves to play with situated associations to olfaction and chemicals. The drink-mixing station evokes both perfume counter and chemistry lab with floral waters and syrups arranged on a mirrored surface with glass vials and droppers. The connection to flowers and perfumery is further reinforced with the physical presence of different kinds of fresh flowers arranged around the room. On the wall, a projected black and white video by Mare Hirsch plays: ink dropping and dispersing into water.

Returning to the sound station and its technical aspects, the interface, built in Max, permits the calibration of auditory pitches, low bass room resonances (affecting audition and chest resonance), and rhythmic whole-body vibrations. See Figure 4.10.

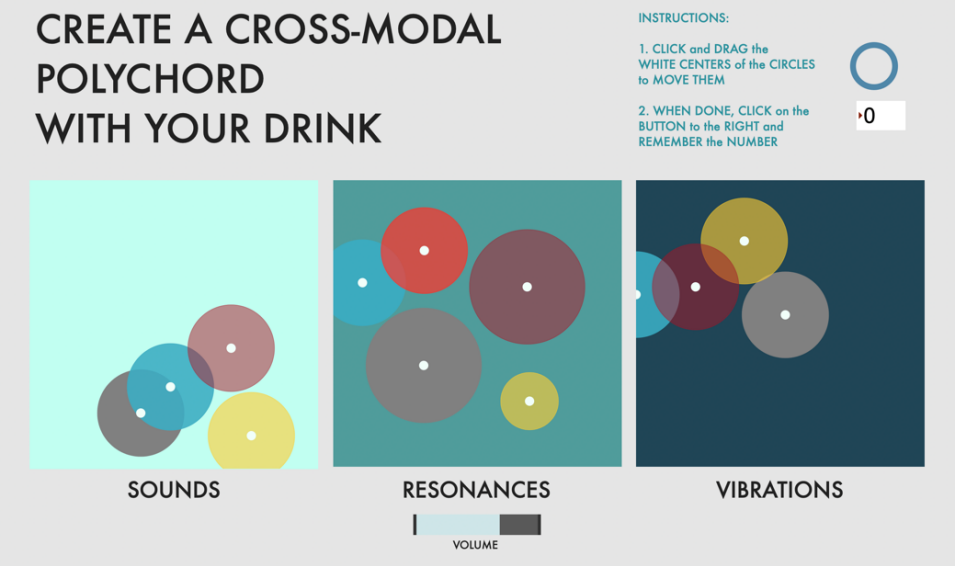

Figure 4.10: *Accords No. 2* user interface (2016).

For the auditory component, there are four circles, each corresponding to a simple additive tone of the first four harmonics each. Displacements of the circles along the y-axis impact the frequency of the tone (200–600 Hz), low position-lower frequency to high position-higher frequency, and displacements along the x-axis impact amplitude, with left-lower amplitude and right-higher amplitude.

The room resonance portion is governed by five circles, where each circle corresponds to two sine waves tuned around the first three room modes of the length of the room and the first two harmonics of the width of the room. This set-up builds off the *Kroumatograph* code. The x-axis and y-axis impact the frequency displacement of these accompanying tones with respect to the calculated room mode, where the x-axis creates a positive offset in one tone of 0–1 Hz, right-lower frequency and left-higher frequency, and the y-axis creates a negative offset in the

other tone of -1–0 Hz, low position- lower frequency and high position-higher frequency.

With respect to the vibratory component, four circles control four phasors, which are all added together in the mix going to each platform. Here, the y-axis impacts amplitude, low position-lower amplitude and high position-higher amplitude, and the x-axis corresponds to frequency (1/16–16 Hz), with left-lower frequency and right-higher frequency. Notably, the infrasonic frequency range is rhythmic rather than pitched, with many of the positions in the interface producing countable beats. As such, the effect with four such phasors is more polyrhythmic.

The circles are differentiated by color and, for de-bugging purposes, are ordered and colored-coded according to the author's numerical grapheme synaesthesia.

Analysis

A:

This work engages action through the composition of a drink and executing the task of tuning a sonic environment to match or complement properties in the drink. The sonic feedback in the environment engages somatosensation, creating a situated link between body and environment. This situatedness has a social dimension too: visitors can experience others' compositional environments using the other vibrational platforms, and we found groups of visitors consulting one another and taking sips of each other's drinks to change the environment by consensus.

B:

Key conceptual structures include consonance and chords, specifically polychords. Relatedly, there is a metaphor of vertical stacking: adding layers. In the interface controlling pitches and low frequency oscillations, there are confusing mixed mapping schemes. Frequency and amplitude each map to x- and y-axes in different modules: in hindsight, we should have mapped the frequencies and amplitudes to the same set of axes in all cases.

C:

There are too many parts to this installation, creating too much detracting unfamiliarity. For sound, we should have only used heard pitches and vibrations. The resonances were too difficult to calibrate from a single position in the space due their spatial properties, even if they added to the ambiance and immersive quality of the work. They could remain as simpler and constant element. Also, we should have designed the arrangement of the drink-mixing, sound-mixing, and dish-washing stations in a more familiar intuitive sequential way, like with a path.

D:

The cross-sensory strangeness and strange tuning task promote a compressed idea of harmony and an appreciation for how our mind creates abstract conceptual mappings.

Computation:

Computation generates and allows for the interactive control of sonic parameters routed to different sonic displays creating auditory pitches, auditory/felt

low frequencies (tuned around room modes), and vibrational rhythms. It allows users to modulate their environment to make a more suitable mapping to their drink.

Value:

This work incentivizes attention to nuance and care in one's actions.

Meaning:

This work is a reflection on sensory conceptual mappings and situatedness, especially challenging ideas about the separation of the senses and hearing-centered views of music.

Regarding cultural situatedness and meaning, we play with olfactory and chemical associations and aspects of musical tradition. As discussed earlier, the mise-en-scène evokes connections to perfumery, gardens, and lab work. The object of a score sitting on a music stand providing instructions serve to frame the steps of the installation as part of a time-based musical experience. Connecting to familiar associations around harmony, the simplicity of the auditory tones helps to evoke the timbre of a pipe organ, and because there are four such tones, there is a further situated connection to the history of Western 4-part harmony writing and Bach's chorales. The notion of a polychord from music is used to structure a cross-sensory experience, helping to promote ideas of music beyond hearing.

***To Eleusis, To Tanayan* (2017)**

Figure 4.11: *To Eleusis, To Tanayan* (2017). Photo: Kuangyi Zhou.

To Eleusis, To Tanayan uses multi-user interaction with a virtual environment to explore situated connections between the body, environment, and social others. Through the strangeness of a computational system that entails collective biofeedback, the piece is meant to cultivate a peaceful sense of personal responsibility and accountability to a collective experience. This is done via a computational conceptual mapping where decreased agitation leads to increased amplitude/intensity of a vibrotactile experience. Intertextual associations serve to frame this multidirectional computational experience as a critique on the unidirectional imposition of colonization.

Description

To Eleusis, To Tanayan is an interactive, hybrid performance-installation. It was realized in collaboration with Zachary Rosen (recreating an ancient drink to

accompany the work), Timothy Wood (as dancer), and Alan Macy (providing biometric counsel). We showcased the piece for Re-Habituation, the 2017 UCSB MAT EOYS in the transLAB.

The performance features one dancer wearing a spatially-tracked vibrotactile glove and head-mounted display, interacting with a mid-air haptic sculpture in a virtual environment. Spectators can see the projection of the dancer's virtual point-of-view on the wall. They are seated on vibrotactile benches that convey the sculpture's feedback at the point where the dancer's hand intersects with the object. Three volunteers are attached to biometric devices measuring for how calm they are collectively (specifically via electrodermal activity). Their calmness impacts how intensely the sculptures can be felt by all.

Upon entering the space, visitors receive a glass of *kykeon*, an ancient barley drink. The event then begins with the dancer's performance (with the three volunteers) set to a composition for piano and voice, with original lyrics in ancient Greek. Following the performance, the piece enters an installation mode where others can take turns interacting with the virtual sculpture or attaching to the biometric devices, controlling its intensity.

On the technical side, the virtual reality environment and vibrotactile feedback were both developed in Max. The vibrotactile sculpture uses a spatial scrubbing approach, where a sound file is mapped to the radius of a sphere, so that change occurs according to the depth of the hand.

On the poetic side, the work makes cultural references both to the Greek city of Eleusis and to Tanayan, the original Chumash village around where Santa

Barbara Mission was built (Sánchez, 2010). Of these references, the virtual environment features a 360° photo of the nearby redwood forest in the Botanical Gardens, next to the Mission Creek Dam. The kykeon drink is also meaningful: a recreation from ancient Greece used as part of the Eleusian Mystery Rites, a sacred ritual in Eleusis that honored goddesses with connections to nature and sustenance (Demeter and Persephone). The ritual also carries associations of life, death, rebirth, and abduction (of Persephone) (S. L. Harris & Platzner, 2012, p. 150). A local plant to Santa Barbara/Tanayan, yerba buena, replaces pennyroyal from the Greek recipe in the *Homeric Hymn to Demeter* (Homer, trans. 2004, line 209), connecting Eleusis to Tanayan.

These associations are meant to emphasize Tanayan as a sacred site in its own right (in contrast to the Mission, in reality a site of genocide), urging recognition and honor of its history. The design of the installation, situated in these references, is intended to cultivate co-operation as an antidote for the unidirectional brute force characteristic of colonial attitudes. Instead, it emphasizes collective listening and appreciation: where multiple users are accountable to one another for the experience of the sculpture by calm attunement to their bodies, their surroundings (for biofeedback), and one another.

Analysis

A:

The work engages the active attention of all, active regulation of emotional arousal on the part of the three volunteers (and also of the audience who share the

social space), and active movement for the person immersed in the virtual environment. The sonic feedback from the virtual environment creates a situated link between bodies, others, and environment.

B:

The computational system creates conceptual links between increased social calm/listening and increased ability to reveal/hear/feel. Given the contextual cultural references, the system's design features a multidirectional network in contrast to an historically unidirectional application of force. Other metaphors for appreciating and gaining insight from others are used in the imagery of the lyrics in the sung music. These include contrasting walls (isolated and blind) to hills (with a vantage point and far view), dams (stagnant) to riverbeds (that flow), and a sculpture (imposed with one author) to sculptures sculpting one another (transactive, where all elements are changed).

C:

In hindsight, the work had several shortcomings as it had many unfamiliar components within an unfamiliar structure. It was trying to do too many things and a simplification of its elements, and anchoring more to familiar design to structure the flow of the piece would likely make for a more effective expression.

D:

The strangeness of the vibratory sonic feedback, and the strange causal relationship between the feedback and summed levels of emotional arousal are meant to provoke a compressed sense of accountability, collective inter-connectedness, and appreciation for how calm focus allows for nuances.

Computation:

The multi-participant design of the virtual system (with spatial tracking, electrodermal activity sensors, virtual reality graphics, and sonic displays) allows for a computational tethering between others, inner bodily states, and the virtual environment.

Value:

This work incentivizes attention to nuance, care in one's actions, collective accountability, and appreciation for others.

Meaning:

The work serves as a critique of colonialism and as a reflection on a more culturally beneficial mindset. The multi-user affordances of the work and other design choices in context with connections to Eleusis, Tanayan, and the Santa Barbara Mission intend to communicate the importance of co-operation, listening, and appreciation of nuance in contrast to the blind imposition of one's will.

Asclepias **(2018)**

Figure 4.12: *Asclepias* (2018) and sample accompanying dish. Photo (left): Briana Markovich. Photo (right): Barbareño.

Asclepias uses strange sensory phenomena and effects to bring attention to embodied situatedness and care for the body. As part of this, action via user movement modulates these effects.

The piece uses computation and special devices to create and project precise vibratory effects impacting internal corporeal resonances. Postural changes impact these sensations. In turn, these resonances also impact the perception of specially developed gastronomic dishes. This chain of influence creates a compressed sense of interconnectedness in the body and agency to explore it. This complex interaction rewards attention to nuance.

Description

Asclepias is a time-based installation exploring sensory and cross-sensory nuance through body resonance, movement, and chemical senses related to eating, specifically through interoception: the sensation of states and phenomena internal to the body.

Asclepias is a collaboration with somatic artist brooke smiley and Santa Barbara restaurant Barbareño. It was presented as part of the 2018 Alliance of Women in Media Arts and Technology Conference.

The work consists of auditory and vibrational music (engaging whole-body vibration through vibrational bench seating) as well as guided postural movement. This postural movement can calibrate the vibrational effects to the body: specifically, skeletal and visceral resonances (Kitazaki & Griffin, 1998). It also

entails the timed tasting of four small gastronomic compositions or amuse-bouches by Barbareño.

These dishes were developed to engage with the somatosensory aspects of food consumption and to cross-sensorially interact with the vibrational aspects. The dishes possessed a variety of textures and densities impacting chewing and mouth feel. The ingredients were selected to be nutrient rich—promoting health—and to stimulate feelings of wellbeing through changes in chemical state (e.g. due to being enzyme-rich, salty). Regarding cross-sensory interactions, in the development of the work, following an informal testing session with different tastes and accompanying low frequency vibrational resonances, we found that different low frequency rates changed which tastes were amplified or attenuated. To play with these aspects, the dishes each contained some degree of all core five tastes—saltiness, acidity, bitterness, sweetness, and savoryness/umami—so that we could cycle through the different taste-altering vibrations to bring out different facets over the tasting of a given dish.

Poetically, the work uses the notion of folding within the body as a conceptual metaphor for health: this includes protein formation, enzyme allostery, and the evolution and development of the gut tube.

The auditory elements consist of a background drone and a simple theme played on piano that punctuates vibrational phrases sent to the seating. These phrases move through different low frequencies which impact flavors in each dish in different ways. In this way, each dish has a flavor experience that evolves over time.

Analysis

A:

This work engages action through postural movements to adjust the effects of the computational vibratory component, which causally impacts flavor. Cross-sensory effects involving interoception engage embodied situatedness.

B:

To highlight the theme of interoceptive awareness, the title refers to the internal becoming external, the hidden becoming known, through asclepias, or milkweeds—with fiber-filled seed pods that burst open. A projected image of a milkweed is part of the mise-en-scène to support this metaphor. Ideas of folding/bending are used to structure ideas about calibrating one's health and attunement to the body. The title also connects to Asclepius, Greek god of medicine, who is affiliated with snakes, reinforcing the conceptual association between health and bending.

C:

This work had some familiar elements of hors d'œuvres and a musical experience but paired them in an unfamiliar way with vibrations and movements, as well as the unfamiliar causal impacts of these vibrations on flavor. The strangeness of the whole experience and all its unfamiliar parts seemed to have been a bit confusing for visitors. This work could anchor more to familiar experiences or benefit from clearer design in the overall structure to better support visitors through this strange experience.

D:

The strange cross-sensory pairings evoke a common connectivity of the senses, emphasizing the unity and integrality of our perception.

Computation:

Computation allows for the generation of the sonic components at precise frequencies and cued in specific sequences, to affect the resonances of the body and the resulting emergent flavors in a musical, time-based manner.

Value:

This work incentivizes attention to nuance, care in one's actions, and attention to the body and its well-being.

Meaning:

This work speaks to situatedness and embodiment through interoceptive awareness, also challenging ideas about the separation of the senses and exploring the integrality of our embodiment. The title reference to Asclepius, the Greek god of medicine, helps situate this work as dealing with health and the body.

***A Vibrotactile "Musical Sculpture" in VR Exploring Apparent Motion Illusions of Frequency Beating and Changing Phase* (2018)**

Figure 4.13: Transaction(s) exhibit of *A Vibrotactile "Musical Sculpture" in VR Exploring Apparent Motion Illusions of Frequency Beating and Changing Phase* (2018). Photo: SBCAST.

This project uses computation to provoke strange yet subtle tactile illusions when interacting with a visible sculpture in virtual reality. This strange interplay of effects, activated via action and movement, invites attention to nuance: close study rewards more detail. It also invites compressed insight about the connection between embodied and environmental situatedness.

Description

This installation entails a touchable sculpture in virtual reality with strange vibrotactile and visual feedback. It entails a wearable vibrotactile device on the arm and virtual reality to explore nuances with haptic and kinaesthetic illusions and cross-sensory visual influences on these illusions. The work necessitates careful attention and movement to reflect on subtle changes in the illusions and their potential interplay with the visuals.

This work was presented as a demo at the 2018 IEEE Haptics Symposium and was also presented as part of the *Transpiration(s)* exhibit in Studio F at SBCAST as part of the April Santa Barbara First Thursday Event in 2018.

Building off of the installation *To Eleusis, To Tanayan*, this work is a more technical and scientific study of the sculptural component.

Analysis

A:

Action is needed to explore the sculpture and engaging with it activates both the environment and sensations to the body, promoting their situated connections. Regarding cultural situatedness, the work uses the proportions of a Greek column (Architectural Orders, 2014) to structure the envelope of sensations as one moves one's hand along the radius of the structure, anchoring the work to the history of architecture/sculpture. However, this mapping is not self-intuitive for the audience to gain this meaningful insight.

B:

This work uses the rotations of a sculpture to structure and influence the directional perception of haptic/kinaesthetic spatial illusions.

C:

This work could better model itself off of familiar experiences as it requires a lot of verbal instructions given all its unfamiliar parts. The experience seems a bit confusing for visitors even with the verbal guidance, but we've found that leaving them ample time to explore and familiarize themselves to the sculpture's strange causal effects makes for a more successful experience. Commercial VR devices were also relatively new at the time, and maybe greater familiarity with VR would make the installation seem less strange now, four years later.

D:

The strangeness of the sensations and the visible reaction of the object, which only be activated through complex computational means, promote reflection on the strange wirings of our perceptual infrastructure and invites curiosity about the wide variety of illusions and phenomena we can only discover through technology.

Computation:

Computation enables the virtual reality experience, spatial tracking, and the synchronization of sonic and visual parameters. It also enables the fine regulation and complex spatial mapping of the sonic signal processing effect that creates the haptic and kinaesthetic illusions. The tactile actuator devices are also necessary for this effect.

Value:

This work incentivizes attention to nuance and care in one's actions.

Meaning:

This work focuses on the situated connection between embodiment and environment, with a virtual world that activates strange new sensory phenomena that would be otherwise inaccessible without graphic and sound signal processing technologies.

***Superadditive Musical Amuse-Bouches* (2018)**

Figure 4.14: *Superadditive Musical Amuse-Bouches* (2018). Photo: Larry Zins.

Superadditive Musical Amuse-Bouches strangely blends and aligns the temporal structures of a gastronomic tasting experience with a musical experience (using hearing and felt vibrations) to create compressed impressions of flavor as a construct of the senses and of music as something beyond the senses.

Computation with sound synthesis enables precise sequential sonic changes that can impact chemical sensing in different ways. Action through postural changes modulates this cross-sensory effect in strange ways, integrating in embodied situatedness. This complex interaction rewards attention to nuance.

Description

Superadditive Musical Amuse-Bouches is a durational installation consisting of four brief musical movements paired with gastronomic amuse-bouches. The musical component entails an auditory component as well as somatosensory one with whole-body vibration, delivered via vibrational benches. The work plays with the cross-sensory construct of flavor and explores the cross-sensory potential of musical experience. The work was exhibited in collaboration with the Santa Barbara restaurant Barbareño as part of Invisible Machine, the 2018 UCSB MAT EOYS.

The work serves as a study for the ongoing *Asclepias* project, and elements of its gastronomic development were the same.

Following discussions with Barbareño and then Head Chef Julien Martinez, they developed four distinct amuse-bouches compositions. While the favor profiles of each one were unique from one another, the goal was for each bite to contain aspects of all core five tastes—saltiness, acidity, bitterness, sweetness, and savoryness/umami. Each of the four musical works and its accompanying vibrations were composed to contain a composite of sonic aspects that could, in theory, amplify or attenuate these qualities to varying degrees. In this way, each musical work could provoke different emergent flavors in each dish over time.

Also, like *Asclepias*, the work entails action through movement: postural changes that can impact the corporeal vibrations, and in turn the percept of flavor.

During the installation, Chef Martinez and his assistant Chef Preston handed visitors the four tastes and gave instructions to sit on the vibrational benched and follow a tasting score projected on the wall, timed to the music. Above the seating, we projected color-coded graphics of each dish with its corresponding musical movement.

The designs and instructions could have been clearer, with more redundancy to avoid confusion given all the parts and strangeness. The set-up wasn't ideal either, crammed next to a wall in a busy hallway. A mise-en-scène evoking the familiar trappings of a musical concert could better situate visitors for such an experience. Despite these shortcomings, the installation was well-received, and visitors reported enjoying the cross-sensory effects on the dishes.

Regarding the sonic technical development, we developed a specialized instrument. As the vibrations we used in *Asclepias* were rather simple and dull, at the suggestion of JoAnn Kuchera-Morin, we took inspiration from the rich timbral qualities of the digeridoo to develop an instrument in Max for future studies and iterations. This instrument combined additive synthesis and amplitude modulation approaches to create complex emergent timbres. We created a multi-touch interface control for the instrument using Mira[20] on an iPad.

[20] Accessed 03/18/2022: https://cycling74.com/products/mira

Analysis

A:

This work engages action through postural movements to adjust the effects of the computational vibratory component, which causally impacts flavor. Cross-sensory effects involving interoception engage embodied situatedness.

B:

The short temporal experiences of amuse-bouche tasting impact the length and form of the musical works and the four-movement musical structure provides a temporal sequence armature for the tasting and consideration of each dish.

C:

Familiar concepts of amuse-bouches and a musical experience are combined in an unfamiliar way with unfamiliar additions of whole-body vibration and movement creating unfamiliar causal relationships between the sensory components.

D:

The strange cross-sensory pairings evoke a common connectivity of the senses, emphasizing the unity and integrality of our perception.

Computation:

Computation allows for the generation of the sonic components at precise frequencies and composed/layered into specific sequences, to affect the resonances of the body and the resulting emergent flavors in a musical, time-based manner. Video editing technologies help pair a visual tasting score with the sonic diffusion to guide the experience.

Value:

This work incentivizes attention to nuance and care in one's actions.

Meaning:

This work speaks to situatedness, challenging ideas about the separation of the senses and exploring the integrality of our embodiment.

***OrchScape*, contribution to *Moon Moons* (2019)**

Figure 4.15: *OrchScape* segment of *Moon Moons* (2019).

OrchScape uses computation to create a strange conceptual blend of orchestration approaches (timbral treatments) in music and objects in a spatial environment. This creates a new situated environment where musical possibilities are mediated as physical objects among which one can spatially travel. This helps create a compressed impression of musical choices as a possibility space, and helps to bridge a sense of body and environment.

Description

OrchScape is a part of *Moon Moons*, a multimedia group performance piece that features dance and a projected camera fly-through of different virtual environments. It was realized for the occasion of the 2019 UCSB MAT End of Year Show by members of the transLAB, including Aaron Anderson, Diarmid Flatley, Anshul Pendse, Gustavo Alfonso Rincon, Mert Toka, Nathan Weitzner, and Timothy Wood.

The author's particular contribution to *MoonMoons*, *OrchScape*, is a one-minute-long segment of the fly-through, featuring a spatiotemporal audiovisual environment exploring "spatial orchestration." The environment contains twelve architectural-scale sculptures, each with an associated audio track mapped to its position. The twelve tracks consist of three separate timbral "orchestrations" (of four tracks each) of an original electroacoustic composition. The components feature different artificial electroacoustic timbres or "instruments." Using a distanced-based panning approach accounting for the positions of the sculptures and their affiliated audio tracks, the tracking of the camera fly-through generates a given audio mix of the tracks, where increased proximity maps to increased amplitude in the resulting mix. As such, the resulting audio weaves in and out of different orchestrated possibilities. The orchestrational approach is thus spatiotemporal, dependent on the moving position of the camera.

On the technical side, the camera's path was precomposed in Unity. And due to other factors concerning real-time playback for the other works, the fly-though audio output was pre-recorded ahead of the performance to be played in synchrony.

The sculptures were 3D modeled from music data, using a similar workflow to that of *Caduceus*. We used FormZ to compose a base form, Mathematica to revolve the amplitude contours of a sound wave file and blend the vertices of the two meshes into a single point cloud, and MeshLab to remesh the object using Poisson reconstruction.

We composed the sonic motifs using our timbral tool in Max (from previous works), and with these sound files, Diarmid Flatley helped us create a link from Unity to Max to spatialize these files according to the placement of the sculptures.

In hindsight, true interactivity in a virtual environment with spatial tracking would have been better. As a watched experience that can only be experienced once, the connection between space and timbral mix is not as apparent. The timbral differences between the audio tracks could have been more pronounced to reinforce the effect.

Analysis

A:

The camera movement creates observed action, an active point of view that interacts with the virtual environment. This moves toward conveying a situated connection between body and environment, but it would be far more effective as an

installation where visitors can move through the environment themselves with spatial tracking to make this causal relationship more apparent.

B:

The work blends timbral possibilities with spatial positions. It structures orchestration choices as a physical possibility space.

C:

This work entails familiar concepts of orchestration/timbre and virtual environments in an unfamiliar blend.

D:

This strange mapping helps provide a compressed sense of unity between body (through first-person viewer position) and environment, time and space. It makes a meta-instrument of orchestration choices, showing how larger aggregate creative decisions can be made into a playable instrument.

Computation:

Computation permits the mapping of sound to a virtual space, as well as the resulting audiovisual flythrough.

Value:

This work incentivizes attention to nuance.

Meaning:

It explores situatedness and creative choices as a fluid instrument.

4.1.3 OTHER INSIGHTS TOWARD THEORY

Given the following retrospective analysis of this body of practice (conducted after developing our themes), we have noticed several interesting trends and gained several insights in connection with our themes. These insights and our detailed analyses allow us to both see how the investigation of these themes initially emerged from practice and also showcase the utility of our themes as an analytical tool in the new media arts.

Trends

Regarding meaning, we have come to realize that our work uses strangeness through the senses to create a compressed idea about music (and its related conceptual structures) as being independent of a sensory medium. All of our significant works here are music-based, intertextual with Western or other musical traditions in some way, with some strangeness introduced into musical structure (e.g. motifs, movements, sonata form) or other musical ideas (e.g. polyrhythms, polychords), mostly through combination with or transposition into other senses. Many of these works, especially the installation works, also participate within the tradition of sound art in the direct use or sensory transposition of sound as artistic material. However, these works are not just sound art but music art in how they rely upon and play with situated constructs of music-making as their artistic basis. Using new media and systems enabled by electronics and computation, this work introduces counterfactual “what if” questions into musical and artistic practices, advancing the dialogue about these practices.

We typically use the affordances of analog media in at least one of three ways:

Sensorial amplification: to interact with the computational elements, to bring computationally-created content into greater relief;

Situated meaning: to steer the interpretative meaning of the computational content through situated associations; and/or

Situated environmental affect: to create a calming ambiance, especially if the computational content is intense or complex (unfamiliar).

In an informational theory sense, the first two categories serve a functional redundancy, where a common variation or connection in a strange pairing of parameters helps lead to compression and recognition of a common cause or principle at work. It also makes sensory or interpretative information more certain, especially where there is strangeness with respect to a greater familiar and situated context.

Insights

Concerning meaning, our works that use interactivity with computational conceptual mappings (like *Dance of the Fulcrum* and *To Eleusis, To Tanayan*) tend to be able to communicate more interesting values and meanings, even if their execution wasn't fully successful.

The more successful works entail more constraint in the number of parts (i.e. less unfamiliarity/distractions), incorporate first-hand action, and leave sufficient

time and space for exploration and discovery (e.g. more time for familiarization and gaining a sense of conceptual structures).

It's important to consider the balance of familiar and unfamiliar elements with respect to the number of senses/parameters involved, the exhibition type and mediation, and whether a mediation serves a direction or the content.

We can create a non-obtrusive sense of environmental situatedness and ambiance by including multiple senses, but some sensory channels and parameters need less information and unfamiliarity to better focus attention on the parameters that matter for the content.

We can leave more nuance in installations where a person may spend an extended amount of time, but it is possible to provide too much nuance and unfamiliarity to parse, and this is less strategic in ephemeral performance type situations where the piece is likely only going to be experienced one time, and/or where the mediation of the environment is so particular that it is unlikely to become part of a regularly performed cannon.

There are times when the information conveyed should be certain and when it should be uncertain and strange/puzzling in a productive way toward compression. Generally, directions should be clear (including instructive steps, scores, etc.) and the content strange.

Given the need to balance familiarity and unfamiliarity, it is useful to consider the collection of materials in a parametric way, in the style of Moles (e.g. hue, frequency, amplitude, x-axis position). Parametrization is already necessary for mapping with the computational platform. Theory from information aesthetics can

help this need, but some additional considerations for situatedness not addressed the original theories may be helpful. We will address some proposed theoretical additions in the following chapter.

Some of the situated and intertextual associations may not be accessible to all visitors. It is advisable to identify which groups are more likely to understand, and which ones may be excluded from this knowledge. In some cases, it may be prudent to yoke to more commonly shared knowledge and/or to create other kinds of redundancies for communicating an idea, so they can still appreciate elements of the experience given their situatedness.

Relatedly, it's worth considering if any extratextual connections are self-evident or if they need to be explained separately from the work itself, written into the description or explained. If recognizing the exact reference is important to understanding, it may be more powerful to embody it in the work somehow. If more complex background information is needed, a verbal explanation may be best, but this should be communicated upfront in a succinct way.

4.2 PEDAGOGICAL PRACTICE

4.2.1 OVERVIEW: TOWARD HOLISTIC THOUGHT

In this section, we discuss our pedagogical practice and how this work addresses the idea of paideia. Specifically, we present pedagogical prototypes we have created to operationalize holistic instruction that supports cultural learning with respect to our learning themes and especially with respect to values and meaning. We explore central ways that the computational platform supports such endeavors.

As with values and meanings, we can provide a working definition of holistic thought in terms of our learning themes: how the contrast and interlinking of different conceptual structures can provide compression; the exploration of complex situatedness through deep and broad mediated causal relationships.

Computation can support holistic thinking, especially through a virtual worldmaking framework in a number of ways. Computation democratizes information: everything is data and computation affords the ability to extract and apply data from one domain to another or to create other algorithmic relationships between datasets. The computational platform allows for rapid prototyping, and thus rapid cognitive offloading into virtual assets. This prototyping can leverage generative algorithms to achieve high complexity with simple rules under many iterations. Virtual environments can serve as a repository for such assets and facilitate the encoding of formalized relationships among such assets (e.g. impacting changes over space and/or time). These environments thus become repositories of not just these assets but of their complex inter-relationships to one another. These relationships, when critically and thoughtfully constructed, can be

effective in communicating complex ideas. In such a way, virtual environments can serve as a site for exploring situatedness and through that, values and meanings. Furthermore, the creation of virtual agents situated in such environments can serve as a means to model the very process of reality-making and cultural creation.

In this section, our related pedagogical contributions include exercises, demonstrations, illustrative original artworks, workshops, starter code and other digital tools, theoretical development, and even some changes to the teaching format of the class (especially as a response to the transition to remote instruction).

As with our artistic prototypes, these efforts also inform our themes and theory.

4.2.2 BACKGROUND

Our paideia-motivated pedagogical ideation and practice spans over eight years. Beginning with class exercises in education courses, this work later informed larger efforts with faculty including an inter-departmental course proposal and participation in a call for reimagining the high school, both of which were ultimately unsuccessful at the time. However, these early efforts helped contribute to the development of the THEMAS model and the realization of the related undergraduate course series Mediated Worlds by Marcos Novak, who had participated in these proposals.

Our early pedagogical practice as a Teaching Assistant in other classes helped to inform our later pedagogical work in THEMAS, particularly using intertextuality in Greek Myth (Classics) and Visual Literacy (Art) and fiction

strangeness in Engineering Ethics (College of Engineering). These efforts also seeded the isolation and development of our four learning themes.

Through a Teaching Assistantship for Greek Myth in Classics, we created original exercises in section for the students to engage in intertextual rewriting as a philosophical thinking tool. Cosmologies and resulting genealogies of the gods (e.g. as conveyed through the writings of Homer, Hesiod, and Ovid) can be said to propose a tree structure for the interrelation of concepts, with more fundamental notions at the top. Using such genealogies as a conceptual structure: where ideas are placed in a tree like hierarchy (e.g. with relationships of parent-child, sibling-sibling), we encouraged student to create their own cosmogonies and genealogies to reflect their interpretations of the world and/or of contemporary scientific understandings. The strangeness of their own variation was intended to promote compression about the purposes these genealogies and their resulting myths might have served as philosophical thinking tools. Critically, the students had to act: making their own genealogies as the original poets would have done, to create a greater ownership over this understanding.

In one course, for a final deliverable, we had them create an artwork featuring a mythical “rewriting” of a Greek myth in their readings. The rewriting was to comment on a contemporary issue of their choosing, in the medium of expression of their choice, directing attention through this unfamiliar and strange deviation.

As a Teaching Assistant in the Visual Literacy course in Art, we used a similar approach in an in-class exercise for their semiotics unit, picking a contemporary problem and creating a visual image using polytheistic gods (as

signifiers of their domains) to create some commentary on the issue. In this instance, the student could use gods of any religious tradition.

As a TA in Engineering Ethics, we successfully advocated for the inclusion of strange dystopian science fiction in the reading as a tool to promote compressed insight about both 1) the interrelation of technology and societal structure, and 2) the importance of engineering ethics in a society to regulate this relationship. In THEMAS (starting in 2020), we were able to encourage this insight through science fiction worldmaking directly as part of the curriculum.

4.2.3 THEMAS MODEL AND MEDIATED WORLDS FORMAT

In order to properly explain our pedagogical contributions to the THEMAS model and the Mediated Worlds course series, it is necessary to provide some context about the general structure and format of the model and courses, as well as their timeline.

The THEMAS model is the invention of Marcos Novak. The acronym THEMAS stands for Technologies, Humanities, Engineering, Mathematics, Arts, Sciences. From the THEMAS website: “The THEMAS model proposes a continuum across disciplines previously separated by narrow specializations. It builds upon the successes of STEM/STEAM, with greater emphasis on the humanities, creativity, and synthesis” (Novak, 2017). Looking at knowledge in a more transdisciplinary way, the model considers how its elements interrelate. It emphasizes three axes in particular: Technologies-Humanities (as tools and purposes, or means and ends), Engineering-Mathematics (as concrete and abstract problem-solving), and Arts-

Sciences (as synthesis and analysis). Across these axes, the model promotes a making and design focus.

The related Mediated Worlds course series (also conceptualized by Novak), employs the THEMAS model in the context of worldmaking, examining how these components “inform all aspects of how we come to know and make the world” (Novak, 2017). With respect to worldmaking, Novak defines three kinds of approaches: worldmaking in fact (how we know the actual world, e.g. via science, math), in fiction (how we understand our world through imaginary alternatives, e.g. via art), and in action (how we affect and enact change in our world, e.g. via ethics, politics).

Regarding the class’s offerings over the years, Mediated Worlds: A THEMAS Course was first offered in Spring 2017 as a pilot or overview course. Class-time consisted mostly of lectures and occasional in-class exercises led by Novak, and workshops that the Teaching Assistants helped develop. By Winter 2018, a three-course sequence was offered, with a greater focus on certain pairs and their interrelations: Technologies-Humanities, Engineering-Mathematics, and Arts-Sciences. This sequence became more studio-like over time, especially after switching to a remote format in Spring 2020. In Summer 2021, we offered an original Special Topics course entitled (E)Utopian Design Tools, which we’ll cover in more detail in the following chapter.

In terms of our role in the class, we served as a Teaching Assistant from Spring 2017–Fall 2018 and a Teaching Associate from Winter 2019–Summer 2021,

proposing and teaching our Special Topics course in Summer 2021. A timeline of the relevant classes is as follows:

Teaching Assistant:
S17: Pilot
F17: Pilot
W18: Engineering-Mathematics
S18: Arts-Sciences
F18: Technologies-Humanities
Teaching Associate:
W19: Engineering-Mathematics
S19: Arts-Sciences
M19: Technologies-Humanities (Creative Computing Initiative)
F19: Technologies-Humanities
W20: Engineering-Mathematics
Transition to remote teaching:
S20: Arts-Sciences
F20: Technologies-Humanities
W21: Engineering-Mathematics
S21: Arts-Sciences
M21: Special Topics: (E)Utopian Design Tools (Creative Computing Initiative)

With respect to the course's general structure, given the ten-week quarter, the course began consisting of two introductory and framing weeks, six weeks covering each element of THEMAS one-by-one, and two weeks for workshops/final project development. We held these two workshops consecutively at the end of the quarter in the first quarter, and through Spring 2021, we separated these weeks and experimented with different arrangements over the various quarters. In Fall 2019, the first two introductory weeks and workshop became more formalized as a unit on design and formal procedures. By Spring 2020, and the start of remote teaching, this design unit was framed in terms of worldmaking as "Cosmogenesis." To illustrate, the Spring 2021 quarter followed the layout below as per the syllabus:

Part I: Worldmaking and Design
W1 *March 30+April 1* *Making, Ideation, Mediation, Modulation, Affect*
W2 *April 6+8* *Formal Constraints and Generative Tools*
W3 *April 13+15* ***Cosmogenesis Worldmaking Workshop***
Part II: Worldmaking and THEMAS
W4 *April 20+22* *Technologies*
W5 *April 27+29* *Humanities*

W6 *May 4+6* *Engineering*
W7 *May 11+13* *Mathematics*
W8 *May 18+20* ***Worldmaking Workshop***
W9 *May 25+27* *Arts*
W10 *June 1+3* *Sciences*
W11 *June 10* *Final Project Presentations*

In terms of the class content, tools, and deliverables, there are several points and general shifts worth mentioning.

When the course was first offered, students were encouraged to make as a general habit (in many iterations) and, for their final project, they could interpret the idea of a mediated world in any medium or media of their choosing. Additionally, over the quarters, to direct their making efforts, Novak encouraged theme-specific making challenges (e.g. a tool for technologies week, a proof for mathematics week). By Spring 2019, these challenges became more formalized into two per week as follows:

Technology: a problem and a tool
Humanities: a value and a meaning
Engineering: a machine and an engine
Mathematics: a symmetry and a pattern of symmetries
Arts: a quality and an exemplar
Sciences: an experiment and knowledge

These challenges were intended to support their final worldmaking project, as the project student would need to entail some degree of making in each discipline.

When we began as the Teaching Associate in Winter 2019, we implemented a more rigorous computing component into the class with Arduino microcontrollers, holding two workshop days in the first half of the academic quarter. Novak eventually transitioned the common computational component into the procedural

modeling program Structure Synth[21] between Fall 2019 and Winter 2020, and in Winter 2020, began transitioning to the modeling and animation platform Blender[22] as a primary tool for computational exploration. Blender became the common making medium of the class by Spring 2020, when the course had transitioned into a remote format due to the global pandemic.

Around Summer 2019, Novak had also started a gradual shift in the final project format. The format moved away from open-ended final projects, where students could interpret a mediated world in nearly any way, to becoming more computationally focused. By Winter 2020, this became a fictional world with an accompanying video and narrative "trailer" to showcase these efforts, and by Spring 2020, this project was to be realized in Blender (or another medium of comparable rigor, pending approval).

During the change to remote instruction, we helped plan and enact a switch to a reverse lecture format, pre-recording non-interactive theory to leave the class-time for more demonstrations and making exercises in Blender around the making challenges.

In general, the class encourages and supports autodidacticism and project-based learning. Despite the above constraints, the framework allows considerable latitude for students to pursue and implement their own sub-disciplinary and thematic interests within the challenges and work. Within a fictional worldmaking process, the THEMAS order also proposes and organizes a cultural recapitulation-

[21] Accessed 03/18/2022: http://structuresynth.sourceforge.net/

[22] Accessed 03/18/2022: https://www.blender.org/

like approach to student learning: where students gain ownership over the range of human making practices by ideating and modeling the first tools, values, machines, arts, scientific understandings, etc. of some fictional agent/creature in a fictional world.

4.2.4 CONTRIBUTIONS

During our time as a Teaching Assistant and Teaching Associate we made various contributions to the model and class. In terms of general duties, as a Teaching Assistant, in addition to teaching section, we contributed to various workshops during lecture. Later, as a Teaching Associate, in collaboration with Novak, we lectured and led various demonstrations and other in-class making exercises. Our pedagogical contributions were motivated by many of the following factors:

- To address various issues that arose with student engagement and output.
- To support students in the realization of the making challenges.
- To promote insights from our research, especially regarding cultural and situated theories that we perceived to be lacking in the original model.
- To create continuity and more connectivity between the THEMAS topics.
- To promote trans-paradigmatic thinking, across paradigms, using different conceptual ideas to promote creative problem solving.
- To support computational implementation with theory.
- To support paideia through computational implementation.

From here, we will detail our contributions to the topics of making, attunement, design, scaffolds and constraints, what-if questions, cosmogenesis, and elements of THEMAS (especially different permutations that connect back to our themes). This order roughly follows the sequence of subject matter as it is delivered in the course.

Making

Creative making and action can entail different degrees of effort, and we found some students taking the path of least resistance in this area. For some, when we would ask them how their final projects entailed making a technology, they would respond that they used a computer, here conflating using and making. In some other cases, as part of their regular making practice, we had students recreating assets in strict step-by-step adherence to online tutorials, conflating replication with a creative act.

To confront these issues and avoid any future confusion with respect to active making and creativity, we gradually developed some principles and theory to support their understanding and corresponding efforts.

To better disambiguate using from making, we (the author) developed a theoretical framework for bridging using to more original making. We would introduce this framework during Technologies Week. These steps considered unfamiliarity and familiarity with respect to formal affordance and a given application. In its initial iterations, we created two matrices to explore these possibilities: a simpler 2x2 one and a more detailed 3x3 one parsed through Aristotle's four causes: material (what it is made of), formal (what form it takes), efficient (who made it), final (its purpose) (Aristotle, ed. 2013b, ed. 2013a).

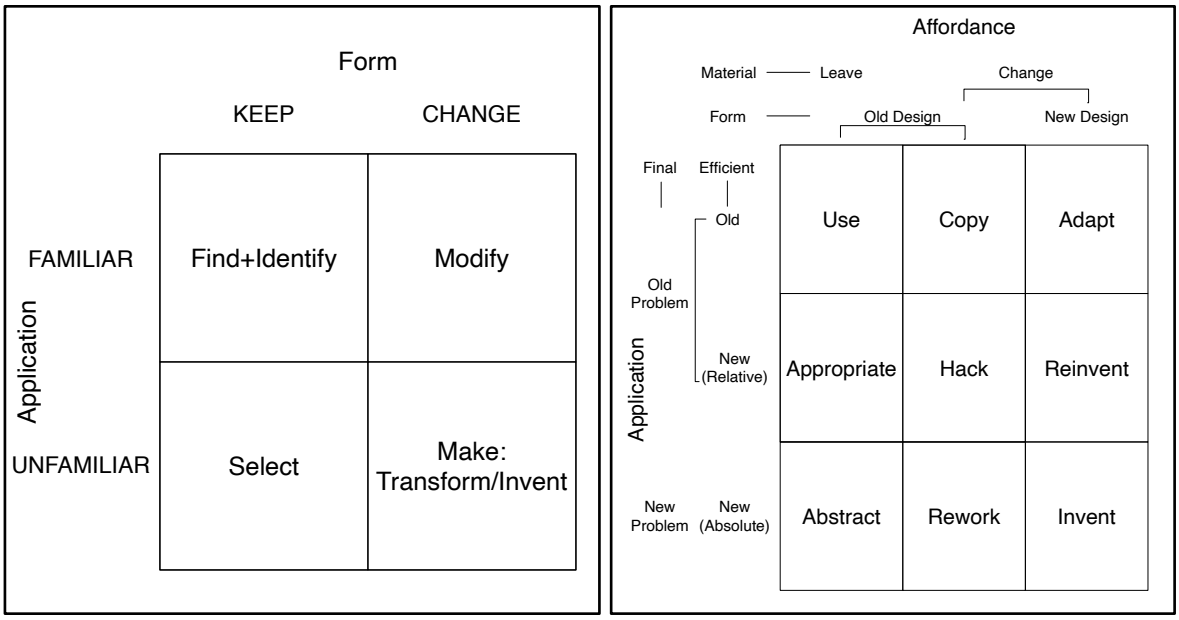

Figure 4.16: Using-making matrices: simple (left) and complex (right).

While we felt there was interesting nuance to explore in the 3x3 matrix, we felt it was too much to unpack and operationalize for an undergraduate class. As such, we would concentrate on the 2x2 grid and by the 2020–2021 school year, we had designed in-class exercises to foster an active understanding of these differences. The following lesson plan excerpt entails pairing sounds to strange machine learning images the students had prepared for class:

> ***Find: e.g. using an instrument for its intended use***
> ***Apply: e.g. you finding noisemaking potential in other objects (to a given end)***
> ***Modify: e.g. you applying effects to sounds (to a given end)***
> ***Make: e.g. you could synthesize new sounds entirely (Mathematica, Max, etc.)***
>
> ***Step 1:***
> *Take 3 minutes and hunt around for different items or collections of items that might produce sound (as is or with modification) (when plucked, stricken, etc.).*
> *[You might not even need to get up as everything makes sound.]*
> ***Step 2:***
> *Take 3-5 minutes and experiment with the sound makers you've collected, trying to get different sounds out of them. Try to get the most unusual sounds you can among your items.*
> *3:30 Foley:*
> *https://www.facebook.com/LADbible/videos/730024250888334*
> *Foley entails the ability to abstract (designed or natural) affordances and apply them toward new purposes.*

Step 3:
Think of a sound you'd like to create or imitate for each of your images and try to approximate it with your items. OR just associate your sound to your images. OR think of a soundscape for these combined items. For each of these sounds, do Steps 4 + 5.
Step 4:
Record
https://sodaphonic.com/editor
(Make some more recordings that can be layered.)
Step 5:
Modify: Effects (try reverb, reverse, pitch shift/stretch, etc.)
https://twistedwave.com/online

With respect to copying tutorials verbatim, we emphasized a conceptual metaphor: between thinking like a cook (following a recipe, rules) and thinking like a chef (deriving rules, creating original works).

To help with breaking out of prescribed tutorial steps and to promote general creativity, we introduced students to Boden's creativity operations. In particular, Boden's combinatorial and transformational rules inspired us to implement the mechanism of "what if" questioning: looking at the existing parameters and assumptions and formulating "what if" questions to find an alternative.

Some further confusion about making came about when the class transitioned more into fictional worldmaking. Here, the making challenges became more ambiguous: is making a tool asset for a fictional agent in a fictional environment the same as making a tool oneself? To draw attention to these nuances, we began to distinguish the two kinds of making given Novak's own distinctions about worldmaking approaches—making in the actual world and making in the virtual world. Moreover, we encouraged the dual execution of challenges for both the real and fictional worlds to gain insight about the actual making from the strangeness of the virtually situated task.

Attunement

We observed that certain students seemed to have difficulty with abstraction and some of their making was lacking intentionality and thoughtfulness in expression. Others made poor imitations of popular styles. We devised a regular exercise we termed “attunement” to help sharpen their capacity to learn from the world around them, and to more effectively transfer qualities of interest into their work. This “attunement” exercise was a mechanism for building off of the situated familiar (nature and artifacts) and transposing it into unfamiliar scenarios in more interesting ways, creating conceptual abstraction if not also extratextuality/intertextuality where desired. We encourage a parametric approach to analysis to facilitate computational description and implementation. An example of the prompt is below:

> ***ATTUNEMENT***
>
> *A component of your weekly making includes a sub-exercise to attune yourself to the world. This exercise entails selecting certain objects to focus on and then connecting and applying what you observe to your making. This can be done very simply. The steps are described below.*
>
> ***Steps: Select | Analyze | Synthesize***
>
> ***SELECT***
>
> - *one natural object (organic or inorganic) of your choosing OR*
> - *one artifact (i.e. something crafted by a human)*
>
> *(that you find to be powerfully beautiful, that profoundly moves you, and that you think would also be appreciated by others.)*
>
> *To find your natural items, take a walk if it’s safe to do so, or find your items in a digital format if not. If you need some inspiration for selecting an artifact, you can select one from the Museum of Artifacts:*
>
> - *https://museum-of-artifacts.blogspot.com*
>
> *Note: Try to not select the objects based on acquired sentiment, which can be accorded at random by happenstance and which is personal or very limited in universal appeal.*
>
> ***ANALYZE (OBSERVE):***
>
> *What aspects of the object lend to its potency? Think about its formal degrees of freedom (e.g. color, shape, texture, rhythm, sweetness): how is it modulated? what does it express?*
>
> ***SYNTHESIZE (APPLY):***
>
> *Transfer an aspect of your analysis into part of your weekly making challenge—for example, as a “make better” criteria. This transfer can be abstract. For example, apply the formal qualities to a new dimension.*

EXAMPLE

If you like the colors of a natural object, instead of replicating the colors exactly in something you're making, you could create a different set of colors with similar ratios between them that produces a similarly powerful effect. To illustrate, maybe that means using 95% of colors in a more muted palette, and then 5% of a bright color that pops (as opposed to the precise RGB values of the colors in your item). Or, you could map one attribute to another, so that texture variations in your found object drive color variations in an object you are making. Think cross-sensorially too.

Design

Around Summer 2019, Novak began introducing and formalizing design principles for the first design unit of the class, terming these steps "gradus ad parnassum." These steps included a sequence of mediation, modulation, and affect (i.e. emotional impact), among others, including the creation of rules and constraints.

To support his theory, we eventually designed a dot exercise, with an accompanying demonstration in Blender, and illustrative examples from various digital artists.

Let's take a dot:

Mediate

What's an easy way for this dot to become real? How do we transfer it from your mind to the world? (e.g. food, fabric, pen, code)

Using your sketchbook or Blender, make a dot.

Modulate

Make a different dot.

Pay attention to the quality of the actions you make.

Make a noticeably different dot.

What did you change about the dot to make it different?

What are the different parameters we could change about this dot? How does our chosen medium affect this? (e.g. radius, contour, shading, etc.)

What are the ranges of these parameters?

Pick three of these parameters: radius, shading, etc.

Make a series of dots that start at one extreme and gradually go to the other.

Pick a gradation from each category to make one dot.

What constraints and choices make the dot more or less interesting to you?

From all the dots you drew, how can these parameters combine to form an interesting family of 3 dots?

What makes them similar to one another from all the other possibilities?

What makes them identifiable as a family from all the other possibilities?

What would alien dots to this family look like?

Make an alien family of dots.

Affect
Thinking about all these parameters:
How do we get dots that can move us? Get different emotional responses out of us?
How would you convey a delightful dot? A scary dot? A sleepy dot?
Make 3 dots of different affects.
What parameters are you changing? What kind of texture does a scary vs. delightful dot have? What shape does it take?

In this exercise, we emphasize a parametric approach, modeled after Moles' information aesthetics idea of repertoires. We stressed that in creating design that's more distinctive and particular, we can add more parameters, more nuance.

This ties into an information aesthetics concept by Novak, about the different between the unique and the rare: any permutation of parameters may be unique, but only certain improbable configurations will be rare. Adding parameters increases information and rarity here.

In sensing that these ideas could be grounded in a more situated way, we have developed some further theory to support such explorations, which we'll address in the next chapter.

Scaffolds + Constraints

One key theme in the course is the idea of the scaffold. This theme, advanced by Novak, connects to bottom-up design and tool-making. A scaffold is effectively a set of formal constraints that can lead to a more constrained palette of choices with inter-relationships between them. This idea has connections to information theory and aesthetics: creating more certainty from chaos, and creating a balance between more familiar and unfamiliar relationships. It is found in architecture especially, and with Novak, we often used such examples in the theory portion of lectures. An illustrative example is a technique of geometric inscription

typical in architect Louis Sullivan's work to produce symmetrical ornamentations (Lenti, 2012; Ruby, 2012). This is also found in the tessellation approaches of Islamic art (TED-Ed, 2015), and the "wheel method" in visualizing rhythm (TED-Ed, 2014). We also find this approach in the research of Jurgen Schmidhuber, who has produced a few such generative drawings to illustrate his algorithmic theories of interestingness (Schmidhuber, 1997).

Early on in the course, to encourage learning through making on this subject of scaffolds, Novak created a class exercise entailing the typographic design of initials in the free mathematics platform GeoGebra.[23]

In 2019, we developed our own tool for the students to use in Mathematica to generate scaffolds via geometric inscription and subdivisions. This code also served a second pedagogical purpose, helping to model the fundamentals of coding for the uninitiated: moving from replacing values to building loops, functions, and nested functions. To demonstrate the potential applications of such scaffolds to students, we printed these scaffolds out and used them ourselves to make structured drawings. In some of our studies, we also integrated in intertextuality to create abstract drawings informed by the conceptual structures of other works (e.g. songs and poems). In one example, we produced a scaffold using the ratios of a Shakespearean sonnet to create a create a visual interpretation of Shakespeare's Sonnet 29 (Figure 4.17). The geometric constraints and content/graphics attempt to convey a similar partitioning to that in the poem between preoccupations with

[23] Accessed 03/18/2022: https://www.geogebra.org/

judgement and insecurities to a sense of confidence and peace from interpersonal support.

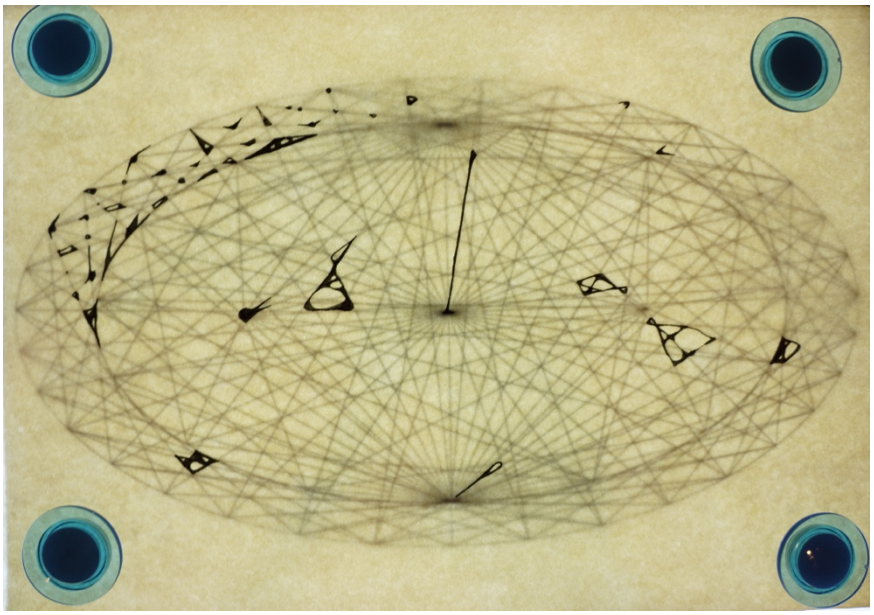

Figure 4.17: A scaffold developed in Mathematica (background) and a drawing-in-progress (foreground) structured by Sonnet 29 by William Shakespeare.

Later in 2021, when we were working with Blender, we took this process a step further, showing how one could use such principles to create a terrain in a virtual environment. As a demonstration, we imported an image of one of our scaffolded drawings (in black ink) into the software and generated an inverted height map from the brightness levels.

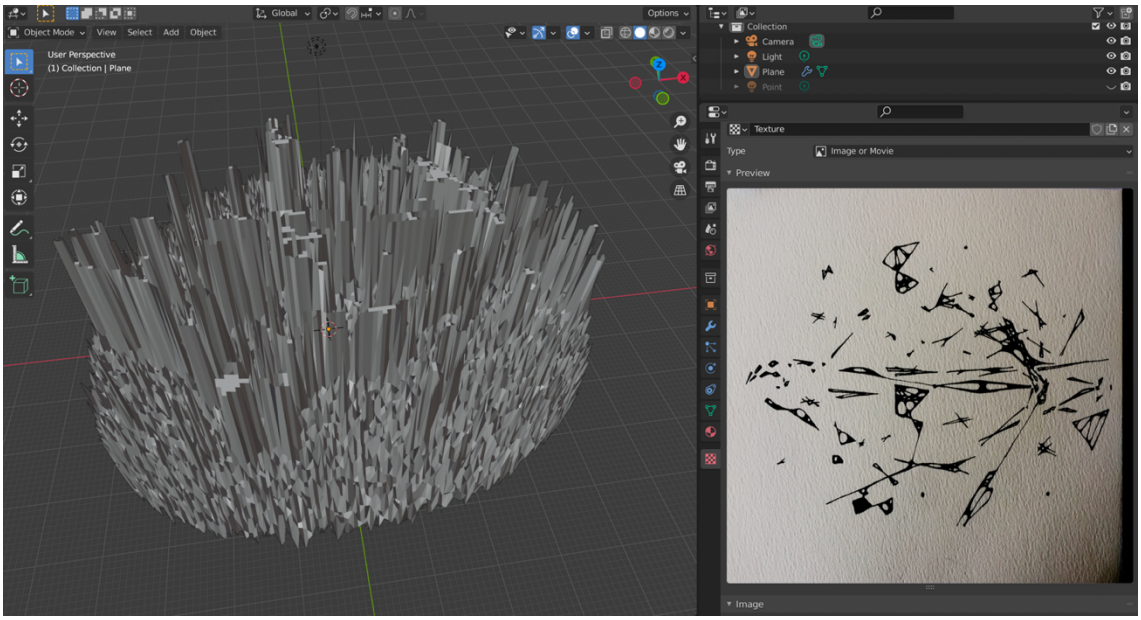

Figure 4.18: A rapidly prototyped terrain created in Blender from a drawing. The drawing was created from a scaffold developed in Mathematica using the macrostructural ratios of an original music composition.

In this spirit, we also demonstrated how they could generate temporal scaffolds for video editing (for their end-of-quarter trailers) using sound files developed with a Euclidian polyrhythm generator.[24]

Outside of scaffolds from geometric inscription, we encouraged creating constraints from other systems of rules. This touches back to our work with what-if physics conditions for the worlds, and using generative methods, including scripting, to govern how terrain clumps.

[24] Accessed 03/18/2022: https://apps.musedlab.org/groovepizza

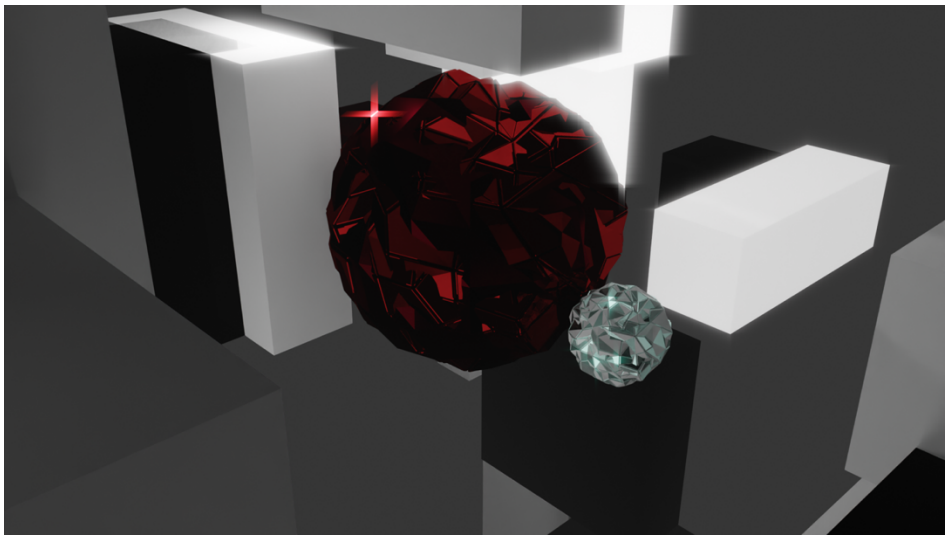

Figure 4.19: A terrain of floating rectangular cuboids created in Blender using Python scripting.

In an example we used in Mathematics week, we shared starter code with students (using Blender's Python module) for generating plants using Bezier curves in recursion.

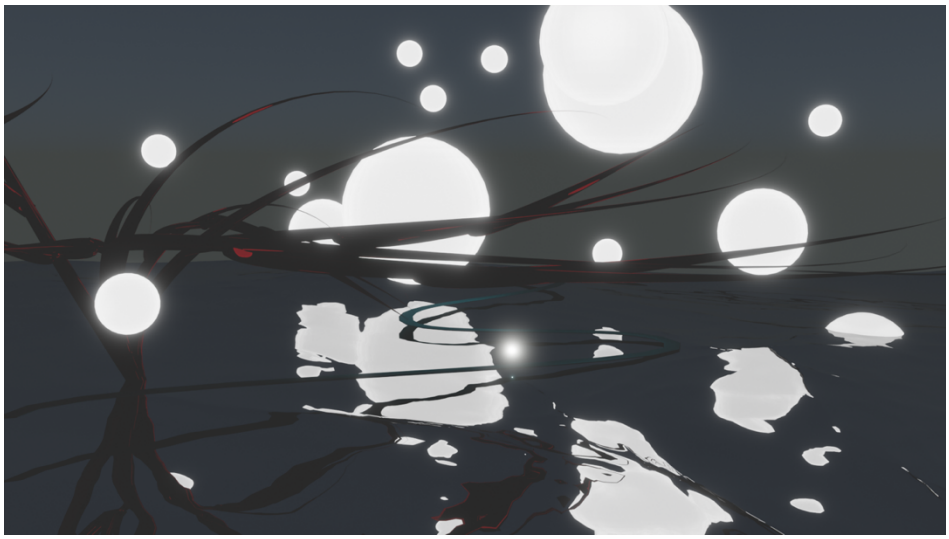

Figure 4.20: A plant created from Bezier curves and recursion in Blender using Python scripting.

In these ways, through scaffolds, elements can gain self-similar relationships, adding more familiarity to the balance of familiar and unfamiliar.

What-If Questions

A considerable contribution to THEMAS was in the emphasis of counterfactual ideation, particularly through fiction. This engages our theme of compression through strangeness.

The origins of this contribution came out of Sciences Week when we would cover hypotheses and paradigm shifts. In section, as an exercise, we encouraged the students to formulate scientific hypotheses, identify the premises inherent in the formulation of their question, and then think about “what if” questions that could challenge each premise.

We brought this “what if” formulation into a workshop in Winter 2020, asking students to imagine some “what if” premises for worlds, considering generative laws that might impact how terrain might have developed in a given world. The “what if” formulation situates itself as some deviation in comparison this familiar world: for example, the question “what if there were a world with four spatial dimensions?” anchors to an understanding of a world in three spatial dimensions and seeks to identify which parameters of our known world would be altered and which might remain constant. Such hypothetical ramifications can be explored gradually, topic by topic, thinking back to the chronology of the formation of our planet, life, and culture.

We later integrated this general “what if” premise exercise into the curriculum (as we’ll discuss further), and finding the mechanism useful, Novak framed the

making challenges in terms of developing “what if” tools, “what if” values, etc. for fictional worldmaking.

Cosmogenesis

One of our major contributions to the THEMAS curriculum was the gradual operationalization of a cosmogenesis making process, helping students develop the kernel of their fictional world for which they could ideate and create corresponding and cumulative virtual assets for the technologies, humanities, engineering, mathematics, arts, and sciences of their world. This cosmogenesis stage came to encompass the development of an agent from a situated ideation process, starting with the development of “what if” physical laws and some resulting terrain environment.

This process encouraged a “what if” and “what then” way of bottom-up, causal ideation, where each layer of decisions created situated constraints for the following layer and making task.

Different kinds of “what if” premises will also have a bearing on how alien this fictional world might be from our own, depending how fundamental the change is: a world with different atomic laws will drive greater differences than a world with slightly different gravitational pull than ours, however both ideas can be greatly insightful. The differences from the latter premise might be more pronounced and relevant to us in some ways, given the stronger anchoring to the familiar.

As part of the ideation process for creating “what if” physical laws, we explored cosmogenesis myths of different cultures, looking at how gods can stand

for physical principles (e.g. in Hesiod's *Cosmogony*, Novak interprets Chaos as a repulsive force and Eros as an attractive force). As we did in our work for the Greek Myth course, we encouraged students to contemplate the cosmogonies of their own worlds.

The process that led to our emphasis on situated agents came about separately in several iterative steps over the years, through different media.

In Fall 2018, the worldmaking workshop we designed with fellow Teaching Assistant Sahar Sajadieh, consisted of collecting objects to make a landscape and making creatures out of clay. As they designed the shape of their creatures, we would urge them to think generatively, from a bottom-up perspective:

> *Consider the inhabitants of the world. What kind of creature might evolve within such an environment? What kind of affordances are in the environment? What kind of qualities would thrive there?*
>
> *What is its prey? What are its predators? How would it need to sense and move to eat and evade each, respectively?*

We took this idea further, in a more computational direction when we began using Arduinos in the classroom in conjunction with a selection of various sensors and actuators. We first stressed the physical computing steps of sensing, processing, and actuation, and would encourage students to each make a system and try to create chains and ecosystems of them with peers, where one's sensor responded to the kind of actuation of another. By Summer 2019, we encouraged the development of a physical computing agent in a more situated fictional worldmaking context:

> *Think about an agent, how it evolved. What's abundant? What affordances are there?*
>
> *Life: What does life need to develop? How would it know how to get it? How would it decouple these streams of information from the background? Think figure/ground. Think*

about direct/indirect mappings—different channels or characteristics in these channels. What means would it use?

Eventually, by Spring 2020, we came to couch this exercise in Blender. Later on, we would create real-time demonstrations using the Blender sculpture module, with an in-class exercise starting with a “what if” terrain and atmosphere and then asking students to sculpt a creature with “what if” limbs and sensory organs, creating a corresponding embodiment to the information in the environment. Figure 4.21 shows a rapidly prototyped creature entitled “Ice Friend” with appendages allowing it to glide and scoot across ice terrains of various friction gradients. As a main sensory organ, its ears are sensitive to distant and directional hearing across vast expanses of its ice world.

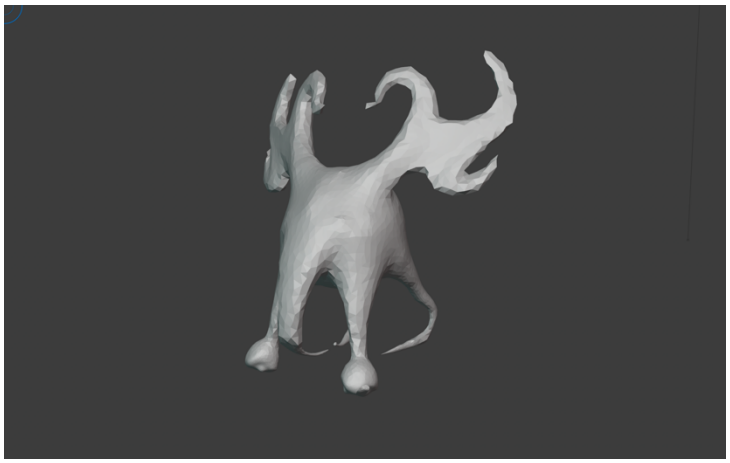

Figure 4.21: A rapidly prototyped fictional situated agent entitled “Ice Friend,” made using Blender’s sculpting module.

To consolidate these ideas, we would give students an at-home exercise to generate two contrasting world concepts so that they could pick one they preferred

and from which they could develop a prototype in Blender. An example of this exercise follows:

ALIEN WORLDS

Imagine two worlds *(alien from one another) with different:*

- *<What-If?> premises (basic assumptions for your world)*
- *Generative principles (basic rules applying to aspects of form: geometry, color, material, and any other property of form)*
- *Agents and agency (the creatures in your world, and their capabilities)*

If you have trouble thinking of a <what-if?>, consider ***combinatorial*** *creativity (combining two familiar things in an unfamiliar way) or* ***transformational*** *creativity (altering or taking away from a set of rules).*

Combinatorial example:

- *[world domination + cute animals]*
- *What if there was a kind of creature that conquered the world by being disarmingly cute?*
- *Example:* ***Star Trek: The Trouble with Tribbles***

Transformational examples:

- *[change the number of spatial dimensions]*
- *What if there was a world with 4 spatial dimensions? Or one with only 2?*
- *Example:*
  - *https://miegakure.com*
- *[change gravitational attraction amount]*
- *What if the gravitational pull of an Earth-like world was a fraction of that here on Earth?*

The ideas can be more ***figurative*** *or* ***abstract****.*

Think about the generative formal principles for each of these worlds.

- *Generative formal principles can be simple or complex.*
- *Some examples: you could have a world where everything is grouped in pairs, or one where everything branches five ways, or follows some other rule/algorithm you devise.*

ALIEN

In making the worlds alien from one another, consider our design steps.

- *How might they differ from one another in your choices of mediation, modulation, affect, etc.?*

Also, consider different orders of "alien-ness" as litmus tests.

In ***The Game of Thrones*** *Dothraki language video here, the word "throne" sounds alien and clearly doesn't belong within the language. Pay attention to how choices of modulation distinguish languages.*

4 min (From 0:46–4:37) Making a language:
https://youtu.be/vDD7bQTbVsk

In the Max Tegmark interview linked below, Tegmark explains how you couldn't visit a differently quarked universe as you (quarked as you are) would cease to exist.

(Watch first 5:10 of 17min) BBC Tegmark:
http://www.bbc.com/earth/story/20161021-why-there-could-be-many-copies-of-you

This alien theme promotes compression via strangeness not only through their differences to our world, but also through their relative differences. This relative alienness helps cultivate compressed insight into what constitutes strangeness itself.

THEMAS UNIT

From here, we would begin discussing the elements of THEMAS, examining the key concepts and key practitioner mindsets through theory and practice. Students would develop the civilization of their agents through the cumulative additions of basic tools, humanities (or more general “agent-ies”), engineering, etc.

Technology

With respect to technology, Novak had already framed technology in terms of tool-making within the context of creating a solution for a given problem.

When we began lecturing in Winter 2019, we brought in affordance theory to this understanding and emphasized media theory and situated cognition theories. We couched tools as extensions of the body (for sensing, for thinking, for acting), as part of nested chains of tools, and emphasized Wartofsky’s and Cole’s idea that artworks and fictional worlds can be tools for thinking about the actual world (Cole, 1996). Later in our teaching, when the final project focused on fictional world development, this became an increasingly repeated point during the ideation and making process.

Additionally, we took advantage of the tool-making topic to explore nuances between using and making, with the approach described earlier in the Making Section. This helped students to engage in a more active way with the class.

Technologies + Humanities: Values

To segue from technology to the humanities, we integrated in theories around engineering ethics and value-laden affordance, connecting the form of a tool with its possible uses, and its greater repercussions. In some earlier workshops and in later in-class ideation exercises, we asked students to consider technologies for their fictional world, and then ideate negative potential uses of technologies, and new problems to solve. For example, in one ideation and sketching exercise from Fall 2019, we asked students to imagine two value-laden artifacts: one for a dystopian society, the other for a utopian society.

We connected the idea of value-laden affordances back to ideas around design parameters: adding more parameters and constraints to direct usage to specific, desired tasks over undesired, potentially harmful usages. An example we used often was Assure, a knife collection made by Viners, a cutlery brand from Britain. Responding to statistics about knife-related crime, they made a collection of knives with a rounded-squared tip. In this way, the objects, while still functional as food cutting tools, couldn't also be used as a stabbing weapon (Hitti, 2020). Here, these extra formal parameters control action probabilities in ways supportive of human survival.

Technologies + Humanities: Meanings

We also experimented with teaching conceptual blending theory to examine how formal affordances in tools shape patterns of thought. In one in-class exercise from Spring 2020, we asked students to ideate and make a prototype of a clock, ideally in Blender, considering the following points:

> *How do we create meanings of time?*
> *What formal choices do we make in conveying time?*
> *How is time mapped geometrically?*
> *What other choices are possible?*
> *What does each set of choices communicate about the values of those who made them?*

Humanities + Engineering: Meanings

We used narratives and formal constraints to bridge from the humanities to engineering (with its stress on causal chains). Thinking back to schematic scripts, narratives can create sequential, causal connections between different actions. We would show students the well-known 1944 animation by psychologists Heider and Simmel used to demonstrate the human capacity to project agency and story onto a set of 2D geometric shapes moving about a screen (Heider & Simmel, 1944). To explore these ideas with the power of computation, we used the parenting functions and constraints in Blender to create reactional relationships between characters.

For example, we might create a parenting function between two objects where if one object approaches the other, the second object moves vertically upwards, out of the way of the first. The parenting function thus creates a structured relationship interpretable as an evasive behavior. In Figure 4.22 we depict this with

an approaching bull-ceratops creature and a retreating pega-pillar creature.[25] We can add a narrative context: perhaps the bull-ceratops is attacking the pega-pillar in predator-prey fashion, and there is aggression and fearful avoidance.

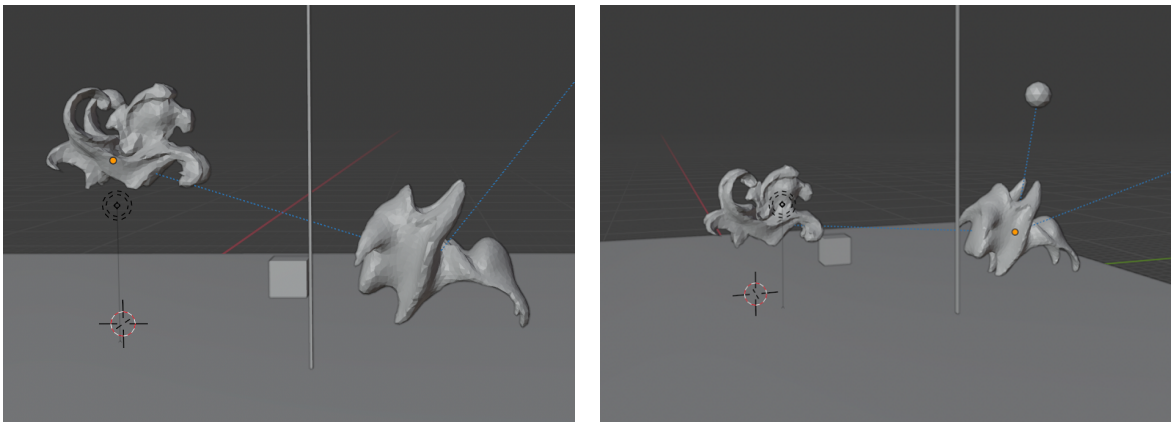

Figure 4.22: Parenting constraints in Blender between two creatures (left) and with a tertiary object (right).

However, we can chain other objects and hierarchal relationship constraints to narratively situate this evasive action to constrain its potential readings. For example, perhaps there is a ball falling towards the bull-ceratops. We can add a parenting constraint whereby the approach of the ball sets in motion the bull-ceratops, which then prompts the retreat of the pega-pillar. Here, we might recontextualize our understanding of the scene: the bull-ceratops may be escaping the ball in fear and the pega-pillar is moving out of the way in kindness, to clear a path. Maybe there is social distancing in the world too and giving others space is an act of care. In this way, the addition of the falling ball reframes our interpretation of the scene.

[25] These creatures were created by rapid sculpting in Blender using conceptual blending: combining a bull with a triceratops and a Pegasus with a caterpillar.

With such situated, formalized relationships that can be expediently programmed, we can explore and constrain possible readings of a given event. We create context. Adding events and relationships in such a way, in a strange and fictionalized environment, may also serve to demonstrate the many situated constraints we operate under in our lives, provoking empathy, as we don't always have the full causal picture leading up to a given moment. Here, strangeness leads to compression, bringing insight about how we formally construct meaning and promoting pro-social values along the way.

And if the implementation is a bit crude and unpolished, that's part of the point: it's rapid prototyping—with Blender, it's possible to sculpt such agents/creatures in a few minutes and create connections in a few minutes to start tinkering, exploring, and refining in further iterations. The ideation and philosophizing accompany the active, real-time making afforded by computation.

Engineering + Technology

While we were serving as an Assistant, within engineering, Novak had been stressing causal chains in machines and engines as key principles, as well as notions of precision, accuracy, and tolerance. When we began lecturing as an Associate, to anchor these concepts back to technology, we stressed the concept of linkages within the context of affordances.

We first urged a consideration of machines and engines in terms of their individual components and compounds: both machines and engines can be comprised of just one component or a compound (or causal chain) of components.

For example, simple machines like a corkscrew are a single component, and a single-component engine can be made from the intermittent heating of a length of shape-memory alloy (converting heat into mechanical displacement).

Linkages are one way in which machine components connect to form a compound causal chain. The links have matched affordances, constraining and controlling probabilities of action between these connecting points. Questions of precision and tolerance are ultimately concerned with limiting the scope of these probabilities, increasing certainty from an information theory point of view.

Along with Novak and Teaching Assistant Diarmid Flatley, we made various simple demonstrations of these ideas in Blender, using the physics engine.

To add in some strangeness to this idea and challenge our own framing around links, we also brought compliant mechanisms (Veritasium, 2019) and auxetic metamaterials (MIT Media Lab, 2018) into the conversation. For the curious, we encouraged active computational exploration of these ideas in the program Evolution[26] and using the rigging and physics capabilities of Blender. In subverting an understanding of engineering through the concept of links, we encourage “what if” strange thinking to promote the creative problem solving needed for engineering, with a “reinventing the wheel” ethos.

[26] Accessed 03/18/2022: https://keiwan.itch.io/evolution

Engineering + Sciences

Another way we encouraged strangeness for causal chains here was in the consideration of making machines within environments with “what if” physics rules: e.g. less gravity, less friction.

Engineering + Humanities

We connected engineering back to tools and humanities, in covering physical computing systems with sensing, processing, actuating, and feedback aspects. We connected these ideas back to agents and embodiment, and we would use the Arduinos to illustrate these ideas for a while. Later, when we moved remotely and to Blender, we would use the plug-in NodeOSC[27] with the signal processing capabilities of Max/MSP to send microphone data over the network to control geometric parameters in Blender, and to send and feedback parameters of Blender back into Max/MSP to influence the signals.

Engineering + Mathematics (+Humanities)

Bridging the engineering and the mathematics units, we connected back to humanities and situatedness through the idea of measurement. The book *The Perfectionists: How Precision Engineers Created the Modern World* (Winchester, 2018) presents a discussion around the development of measurement systems, and we used this as a guide for our own exercise. We asked student to create a “what if” measure, considering scale (e.g. if linear, logarithmic), units, standards, and the

[27] Accessed 03/18/2022: https://github.com/maybites/blender.NodeOSC

reference. Regarding reference: is the standard unit based off…the length of a specific king's foot? …some subdivision of the distance between the planet's equator and pole? …some atomic constant? Depending on the agent's embodiment and their lived environment, different units and references will be useful to them for the things they might measure. They might want to anchor their measurement system to something particular to their species, their environment, or something more universal. These measurements might influence the objects they engineer in their environment and their ratioed relationship to one another.

Such precise relationships can be easily governed through computation, in Blender, by parenting to "empties," which maintain ratio, scaled relationships between collections of objects.

Mathematics + Humanities (+Technology, +Art)

During mathematics theory, we urged situated reflections about choices in mathematical representation and tools. For example, we invited them to consider different base counting systems, and how embodiment or culture might impact number systems and the kinds of patterns a culture may be drawn to create. For example, a creature with three digits and three arms might possess a nine-base counting system and that might motivate more triadic symmetries in the objects they create. As part of this ideation process, students might use the sculpting feature of Blender to explore different embodiments that could lead to different counting systems, and explore symmetry and pattern-making with such add-ons as Tissue.[28]

[28] Accessed 03/18/2022: https://github.com/alessandro-zomparelli/tissue

Arts + Mathematics

To bridge our Mathematics and Arts units, and to work toward the challenges of making a quality and a cultural exemplar, we explored how adding algorithms and constraints to complex systems gave them more specific qualities in an unfamiliar combination, making them rarer and more extraordinary. To demonstrate this idea, we used the more recent Geometry Nodes module in Blender that allows for the procedural generation of object systems among other uses. We added layers of complexity to different systems, controlling behavior over time with increasingly complex trigonometric algorithms introducing polyrhythmic behavior.

Arts + Technologies + Sciences

In the Arts unit, we would stress art's role as a strange tool and highlight its ability to provide strangeness about physical reality, providing insight through fictional contrast. We encouraged student to contemplate the physical reality particular to their fictional worlds and the kinds of fictional worlds their agents might create to make sense of their situated blindspots.

Relatedly, more often in Mathematics or Sciences week, we would share physicist Frank Wilczek's Fish Newton example (Wilczek, 2013): this fish physicist, situated in their aqueous environment has difficulty deriving Newtonian physics from the obscuring fluid mechanics, through which they must make observations and measurements. He compares Fish Newton's plight with our own in understanding the Higgs mechanism. Through this strangely situated example, we come to

recognize our own scientific shortcomings and can ponder other greater universals that may be obscured from our physical situatedness.

Fictional worldmaking in Blender can help them explore these ideas in various ways.

Sciences + Humanities (+Technologies)

In Sciences Week theory, we shared considerations for ways that situatedness impacts the practice of science and its serious ramifications for society. We addressed pitfalls in experimental design concerning how test subjects are sampled from the population and which testing parameters are considered. We highlighted problems in not using “what if” questioning to consider diverse demographics. This can especially be a problem in developing technologies (e.g. if a tool might be more hazardous for a left-handed user, if an automatic car doesn’t stop for pedestrians with darker skin tones (Childs, 2019)). We also discussed how implicit (i.e. situated) bias can lead to conflating correlation with causation, reinforcing harmful narratives. Asking strange “what if” questions about the premises of our hypotheses and isolating for a variety of variables can help avoid such mistakes.

As a part of this, we discussed Kuhn’s philosophy of science work on paradigm shifts (Kuhn, 1962), and the importance of questioning premises to break us out of old conceptual structures and gain new compressive scientific insight.

With respect to practice, we encouraged students to consider how the agents of their worlds might contend with these ideas.

Overview

To illustrate how all these ideas come together into a final project, below is an example of questions we have sent out to students in developing their projects and related documentation:

> ***What If/Premise:***
> *What's the premise behind your world? In honing your what if, think about your* ***question****. How might this "what if" help you make a world that's a tool for answering your question? For example, you might think about what the premise behind a movie like the Matrix is and how that choice helps explore certain greater questions. How can a fictional premise help us understand this world better?*
>
> ***Generative Principles:***
> *What's your set of formal ideas and rules?*
>
> ***THEMAS Ideas of World:***
> *What are the T+H+E+M+A+S in your world?*
> *If you feel stuck, these questions might help:*
> *T: What resources are available? What problems does it have? What tools have been made to address them? What affordances do they have? Have these had unanticipated consequences? How are these dealt with?*
> *H: Who are the agents or inhabitants of your world? What kind of society do they have? What are their values? How do they derive meaning? What kinds of myths and other narratives have they made? Who are their heroes? What are their customs and rituals? What can be said of their ethics, economy, and politics?*
> *E: What kind of causal chains are there? What are their machines like? What kind of engines do they have? How do they select from the unique to get the rare?*
> *M: What symmetries do they make? For example, maybe a starfish world likes pentagonal radial symmetry. What kinds of patterns and motifs do they create? (Think about how patterns can let you know whether you are sitting in a gothic cathedral or in a mosque.)*
> *A: What qualities do they make? What are their preferences and sensibilities? What are their exemplars? What are their greatest cultural achievements? What is their equivalent of Beethoven's 9th Symphony?*
> *S: What kinds of questions do they have about their world? How do their preconceptions constrain the kinds of questions they ask? What kinds of hypotheses do they make? What kinds of experiments do they conduct? How do they make new knowledge?*
>
> ***Qualities/Moodboard:***
> *What qualities does your world have? What does it feel like to be there? Think through all the sensory channels. What is the ambiance like? Create a moodboard out of found or made images/sounds/etc.*
>
> ***Diagram/Schematics:***
> *Include diagrams or schematics of your world design.*
>
> *…*
>
> ***Making in THEMAS:***
> *What technology, humanities, engineering, mathematics, art, and science are you making in this world for your project? How are these parts either embodied in the product of your project itself or made along the way to serve the process of its creation?*

With their worlds, they then create a narrative trailer or short film to showcase their work. This allows students to think about their worlds as phase spaces for many potential stories. It's a distinction that author Philip Pullman makes about storytelling (Pullman, 2018), where the world is a forest and a story is a path, except here, with computation, we can mediate and dynamically tinker with these worlds in rich ways that would be difficult to do in writing alone.

4.2.5 REFLECTIONS

In these ways, the theories and exercises that we have detailed have helped implement situatedness and our other themes-in-progress into the framework of THEMAS and have promoted causal, creative thinking across these areas. Over time, the class has gravitated toward a speculative design and design fiction curriculum, and our contributions have attempted to operationalize a more holistic viewpoint to this end.

The computational platform has aided our aims to infuse our themes-in-progress into THEMAS, supporting rapid prototyping and serving as a networked repository for assets and relationships embodying all these ideas. We have supported explorations of situatedness, values, and meaning by showing students how to formalize complex relationships among collections of assets through generative procedures and causal scripts (if-then relationships, e.g. through parenting hierarchies and real-time NodeOSC control).

Through theory, we have contrasted different organizational concepts for disciplines to encourage a composite paradigmatic view, reinforcing the idea that

new conceptual models can yet be theorized to provide new disciplinary and cross-disciplinary insights. In this way, we hope to have encouraged critical theorizing and philosophical engagement by the students. Also regarding theory, our emphasis on parametric analysis has attempted to support design through the translation of observations in the real world into computationally definable relationships. This emphasis can also support different translations across sets of data, e.g. across sensory modalities.

Additionally, with respect to practice, cognitive offloading through virtual mediation permits new perspectives, providing cognitive affordances for asking new "what if" questions. Moreover, our encouragement of students to make an example both in the fictional world and in the real world has the potential to bring insight through strangeness and spark creative problem solving out in our world.

Our contributions to the model and course are not perfect. Many of our contributions could benefit from streamlining: clearer theory, more succinct communication, and better practical examples. Students still didn't tend to engage with all the challenges despite our examples and exercises, and not all students thrived in the class (perhaps also due to factors beyond our control, such as the pandemic). However, over the quarters, through the teaching team's and our adjustments, we have seen increasing proportions of successful student projects, rich with mediated cultural philosophical ideation. Performance and personal investment improved among the students who remained in the classes. The course also appears to have been impactful to several students: the teaching team has heard back from past students now creating successful start-ups, entering graduate

school, or pursuing other fulfilling interests who cite the course as part of their successes.

4.2.6 NEXT STEPS

Given these pedagogical prototypes and insights gained from our artistic ones, we have identified some theoretical areas where we see the potential for formalization and further exploration.

These areas include:

- computational approaches to intertextuality for promoting meaning,
- a more situated approach to parametric information aesthetics and related design, and
- explorations on measuring strangeness with respect to probability and causal scope.

We will address these topics and some practical applications in the next chapter.

5. THEORY AND APPLICATION

Following the insights of artistic and pedagogical prototypes, we have formalized several design theories. For the most part, these theories address considerations for combining our themes together in the context of making, particularly computational making. We propose these theories to better operationalize paideia in practice. Specifically, these theories help support meaning-making and holistic thought in artistic practice and in our pedagogy, with strategies to optimize the balance of the familiar and unfamiliar.

In the second part of this chapter, we briefly discuss some ways we have already applied these theories within an original Mediated Worlds THEMAS course entitled (E)Utopian Design Tools.

5.1 THEORY

This section is divided into three parts: *Meaning via Intertextual Computational Interventions*, *Situated Parametric Design*, and *Measures of Strangeness*. The first part chiefly addresses meaning, exploring uses of computation to enrich intertextual meaning-making. This process of computational intertextuality serves to make familiar, culturally-established artistic works strange within new conceptual structures and contexts. The second and third parts principally address holistic thought. Situated Parametric Design uses parametric analysis to tie together situatedness and the balance of the familiar and unfamiliar. Parametric analysis also facilitates computational implementation of real-world observations and facilitates translations of data between domains—all with a

situated consideration for familiar/unfamiliar balance. Lastly, our theories for measuring strangeness help us to optimize the balance of the familiar and unfamiliar and assess potential situated impact of the unfamiliar. This serves in creating significant strangeness for compression. Related considerations of causal scope also aid the process of cultural ideation and making.

5.1.1 MEANING VIA INTERTEXTUAL COMPUTATIONAL INTERVENTIONS

Intertextuality can be a vehicle towards creating meaning in introducing new situated relationships to familiar, pre-existing cultural works.

To recall from Chapter 2 in Section 2.2.3, an intertextual reference can sample from a specific source (e.g. a specific work) or a class of sources (e.g. a genre), the sample itself can comprise the source in part or in whole, and the sample can map onto to the target work in part or in whole. We call a source work (or group of works) a hypotext and a target work a hypertext.

In exploring the work and research of others and from the insights from our own original practice, we have come to recognize three intervention approaches by which the computational platform can leverage intertextuality. In 2018, we presented a paper on this theory for the Distributed Authorship Conference at UCLA in collaboration with Marcos Novak (Crawshaw & Novak, 2018). In adjusting some of the original vocabulary, we term these three approaches here *mapping*, *abstraction*, and *execution*. The differences between these approaches concern

where in the creative process computation intervenes. These approaches can also be used in combination in certain cases.

Mapping

The first of these approaches, *mapping*, concerns a one-to-one mapping where some selected set of source elements directly map to some selected set of target elements. Computation encodes these mappings, creating a digital shortcut and conversion, and in some cases, it may constitute an "algorithmic synaesthesia" (Sagiv et al., 2009). This mapping can include some scaling or other mathematical tailoring. Within this process, several variables rest at the creative discretion of the artist:

- the source medium and unit (e.g. letter, color, frequency, structural section),
- the target medium and unit (e.g. letter, color, frequency, structural section), and
- the specific mappings (e.g. the number 5 to the color red, a reference to a certain character to a musical phrase).

Depending on the aims of the artist, we can use our themes, and in particular cultural situatedness and conceptual structure, to assess the readability and efficacy of these particular choices.

To illustrate the general concept, a more straightforward example of this approach is an original proof-of-concept visual piece derived from an English translation of Plato's "Myth of Er" (in the last book of *The Republic*) (Plato, ed. 2012c, Book X). We created this work with a grapheme synaesthesia visualizer developed in Mathematica in collaboration with Marcos Novak. The program allows the user to select colors to correspond to graphemes including the English alphabet,

numbers, and punctuation. The user can then upload a given text, and the program will convert the text into a grid of colored squares. In this piece, we visualized the whole text of the myth according to our (the author's) particular grapheme synaesthesia (with some slight color tuning for a more appealing overall harmony). Figure 5.1 shows a small excerpt of this piece next to a miniaturized version of the full piece.

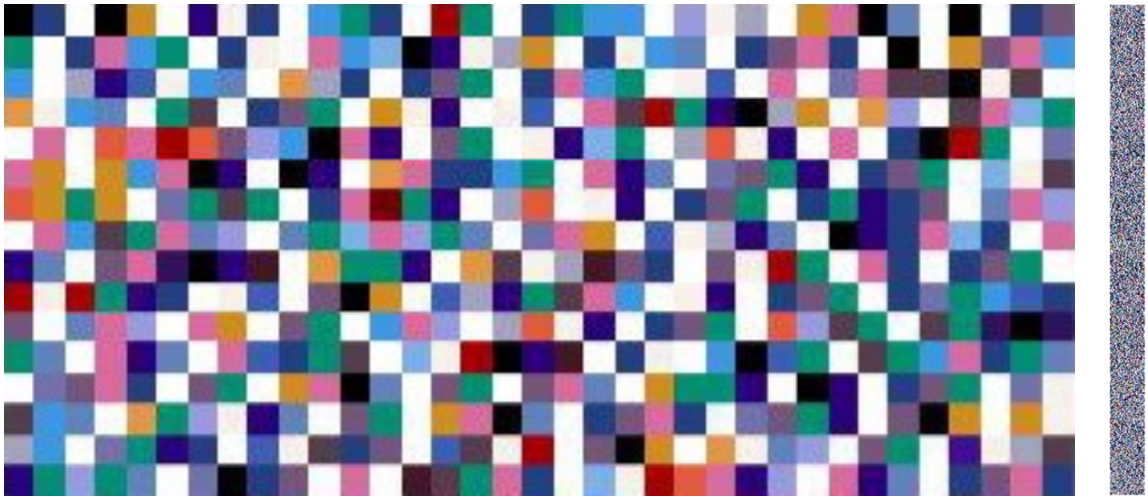

Figure 5.1: An excerpt from a grapheme synaesthesia translation of Plato's "Myth of Er" (left) and a miniaturized version of the full work (right).

Computation is a valuable tool in creating such a work. Given the extensive length of the text, this process would be highly time-consuming to execute by hand. The instantaneous generation of the conversion allows for many iterative adjustments to parameters to optimize the full visual effect and balance of the colors. This iterative capacity was integral to us in developing the piece.

In terms of the intertextual meaningfulness of the work, there is a lot left to be desired: it's rather an insightful cautionary tale for our meaning-making aims. There is not much about the realization about this work that is particular to the hypotextual

source except the particular ordering of the colors, and after a certain length of text, switching out the source text for another source text of similar length isn't going to make a profound difference in terms of its visual impact. Nothing key to what makes the "Myth of Er" *the* "Myth of Er" (versus another text) substantially carries over into the abstract visual medium given this mapping. Only the artist and perhaps some skilled cryptographic enthusiasts can read the colors back to text in real time to access any specific information about the hypotext. This ability is due to our own situated familiarity with our grapheme synaesthesia and for a cryptographer, their situated familiarity with letter frequency patterns and combinations in language. The particular grapheme-color mappings are not anchored to properties outside the situatedness of the author: they are idiosyncratic to the author alone (although it is our suspicion that our synaesthetic mappings are not fully arbitrary: that we developed our color alphabet with certain affordances optimize relief between common letter patterns in the English language). In the end, this piece tells us more about synaesthesia than the intended hypotext, which is interesting in its own right, but ineffective if we want to anchor to specificities in the hypotext that can lead to meaning. The grapheme as a unit (especially in a translated text) makes for a poor dimension for extraction here in making a meaningful conceptual mapping. To compound this, here, grapheme to color mappings don't possess situated associations or conceptual mappings to semantic information in the text.

Other examples of this mapping approach can also include certain music visualizations, including our own *Caduceus* (2015) sculptures and the structures in *OrchScape* (2019). In these works, amplitude changes over time in a hypotextual

musical work map to transform the geometry of another shape over its spatial length. In *Caduceus*, we sampled a musical motif from a larger work for our contour, with complementary voices shaping each respective staff. In *OrchScape*, we chose the amplitude contour of an entire song. For both these works, the ability for a viewer to recognize the specific hypotext from viewing the hypertextual object wasn't important to us. For both works, it was desirable to convey some qualities of the broader hypotextual medium—music, and perhaps this could have been more successful in its realization. For *Caduceus*, we were hoping to convey the complementary exchange of material in the two voices. The amplitude curves of the two sound files formally conveyed aspects of complementarity and symmetry, and were thus an appropriate conceptual extraction parameter. These traits held true when converted into 3D geometries, but were somewhat diluted and less effective in the transformation with a secondary geometry. In *OrchScape*, we wanted to convey the macrostructure of the chosen song, but the amplitude changes only corresponded somewhat to these structural divisions. As such, amplitude as a parameter was not the most effective choice for our conceptual mapping for musical structure, and this in turn does not translate well to a 3D geometry.

Some of our scaffolded drawings are an example of this mapping approach, especially the Sonnet 29 one, where we can map macrostructural ratios in the text to ratios of visual parameters. The volta, or turn in tone, occurs at the third stanza at 4/7ths through the poem, and this impacts the visual geometrical divisions and how we partition the drawn content to convey this tonal distribution.

The mapping approach is also at work in our vibrotactile music sculpture installation. It maps column proportions, specifically Vignola's rule for the Corinthian order (Architectural Orders, 2014), to frequency changes along its radius. This mapping intends to yoke our structure of felt signals to the history of architecture. While the felt transitions may feel structured to a visitor, the specific connection to a column is not otherwise recognizable. This connection would have to be better established and cultural situated through other parameters for redundancy.

Abstraction

The approach of *abstraction* entails some computer-led analysis (i.e. feature extraction) of the hypotext, producing some algorithm to generate or otherwise structure a hypertext. Here, variables at the artist's discretion include:

- features for extraction or evaluation for analysis, and
- how the algorithm is applied to a target medium.

In addition to mapping, we also used abstraction in the creation of our *OrchScape* structures: we used an edge detection filter in Mathematica to extract the amplitude contour from a soundwave visualization of the song. (This operation was integrated with the mapping approach when this curve was later sampled and mapped to vertices.)

Machine learning can be leveraged for the task of abstraction in powerful ways. Take for instance a project by DADABOTS using the JukeBox neural net from OpenAI (Robitzski, 2020). They used a neural synthesis approach trained on Frank Sinatra's work to create a new song in the style of Frank Sinatra (and

ventriloquizing his vocal timbre), also shaped by the lyrics of the more recent popular song “Toxic” by Britney Spears, making for two hypotexts. The final outcome, although serving more as a fun proof-of-concept for a technical process than as a proposed work of art, does put the hypotexts into dialogue in an interesting and meaningful way: given this strange pairing, with their formal qualities blended, we see the space of their similarity, offering an interpretation back onto its hypotexts. In this way, “Toxic” is advanced as a modern “I’ve Got You Under My Skin,” part of the same continuity of popular song. This insight is compression through strangeness.

Machine learning, with its ability to find parametric overlap, could be leveraged in more profound ways for such blends (e.g. beyond the simple addition of lyrics from a second source). As such, it can be an intriguing tool for hypotextual blending and meaning-making.

Although our focus in this dissertation is more on non-verbal expression, predictive keyboards are another useful illustrative example of abstraction. They analyze the frequency traits of some textual input, and, using stochastic processes, make probable suggestions for the words to follow based on the text in progress. In this way, the probabilities of a given text input can help shape a new text. Using the online platform Botnik,[29] one can upload a .txt file to generate a predictive keyboard derived from its contents and the probabilistic weightings among them. For the 2019 UCSB MAT EOYS, we created some comical imaginary future EOYS event titles using this feature. Our hypotext here was *The New Media Reader* (Wardrip-Fruin &

[29] Accessed 03/18/2022: https://botnik.org/

Montfort, 2003)—a collection of key texts for the media arts—to ground the titles in field-situated “art speak.” For some invention and unfamiliarity, we added mathematic, weather, aerospace, and animal terms. As the Botnik interface offers multiple word prompts for each new word, there is a degree of selection and thus human co-creation in the process. Our results included phrases like “viscerally cyborg,” “an even more profound labyrinth of deconstructed ideologies,” “a period of abnormally warm media,” “and the principles of algebra moved infected neurons from the gutenberg associative to the redemptive hand of the new divine knife,” and “back beyond our humanity to the bottom of all clawed promises.” Figure 5.2 shows how these titles were exhibited in the CNSI Hallway.

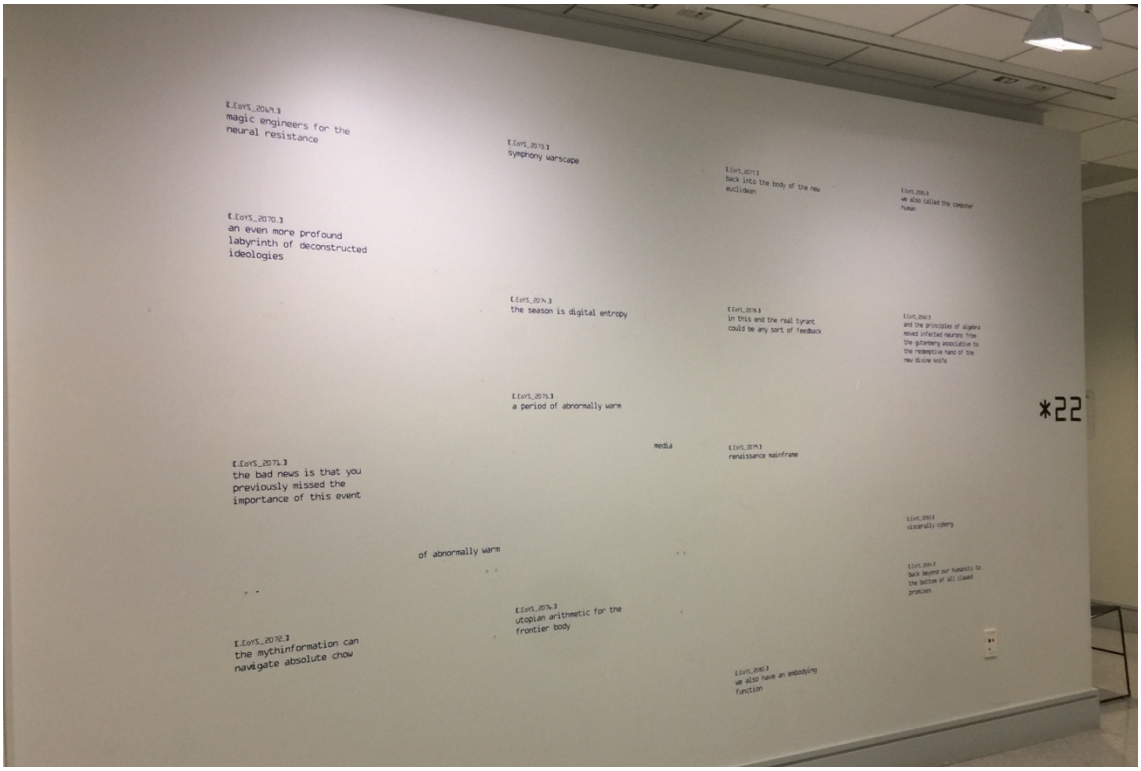

Figure 5.2: Exhibit of “the bad news is that you previously missed the importance of this event” (2019) in the UCSB CNSI second-floor hallway.

For our paper on the subject of intertextual approaches, we had also realized a set of text-based studies using the “Myth of Er” text, generating different texts with different levels of creative freedom: when only choosing the first suggestion, and then among the top three, six, and eighteen. From this process, we found that the “Botnik examples ventriloquize Plato’s voice, but without much to say unless the hypertextual author has more choices and something to say” (Crawshaw & Novak, 2018).

Execution

The third approach of *execution* entails some computer-led synthesis, where the hypertext artist, having analyzed the hypotext, has conceived of some algorithmic metaphor (i.e. conceptual structure) that can be programmed and executed by a computational platform, leveraging computational advantage.

Iannis Xenakis’s “La Legende d’Eer” (1978) is a strong example of an algorithmic conceptual structure. As explained in Section 2.3.2, Novak observes that Xenakis uses stochastic laws and a Lorenz attractor as an apparent metaphor for the shape of transmigration cycles before philosophical learning in Plato’s “Myth of Er” (Novak, 2014). In this way, his mathematical idea provides profound commentary on the hypotext, reinforcing a notion of random futility in hoping individuals will act justly without philosophical instruction. To realize such a complex mathematical idea, computation can provide valuable precision and calculating muscle: efficiently running many iterative cycles according to specific rules beyond our innate mechanical capabilities.

Another example is our *Dance of the Fulcrum*, which uses this approach with respect to Aristotle's book on friendship in the *Nicomachean Ethics* (Aristotle, trans. 1926, Book VIII). Aristotle effectively presents a view of ideal friendship where individuals of good character encourage one another to grow into better versions of themselves. As discussed in Section 4.1.2, we designed algorithmic metaphors to represent this idea, but also with the intent to aid in and embody this process in a real way. We measured for three parameters:

- the distance between two users: proximity as a measure of the potential for social engagement;
- the same velocity of yaw rotation: mimesis through parallel movements as a measure of social attention/gaze; and
- changes in acceleration: movement rate changes (against sounds/music) as a measure of risk taking and collective growth.

Aside from the written description of the work, we did not provide other references to the *Ethics* in the production to make this derivation source more explicit. Also, the work is not well known. This makes some layers of meaning inaccessible to a larger audience. However, the work intends to operationalize its message, and so the source speaks non-verbally through the artwork nevertheless.

Remarks

Given what we've learned through these different approaches, we present several questions for consideration in optimizing meaning-making:

- Who is likely to be familiar with the source material? (I.e. what is the cultural situatedness of the audience?)
- Are the selected source dimensions characteristic of the source material?
- Are the patterns in the source dimensions distinctive to the work or source genre (in contrast to others: e.g. other genres, authors, same subject matter, same form)? Are these differences amplified/readable in the target mediation?

- Is the hypotext itself distinctive from comparative works? (I.e. is there sufficient originality in the work to be identifiable in mediated translation?)
- Does the target medium/parameter suit the patterns of the material?

Regarding this last point, Kuchera-Morin makes the point that the choice of medium must connect to the affordances of the medium and what that brings to the fore: e.g. sound will accentuate the temporal, visual will accentuate the spatial.[30]

In general, Fauconnier and Turner's suggestions for creating blends apply here too (e.g. compressions at the human scale, going from the many to one) (Fauconnier & Turner, 2002).

We can also consider transposing ideas to multiple parameters for interpretative redundancies, which can also help to collapse unwanted ambiguities. On the other hand, we can add different possible redundancies to strengthen multiple readings/interpretations.

With these ideas in mind, we believe computational intertextuality may reach new heights of exploration.

5.1.2 SITUATED PARAMETRIC DESIGN

As we have seen in our survey of the literature, balance of the familiar and unfamiliar is key to building learning and meaning. Information aesthetics reveals that anything too familiar won't register as information, and yet we need to anchor to what we already know in order for anything novel to be adequately comprehensible, or at least to provide space for productive contemplation (on the more extreme side

[30] (J. Kuchera-Morin, personal communications, August, 2021)

of originality). Information aesthetics also offers promise for exploring and applying these ideas in design. Of particular utility, Abraham Moles (Moles, 1966) advances a parametric approach to the analysis of different media which can facilitate translation into code, and thus the implementation of such idea in the digital arts. However, such theories could take better account of context or situatedness—particularly with respect to given cultures—which we have seen is critical to determining what is “familiar.” While information aesthetics authors like Moles acknowledge the role of cultural education as informing what constitutes as familiar and frames his “esthetic” bits in terms of the limitations of our sensory faculties, he does so in the context of Western art, and not with a view to more universal mechanisms. As such, this theory could be better grounded in a situated framework.

Parameter Spaces

Repertoires, as we discussed back in Section 2.2.3, are a tool advanced by information aesthetician Abraham Moles. They effectively serve as N-dimensional sensory parameter spaces.

As a reminder, repertoires consist of the degrees of freedom of a given medium or collection of media, including dimensions such as pitch, amplitude, color, spatial position, etc. Defined in sensory terms, these dimensions are bounded on either end by thresholds of detection and saturation, and divided up between these bounds by just-noticeable-difference thresholds.

We can take Moles’ repertoire approach to isolate and combine different expressive parameters. In doing so, we may make some additional distinctions

about the construction and categorization regarding repertoires, distinctions which we term *components*, *kinds*, *elements*, *element selection*, and *conventions*.

What we term a repertoire *component* concerns the parameter type. A parameter might be a set of continuous or discrete values along a given degree of freedom. For example, hues along the visible color spectrum, or spatial positions along a single Euclidean axis. Another component might be a binary state. An example of such a binary state would be designations of static or dynamic to describe the absence or presence of spatial movement.

Representations of repertoire parameters and spaces can be executed on a computer, for example, by calling visual color data parameters such as RGB values. The maximum resolution across a given parameter will be contingent upon the hardware and software employed, and unit differences across a given pre-programmed parameter will not necessarily reflect just-noticeable-difference perceptual weightings unless they are so accordingly programmed. However, a finer grain resolution based on more physically objective measurements does benefit mathematical precision in rule-based operations. This point leads us to our next distinction of repertoire *kind*.

In considering such parameter types, we can also recognize different *kinds* of repertoires that influence one another. While Moles speaks of repertoires with respect to the senses, this idea can be more generalized. We can frame the interacting cybernetic or experiential/situated levels at which a given parameter operates. For example, such levels could include material, perceptual, or cognitive designations. To illustrate, we can compare general frequency with the frequency of

an acoustic wave, a pitch, and a note. The first is an abstract notion of rate of oscillation as a function of time (informed from observations and study of the natural world); the second is a physical, material phenomenon contingent on the composition of the physical environment (e.g. gas-filled atmosphere to enable acoustic wave propagation) and certain physical circumstances (e.g. measured differently given relative speeds of the measurement position with respect to the source position); the third is a construct of our embodied human perception (this would be Moles' original repertoires); and the last is a culturally codified and cognized convention.

Again, Moles' repertoires typically operate at the level of perception, but we can consider the tolerances of the other levels.

From here, we can consider given elements (collections of bits). In terms of the amount of parametric repertoire space that an element could be said to occupy, we can borrow some concepts from geometric and spatial studies. An element could be tightly defined or open-ended, described in 1–N parameters. Across 1–ND, it could occupy a single coordinate (a point), a range/length of values (a line), a region (e.g. from a 2D plane to greater ND volumetric spaces).

Relatedly, the boundaries and edges of the defined space for an element may be soft or hard: they may have unequal distributions over their range and taper off gradually or have a more abrupt end. For example, we may consider the RGB value [0 0 255] to be blue proper, but there is a greater range of values we consider to be shades of blue, others that are ambiguously bluish, and others still that would not be considered blue in isolation but appear blue in certain circumstances of

contrast (e.g. a bluer shade of red). The engineering notion of tolerance is relevant here.

As a next step, we can create groupings or *selections* of these elements. There are a few aspects to consider when constructing such selections. We can consider if the set members are comprised more of discrete nodes or if they blend together in more continuous ways. (This ideas anchors to points Curtis Roads makes about intervals versus morphologies in sonic aesthetics (Roads, 2015).) Furthermore, we can create selections based on rules, creating formal relationships among set members. We can use scaffolds too to guide such internal coherence. To optimize the balance of familiar and unfamiliar, scaffolds and rules should be somewhat selective: if they are too subdivided and complex, the elements may lose perceivable connection to one another.

Conventions

Next, through the selection of elements, we can begin to contemplate what we term as *conventions*, situated associations, within repertoires. Conventions may be described in terms of what element sets or patterns are probabilistically available and abundant. We have associations (acquired as schema/internal models) that are observed in physical nature or in memes transmitted via artifacts across shared social groups with various scopes: for example, universal-local-familial-individual-intraindividual (œuvre-work)-etc.

When applying the notion of conventions to our previous concept of elements, we might consider *conventional nodes*, *node sets*, *weights*, and

relations/rules. We'll provide examples of conventions from Western musical practice as applied to frequency. A given *conventional node* could be A as 440 Hz, which is one common standard for tuning. A *conventional node set* could be equal tempered tuning, which selects for discrete "notes" within a certain tuning tolerance over the range of all potential frequencies. This node set from a physical or abstract repertoire now could said to become its own cognitive repertoire, as per our earlier distinction of kinds of repertoires. Given such a node set, there may also be *conventional weights*. One such example is a major mode, which not only isolates a set of notes within equal tempered tuning (or a similar tuning convention), but emphasizes certain notes within the selection (at times guided by close mathematical harmonic relationships). For another illustration, two musical modes (e.g. dorian and locrian) may share the same set or palette of notes, but the notes will have different probabilistic weightings between the two sets. As a next step, we can consider *conventional rules* or relationships over a certain range or selection of elements. For example, the rules of 18th century counterpoint govern relationships of notes over time.

Such a situated consideration of conventions in these parametric terms helps provide a basis for introducing unfamiliarity in a systematic way, especially via computation. By using mathematics and signal coding platforms like Max MSP, it's possible to create original sets using an original set of rules and to apply these ideas to any degree of freedom in any medium. This impulse echoes the points made by composer Iannis Xenakis in his book *Formalized Music* (Xenakis, 1992). We can choose to retain certain conventions and use "what if" questioning to play

with others (e.g. creating an 18th century contrapuntal approach to a ten-note microtonal scale, or crossmodally, to an arrangement of color hues over time). In this way, we can more strategically balance the familiar and unfamiliar.

5.1.3 MEASURES OF STRANGENESS

We propose here various factors for assessing the extent of strangeness, looking at probability and scope.

Probabilities

Information increases with the number of choices (from parameter resolution and/or parameter quantity), and the distribution of randomness among them.

As we saw with Shannon, information is a measure of uncertainty which can increase with both the number of possible choices and when there's more equally distributed randomness/probability among those choices. Given the balance between certainty and uncertainty that we need to strike for learning or meaning, to bring in some degree of certainty, we would want to introduce some constraints upon the number of possible choices and/or some probabilistic weighting among our choices. Such weighting could be due to situated conventions, as we have described, which steer expectations. From such a probabilistic distribution across possible choices, we could aim for more or less improbable selections.

We can consider the construct of certainty and uncertainty (from more or less probable selections, respectively) within a parameter or across a collection of them (within one medium or across different media).

Relatedly, in his teachings of design information aesthetics, Marcos Novak has introduced the terminology of the *unique* and the *rare* with respect to microstates, particular configurations of selections. Any given microstate configuration is unique, but only the improbable configurations are rare. To illustrate, we can consider the frequency of possible sums from possible throws of two die. Each kind of die throw will be unique (e.g. 5+6=11, 3+4=7, 2+5=7, 1+6=7), but only certain sums will be rare (e.g. only throws of 1+1=2 and 6+6=12 yield their respective rare sums whereas many combinations of throws can produce the common sum of 7). It should be noted that adding parameters can increase rarity by adding more choices and potential configurations. We can extend these concepts to our design ideas.

The color hue palette used by Google with vibrant red, blue, yellow, and green is unique, but it is culturally ubiquitous and close variations of it are in common use. Color palettes with groupings of red-violet, turquoise, coral, and chartreuse may be more culturally infrequent and thus rare. Very close colors without much contrast may be rarer still but perhaps less interesting as they don't have enough perceptual relief between them given our embodiment.

Given our understandings from Section 2.2.3, too much of the rare would prove chaotic, so some tempering of this concept is needed in theory. And yet, insofar as pedagogical application goes, in our personal experience with undergraduate students, they regularly gravitate toward conventional choices (some more so than others) and so we have not yet needed to temper the encouragement of the rare in such teaching contexts.

These principles apply to larger ideas like our paideia practices. From our artistic practice we have come to recognize that some design and art should sit at different points on the certainty spectrum: functional design needs to be intuitive (relying more on situated conventions), and art needs strategic uncertainty (subverting conventions).

Scope and Culture

Here, we propose some assorted thoughts on situated probabilities and how considerations of their causal scope can be useful for cultural ideation and making.

Within worldmaking, we can increase strangeness with causal depth, changing initial seeding conditions and making decisions following the morphologies of their phase space over time. For example, given a particular environment and terrain, we can ideate the biological evolution of potential living agents and their embodiments. For example, we can imagine what kind of limb morphologies will more facilely locomote over a given terrain. These limb choices might pose other obstacles in their lives, and perhaps they need to develop unusual tools to overcome these problems. If we alter more fundamental premises and seeding conditions about their reality (e.g. mathematical laws, physical laws), we can amplify the strangeness of the emergent consequences.

We can evaluate causal breadth in terms of the scope of shared associations and consequences. For example, waking up as Edward Scissorhands would affect all kinds of relationships to artifacts, environment, and social others.

We can assess the scope of associations and shared knowledge through the scope of shared situated probabilities. For example, the intensity envelope of a gust of wind might be more universal than cultural conventions such as using a green light to signal “go” for traffic and red for “stop.” Intersectional and parametric thinking can be useful to identify neglected groups. For example, young children may be less attuned to certain situated understandings adults may take for granted (e.g. they may lack certain subtle proprioceptive understandings of force, they may be illiterate).

We can parse power, influence, and impact through probability and affordance, given the downstream depth and breadth scope of changes to other agents and networks of artifacts.

Relatedly, in assessing stakes and risks, we can consider how a decision or information threatens the relationships of probabilities upon which other mediated artifacts and networks of such artifacts have been designed and tailored. Certain changes in probability distributions will have greater downstream disruptions to mediated networks of artifacts. Changing a law, cutting off a limb, or increasing the global temperature are all going to change other networks of affordances downstream, over time in different ways.

This notion impacts meaning too. Consider a photograph of a desolate landscape. This image can generate different meanings to an observer given whether we explain to them that this is part of a natural landscape, perhaps a desert, or if we explain that this is a photograph taken minutes ago of where their current home and surrounding vegetation once stood. The first explanation

connects to an abstract space without situated affordances to the viewer. The second explanation creates a causal relationship that is significant to the viewer and can be emotionally charged for them. This connection to the familiar (now unfamiliar) brings information that impacts future probability spaces and future relationships to their environment and to others.

5.2 APPLICATION: (E)UTOPIAN DESIGN TOOLS

We have applied some of these theories to an original THEMAS class based on operationalizing worldmaking in action. These theories support the design foundations of the class, helping students see how digital tools like Mathematica can aid in the feature extraction of parameters, and how they can describe rules computationally to create different element selections. Connecting to our work on the measure of strangeness, we use visual aids to show how they can connect information theory and probability to their cosmogenesis terrain and agent activity.

In Summer 2021, the UCSB Summer Sessions Creative Computing Initiative accepted our proposal for a THEMAS Mediated Worlds Special Topics course. This condensed six-week course allowed us to integrate some of the above theory into the class.

The class was entitled (E)Utopian Design Tools. As a critical design and future-making class, we proposed ideation and making toward eutopias (good, possible places), which could be operationalized, as opposed to utopias (inherently impossible places, etymologically speaking). A one-minute promotional video summarizing the class's ambitions can be found at this link: https://youtu.be/rasIrsOATzg. A more detailed course description is in the Appendix.

In contrast to the regular Mediated Worlds Course Series, this class gave a greater emphasis to worldmaking in action: how we affect and enact change in our world. For the final deliverable, we explicitly asked students to identify a contemporary problem and address it with some worldmaking-in-action project realized through Blender. We were quite flexible regarding potential project

approaches. Among the suggestions we gave, we proposed interactive virtual environments that incentivize for certain behaviors, speculative models for real-world fabrication, or fictional worldmaking to motivate social-technological change.

In the end, most students pursued fictional worldbuilding and storytelling. We had kept a lot of the fictional worldmaking elements of the course series to support actual world reflection through strangeness, and we believe our own emphasis was a large motivating factor in the students' decisions to pursue this approach further.

Here, we used the contrast of real-world and fictional making very intentionally and explicitly. We emphasized how fictional making aids abstraction of real-world issues, helping unfetter students from the anchoring biases of our world, to imagine new possibilities for creative real-world problem solving.

5.2.1 STRUCTURE

In terms of the overall structure, we used the first two weeks to cover fundamental concepts related to making, design, information theory, and situated affordance. The next three weeks we used to cover THEMAS in order, and the last week focused on the finalization and presentation of their projects.

Regarding changes in our approach, we made the most adjustments to the first two framing weeks. We listed explicit challenges to these weeks (although the first week's challenges are instructions we would give verbally or in class in other quarters):

WEEK 1:
Making
1. make something
2. make it better

Design
1. make modulations
2. make a rule
WEEK 2:
Information
1. make a probability
2. make a (Dawkins) meme
Context/Form
1. make (a set of) affordances
2. make a situated agent

We made sure to specify that after Week 2, for THEMAS the challenges should be applied dually: in their own making in the actual world and in the agent's making in their fictional-world-as-thinking-tool.

5.2.2 THEORETICAL IMPLEMENTATIONS

Within the design portion of the class, we tried to simultaneously provide ideas for the attunement exercises and support a parametric perspective of design, especially one that would help segue into the next unit on information. To this end, we created Figure 5.3 with some image filters in Mathematica to demonstrate parametric analysis and the capacity of computation to perform feature extraction to isolate parameters. Such operations can give them data to apply elsewhere in any way they might chose.

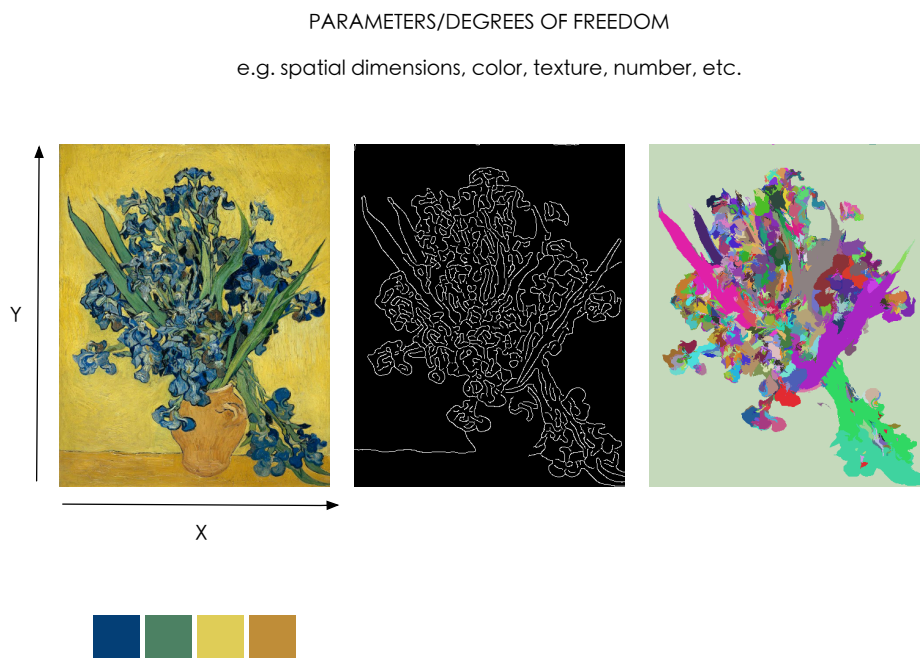

Figure 5.3: Teaching slide demonstrating parametric analysis, with help from Mathematica filters.

Figure 5.4 shows how we introduced the idea of creating a rule across a given parameter (from a more perceptual range or a range with situated constraints) to select a group of elements. This image illustrates our theory of *elements* and *element selection* from earlier and helps show them how they can define computational rules to derive them.

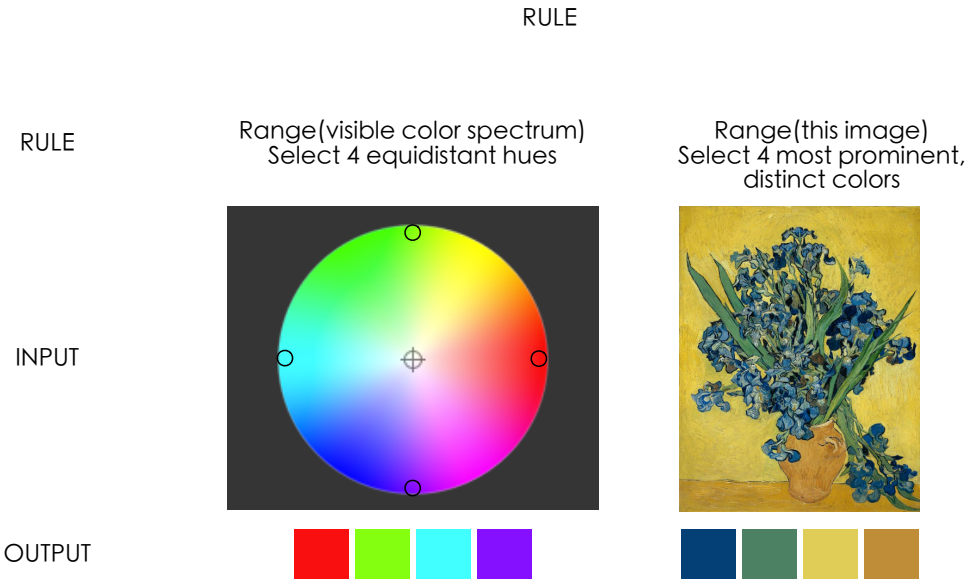

Figure 5.4: Teaching slide demonstrating rule development.

After introducing information theory to the students and discussing probability distributions, we explored the creation of terrains and situated agents from such perspectives. We can imagine terrains as weighted probability spaces given the situated factors of an agent: e.g. their embodiment and cultural scripts. A simple illustration of this notion is in Figure 5.5.

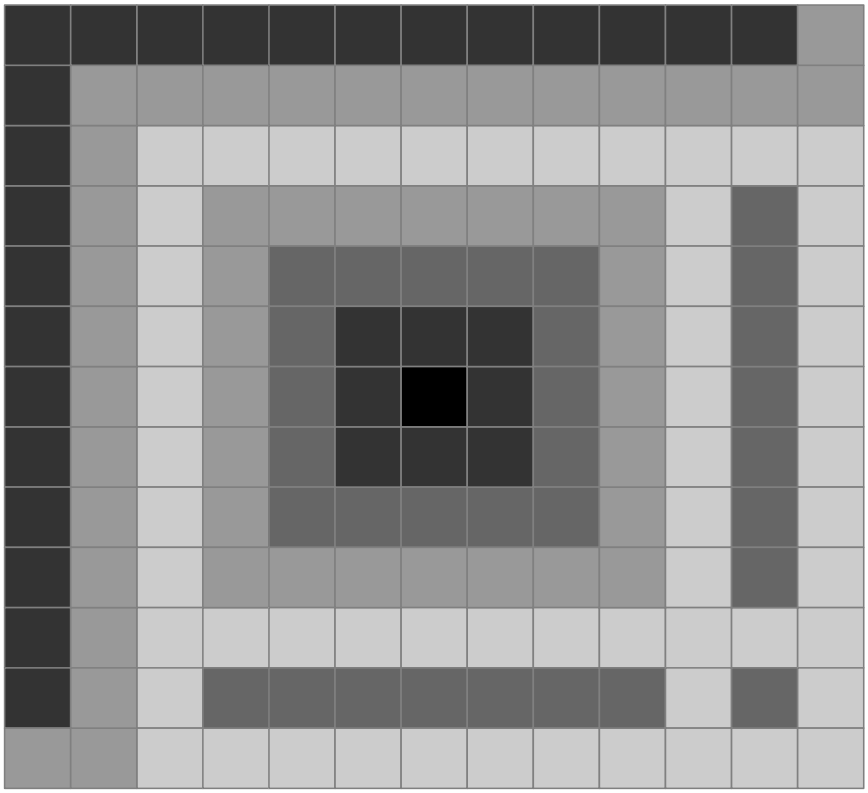

Figure 5.5: A grid representing elevation across a terrain and the probability of a spherical creature occupying a given spatial position at a given time (where brightness corresponds to elevation and improbability).

This grid represents the spatial positions of a terrain, viewed from above, and the grayscale conveys both a topology (of elevation) and a probability space for the position of a spherical creature at any given time (where brightness conveys height and unlikeliness). Given a spherical body, such an agent's position is more likely to conform to topology, most often rolling to points of low elevation. A mountain goat-like creature or a bird-like creature would likely have positional probability spaces that would deviate from such a topological map.

Given this kind of thinking we can unfold out other kinds of probabilistically situated decisions: where it builds shelters for itself, what kind of tools it might need to develop to reach prey at higher elevations, etc.

We believe these simple adjustments to our theory in teaching reinforces and clarifies our causal approach to worldmaking. From the quality of their creative exercises, a few students in the summer class seemed to grasp these ideas more readily than students in previous classes. However, their final projects were less developed and polished than in previous quarters, but we believe this had more to do with adapting the ten-week structure into a six-week format. This also meant students had less time to incubate and meditate on these rich and dense ideas. We hope to implement these ideas again in a longer ten-week structure and conduct a more formal study with questionnaires to better assess the efficacy of these refined methods.

6. CONCLUSION AND FUTURE WORK

In this final chapter, we will conclude the present work and outline our future work. In our conclusion, we will briefly recapitulate our progress and respond to our research questions. In our section on future work, we will highlight works-in-progress, future directions of inquiry, and future projects (by discipline).

6.1 CONCLUSION

6.1.1 SUMMARY

In this dissertation, we have outlined an approach for contemporary paideia through the new media arts, grounded in the fields comprising the field (art and computer science), as well as in classics, cognitive science, and education.

In the spirit of paideia—the ancient Greek approach to education— we first made the case for a similar holistic making-based approach to research and pedagogy centering on cultural learning: the ability to interpret and create culture, particularly via artifacts. We identified value, meaning, and holistic thought as three important qualities of paideia and cultural learning. We were curious about how contemporary theory (specifically regarding learning and creativity) and tools (specifically the computational platform) could support such an endeavor.

To address the question of contemporary theory, we surveyed our disciplines for common threads on learning and creativity. We found four reoccurring and interwoven ideas that tie back to culture: situated media action, conceptual structure, balance of familiarity and unfamiliarity, and compression through

strangeness. These themes, when reapplied as an analytical framework to ancient Greek cultural works, help to highlight the efficacy of these works within the aims of ancient paideia practice.

We proposed some principles for optimizing learning environments including learning via action; learning through social, whole-body interactivity through many tools; and the strange making and breaking of familiarity, mediated action, situatedness, and conceptual structure.

To explore the potential of this contemporary theory in combination with our contemporary tools of computation, we used our themes to evaluate our own computational artistic and pedagogical prototypes. Particularly, we explored ways in which computation could enhance the principles of learning and creativity toward paideia: reinforcing given values, meanings, and holistic thought. As part of this evaluation, we created working definitions of value, meaning, and holistic thought in terms of our themes.

Following the insights from this survey, we were able to formalize a few theories on ways computation could better advance paideia, particularly meaning and holistic thought (given our themes). We shared some ways we applied this theory to a new class we offered in Summer 2021.

Figure 6.1 summarizes this effort in chart form.

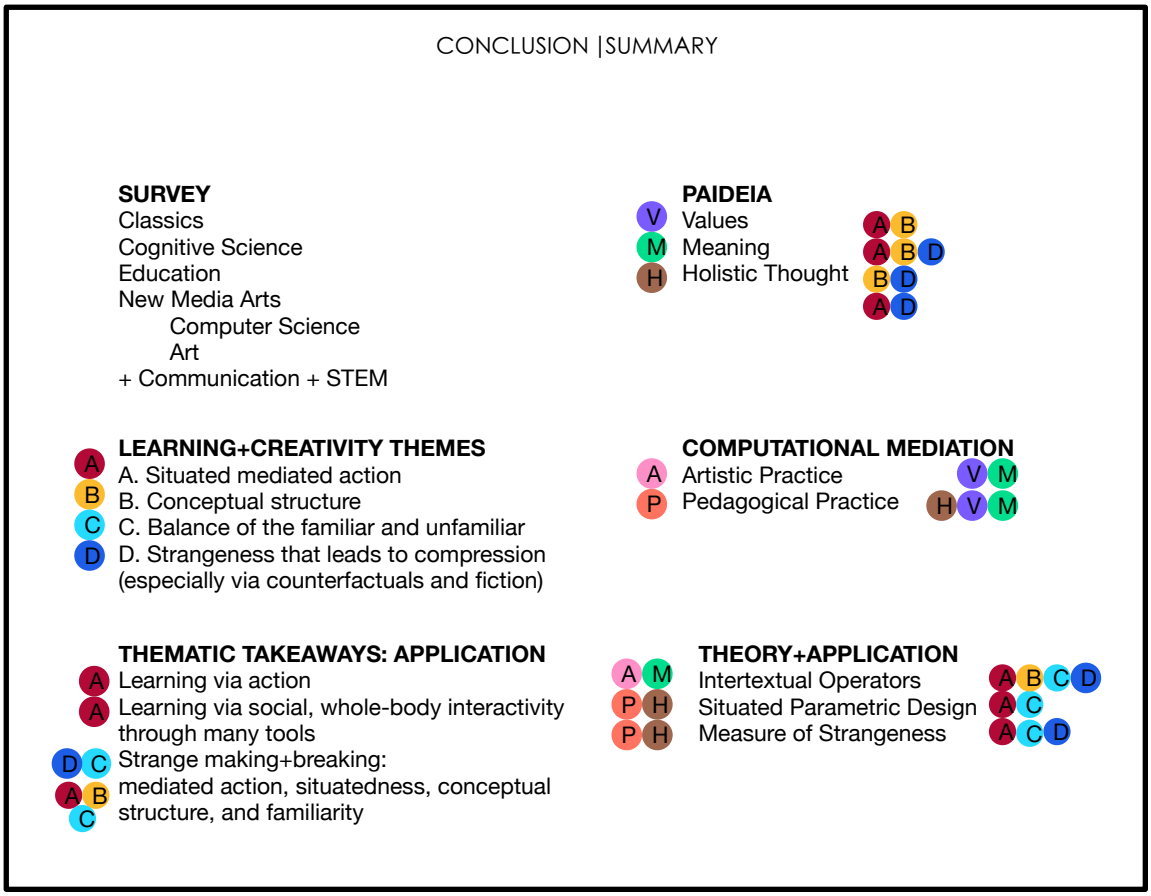

Figure 6.1: Color-coded summary of efforts.

6.1.2 RESEARCH QUESTION RESPONSES

Q: How can we fashion our artworks more deliberately as design tools to help bring about the society we desire?

To address this question, we'll first unpack its parts and premises. The framing of this question entails some change of self/society (and presupposes the ability to change), the consideration of many possible selves/societies, the selection of certain selves/societies from these options, and the development of selection

criteria for what constitutes as more “desirable.” Also, there is the question on how to mediate for this in the artwork.

Education and learning are predicated on the ability to change, and with Kimmel especially (Kimmel, 2013), we have seen that cultural learning and values can be shaped by the way the environment and society emphasize certain actions with a conceptual structure over others.

Pedagogy that supports the ideation for alternative possibilities entails creativity. In particular, counterfactual and fictional thinking help with imagining strange permutations of the familiar. Holistic thought can help consider different causal paths to be able to consider the possibility space of potential directions for growth. Speculative design and design fiction support this kind of imagination through mediated objects.

We need values and meaning to select for the directions that can be most beneficial to us.

In terms of criteria, a consideration for impact and affordance can help us decide what is most beneficial. While the purpose of this dissertation is not to prescribe an ethical model, we can state that it’s generally important to balance things ecologically, economically, and socially so that people can survive and thrive. Furthermore, the philosophical development of our ethical values can itself derive from artistic practice: creating and observing strange causalities in the making of interactive multi-user social systems and through the process of worldmaking (the ideation and making of rich causal systems).

To operationalize this, throughout Chapters 4 and 5, we have addressed numerous strategies for mediating learning, creativity, values, meanings, and holistic thought into objects.

We don't have all the answers, but we're getting there.

Q: How can both the affordances of the computational platform and contemporary understandings of learning and creativity facilitate paideia—specifically, the development of cultural values and meaning through artistic works and holistic instruction?

To this end, from our extensive survey into learning and creativity, we have isolated four key themes:

A. Situated mediated action

B. Conceptual structure

C. Balance of the familiar and unfamiliar

D. Strangeness that leads to compression (especially via counterfactuals and fiction)

We have used these themes to create working, mediated understandings of ideas central to paideia—value, meaning, and holistic thought:

Value: how media shapes and prioritizes actions according to a conceptual structure.

Meaning: how the mediation of familiar elements in strange new contexts or conceptual structures can provoke compression.

Holistic Thought: how the contrast and interlinking of different conceptual structures can provide compression; the exploration of complex situatedness through deep and broad mediated causal relationships.

Through artistic practice, we have explored some ways computation might leverage value and meaning, and through transdisciplinary pedagogical practice, we have explored some other ways computation can leverage value and meaning within a holistic instructional framework. From this practice, we have gained insight and formalized some theories about the role of computation in promoting paideia.

Value:

Computation can structure actions and attention via real-time interactive design and the precise generation of strange nuance. It can amplify real-time consequences of behaviors and actions.

Meaning:

Computational systems can play with familiar somatic conceptual structures with immersive sensory displays. They can play with familiar cultural information through mapping, abstraction, and execution operations.

Holistic Thought:

Computation facilitates the rapid prototyping of assets and the creation of complex causal systems among them. Virtual worlds can serve as repositories for such complex relationships between mediated objects (through means such as generativity and interactivity). Virtual worldmaking allows for the mediated exploration of deep, causal chains and a breadth of interrelationships. This allows for dynamic mind mapping beyond the capacity of human memory. These worlds

can serve as cultural models and model the process of reality-making from the perspective of agents. In these ways, these worlds serve as sites for the exploration of value and meaning.

Furthermore, computation supercharges the paideia approaches of ancient Greek media in several ways. In contrast to a tragic play which offers one causal chain of events that unfold in time, virtual worldmaking and storytelling presents a phase space for rapidly exploring many possible relationships. Such storytelling can entail many angles/paths through one set system of causal relationships. Virtual worlds also facilitate the editing and adjusting of these causal relationships to explore new phase spaces of expression, in the spirit of mythical rewriting. Worldmaking as a practice facilitates the rapid prototyping of new mythological systems entirely and the formalizing of conceptual relationships among assets. Ritual can be leveraged as well (at a smaller scale) with sensing devices and feedback among groups of individuals, amplifying and encouraging certain pro-social actions. Aristophanes transposed formal parameters from other works into his play *The Frogs* to create intertextual meaning (Aristophanes, ed. 2002): we've shown rich and complex ways that computation can support these kinds of intertextual transpositions and transformations. In the spirit of Plato's stichometry (Kennedy, 2010), computation can also create complex, organizing conceptual structures through algorithmic rule systems, like with our scaffolds.

Q: How might a humanistic framing of digital art practice inform educational reform efforts, particularly those seeking to bridge STEAM with the humanities?

Our themes and paideia framework have already been useful in our own learning-research. They have helped us evaluate the shortcomings in our own art and pedagogy for both teaching and promoting particular values and meanings.

In combination with STEAM-inspired pedagogy like the THEMAS model, these themes help provide glue and continuity between more codified, disciplinary parts. In particular, we can identify key conceptual structures that define disciplines and the mindsets of their practitioners. We can play with them through creative making with the powerful capabilities of the computational platform.

Q: In a holistic educational framework, all knowledge is inherently present, but not all ideas can be emphasized equally: are there certain fundamental notions and approaches that can help better organize collective knowledge and practices with cultural learning in mind?

Regarding fundamental notions, our four transdisciplinary learning and creativity themes seem to offer a promising starting point for such an endeavor. They help us in defining and promoting value and meaning. Our theory from Chapter 5 proposes ways we can integrate these ideas together, especially with computation, to advance art-making and pedagogy. Also, within our themes, Kimmel's conceptual building blocks (Kimmel, 2013) and Fauconnier and Turner's blending fundamentals (Fauconnier & Turner, 2002) offer promise for more detailed exploration and application. Given trends in our work, the concepts of parameters, causality, and probability may also hold promise as key notions.

Regarding fundamental practices, the areas of computation, learning-by-making, and art—and their combination—have proven especially useful to this end. In conjunction with aspects of our fundamental notions, such practice has already proven useful especially in the formulation of not only this dissertation on cultural learning, but also in generating a second highly transdisciplinary dissertation-in-progress (as we'll discuss below).

6.2 FUTURE WORK

6.2.1 WORK-IN-PROGRESS

Dance of the Fulcrum v.2.0

We have been working on a new iteration of our *Dance of the Fulcrum* project. We have simplified the work in several ways, eliminating elements that are less essential to the interactivity of the key algorithms, like the real-time drawing in virtual reality. The newer version uses Blender, Max, and NodeOSC. Our spatial tracking paideia algorithms impact sound in Max and visual elements in a virtual environment created in Blender. Our algorithms impact changes to the sound and visuals in more foregrounded and prominent ways than in the previous work. The modulated sound includes a recording of our vocal and piano composition. The visual environment includes generative materials created in Blender's Python and Geometry Nodes modules that reinforce ideas in the ancient Greek lyrics and the other conceptual metaphors of balance and mirroring. Importantly, this work is more of an installation environment, leaving time for pairs of participants to actively explore and test the interactive nuances of the piece.

Electro-Somaesthetic Music

Our thematic insight has helped inform another dissertation-in-progress with the Université Paris 8 in their École Doctorale Esthétique, Sciences et Technologies des Arts. This dissertation explores spatial rendering techniques and other aesthetic spatial considerations in the making of computer music that engages the somatosensory system through sound. This second dissertation has also helped

inform our present explorations here of situated embodiment and attention to nuance through subtle spatial changes. We believe this kind of artistic practice will continue to be useful in future research with our themes. We believe somatic learning can help in understanding conceptual metaphors, and spatial electro-somaesthetic music can be an important tool in encouraging somatic literacy and playing with new somatically-grounded metaphors, as we've already seen with some of our artistic prototypes like *Vibrotactile Sleeves* (2014).

6.2.2 FUTURE DIRECTIONS

In our pursuit to enrich new media arts and education, there are several other related directions we are curious to investigate.

Emotion

Accounting for emotion is important when considering meaning and impact. We would like to explore this dimension further in further theoretical development.

Empathy

In continuing this work as a means to conduct cognitive science research, we are interested in identifying the universal mechanisms by which biases, injustice, and harm take root, so that we may not only tackle the most pressing contemporary manifestations of these issues (with respect to race, colonial oppression, gender, disability, and neurodiversity, among others) but avoid new instantiations of

injustices and new kinds of biases as our rapidly changing technologies transform our social landscape.

Machine Learning

Machine learning is perhaps the most powerful contemporary tool for working with large datasets and identifying patterns therein. There are many directions we are curious to explore with such tools. We are interested in exploring the interwovenness of context within cultural datasets, examining different scopes of shared context within aggregate datasets, and examining different local measures of conceptual blending creativity given the scope. We are interested in leveraging this tool for feature extraction in the context of conceptual blending operations. We are interested in tracking how familiar patterns (memes) propagate and mutate over time.

Artificial Intelligence

We are interested in applying our insights to the training of artificial agents in virtual and robotic settings (taking account of their embodied situatedness) and examining how these insights impact their behavior in social groups.

Mathematical Formalization

On the more speculative side (and as mentioned in Chapter 2), we suspect there may be promise in looking at how Schmidhuber's model of interestingness (Schmidhuber, 2009) could be integrated with symmetry groups and cultural

datasets. Such a formalization could prove useful understanding effective design and creativity in more situated ways. We intend to collaborate with a group theorist with related expertise to investigate this possibility further.

Communication

In addition to AI, we believe this work could also help advance learning and communication with other species. There is a growing trend of teaching domesticated pets like dogs and cats how to communicate with human speech using pressable buttons with pre-recorded words, arranged in certain semantic configurations. In several social media videos, some animals use combinations of familiar words to convey new ideas—apparent cognitive blending. For example, to communicate "window," Justin the cat presses the button combination "outside bed" (justinbieberthecat, 2021). To communicate "flatulence," Bunny the dog presses the combination "play poop" or "sound poop" (whataboutbunny, 2021a). She previously used "sound tug" and "sound walk" to communicate "talk" (whataboutbunny, 2021b). A new version of these commercial buttons[31] will digitally track and record button presses. We have two trick-trained cats of our own and intend to apply our learning themes to this button speech training. We are interested in starting from core embodied conceptual structures particular to the animal to explore blending and learning.

For all these topics, we intend to explore them through artistic works, in keeping with our new media arts methodology. Through an iterative research cycle

[31] Accessed 03/18/2022: https://fluent.pet/products/fluentpet-connect

of such probing and playful exploration, we hope to sharpen our research questions, formalize theory, and generate further research questions and directions.

6.2.3 FUTURE PROJECTS

Cognitive Science

Through experimentation and artistic works, we intend to explore strange sensoria (including strange distortions of the body) in virtual environments in conjunction with vibrotactile feedback and how this impacts new kinds of situated embodied schema. This idea puts into practice Novak's idea of avatarchitecture (Novak, 2002) and continues some previous work with a student in this area (Hurvitz & Crawshaw, 2018).

Classics

We would like to promote our themes as analytical tools in classical scholarship, analyzing meaning-making and paideia in different artistic works. To start, we would like to develop our work in Section 2.5 into a publication in the field. Additionally, we would like to use machine learning on a Greek language dataset to explore the conceptual blending within the language, given its highly modular character.

New Media Arts

In addition to the areas mentioned earlier in Section 6.2.2, we would like to use our thematic insight to explore data representation further, and explore strategies using AI for algorithmic synaesthesia in music visualization in particular.

We also plan to work on a generalized textbook for new media arts and design education.

Eventually, we'd also like to create an online handbook and scientific repository for "orchestrating" media, particularly from a situated, perceptual perspective. In the spirit of traditional orchestration handbooks, it would look at the expressive profiles of given media as "instruments" (e.g. vibrotactile sound and its two-limen spatial acuity across the skin) as well as considerations for their combination (e.g. cross-sensory impacts of whole-body vibration frequency on the gustatory percept of saltiness).

Education

Of paramount concern and interest is in adapting this research into a more general proposition for transdisciplinary public education and for PreK–PhD. We hope to start this effort with a proposal for a revised "homeroom" or "hub" class that would be a transdisciplinary computational making class based on our insights. In this way, it could serve as the synthesizing glue between other discipline-specific material or courses.

6.3 FINAL REMARKS

To conclude, we believe this research holds considerable promise in advancing research and practice in the areas of classics, cognitive science, education, and the new media arts. We look forward to continuing this exploration in the years to come.

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APPENDIX

COURSE DESCRIPTION: (E)UTOPIAN DESIGN TOOLS

(E)UTOPIAN DESIGN TOOLS

Mediated Worlds | Special Topics: A THEMAS Course

MAT 80XU, Summer Session B 2021

What does it mean to “make the world a better place”? Practically, what might that entail? What is the measure of “better”? How do we unfetter ourselves from clichés and biases and pursue specific and creative actions? How do we enact eutopias (good, possible places) rather than merely imagine utopias (ideal, impossible places)?

(E)Utopian Design Tools is a creative-computing and project-based class that operationalizes positive and innovative change.

Working with the 3D graphics program Blender and related platforms, students learn to leverage the mechanical advantage of digital tools as the arm of their imaginations.

As a first step, this class reframes problems as creative opportunities. We engage worldmaking and speculative design through the transdisciplinary pedagogical model of THEMAS (STEM+Arts+Humanities) to equip students with a trans-paradigmatic thinking and making toolbox. Additionally, we train a making reflex through an emphasis on iteration and prototyping as habits. The intent, creativity, and efficacy of their efforts are further refined via frameworks and concepts from cognitive science, human-centered design, engineering ethics, and

information aesthetics, among others. A selective survey of the literature of utopias also contextualizes this undertaking.

In these ways, students are empowered to meet challenges holistically, imaginatively, and compassionately, with a 21st century toolkit supercharged with computation.

In terms of its offering, this class acts as a special topics course as part of the MAT 80 Mediated Worlds THEMAS Course Series. The MAT 80 Series is a collection of courses based on an original pedagogical model called THEMAS: STEM+Arts+Humanities. THEMAS is more than the mere sum of its disciplinary parts—it is an integrative framework focused on transdisciplinary connections and is anchored around a designer-maker approach to learning. The Mediated World courses that comprise the MAT 80 Series explore THEMAS through the lens of worldmaking: in fact (how we know our world), in fiction (how we understand our world through imaginary alternatives), and in action (how we affect and enact change in our world). Importantly, these levels are interwoven. Furthermore, the emphasis on “mediated” in Mediated Worlds refers to the (creative) computational mission of the series, and the bridging of the digital medium with analog media in the actual world.

In the standard format of these classes (MAT 80 TH, EM, and AS), the primary deliverables consist of a hypothetical <what-if> virtual world along with an animated video documentation. The world—imagined and developed from philosophical first principles— is realized in the versatile open-source computer-animation program Blender, which can be scripted in the Python language and

which is used and supported by a large international community. The video documentation, at the discretion of the student, can take the form of trailer, short film, or audiovisual expression to showcase this work.

(E)Utopian Design Tools contributes to the MAT 80 course suite and its traditional deliverables with a particular emphasis on worldmaking in action. Students are asked to identify and creatively address a contemporary problem through a digital worldmaking project. Such a project could take the form of an interactive learning experience, a speculative design proposal, a working prototype, or fictional storytelling, among other possibilities.

Some potential examples:

- *To address the isolation of social distancing and the trend of ideological polarization, a project could promote closeness and compassion through a shared and interactive virtual experience that connects participants using sensor data (e.g. heart rate via smart devices, or other data via Arduino microcontrollers).*
- *To speak to institutionalized racism in the prison system, a project could reimagine the justice system through speculative design in a virtual society, for example, by working through a set of public policy changes and their larger reaching implications, as well as modeling a new kind of public building as an alternative to incarceration.*
- *Concerned about the climate crisis and the related impact of driving, a student could design their own take on the idea of a 15-minute (walkable radius) city.*
- *In looking at the latest research on coronavirus aerosol propagation, a student could create a virtual model for a hospital wing to address ventilation and other novel safety concerns.*
- *As a response to the learning-by-rote educational model in public mathematical education, a student could design an interactive game to cultivate a more intuitive understanding of hyperbolic or higher-dimensional geometries in a correspondingly hyperbolic or higher-dimensional virtual environment.*

As such—through creative problem-solving frameworks, habit-building exercises, and an emphasis on learning by making—this class discourages a

passive assimilation to some preconceived and immutable notion of the “real world.” Instead, it proposes that the “real world” is music in motion, and it encourages and prepares students to be its active, creative, and empathetic composers and performers.