Multisensory Mold: An Interdisciplinary Investigation of Ubiquitous Indoor Fungi

by

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Abstract

At any given time, we are surrounded by microscopic fungi. Our cohabitation with these invisible molds and yeasts is quite normal, regardless of where we live or how clean we keep our spaces. This research project aims to exemplify this reality by making the invisible visible and presenting a variety of fungi sampled from homes around the world. The visual component of the exhibition, fungal cultures within glass terrariums, is accompanied by sonic and tactile interpretations of the cultures as well. By means of a multisensory approach, this research project not only intends to demonstrate our entanglement with microscopic fungi, but also to counter unwarranted apprehensions and misconceptions. The mixed media tactile pieces and cross-modal sonifications invite the public to engage with and think about fungi in entirely new and non-threatening ways. This accessible, multisensory unveiling of our fungal roommates conveys just one microscopic example of the many interspecies entanglements that humans take part in.

TABLE OF CONTENTS

List of Figures

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Chapter 1

INTRODUCTION

Multisensory Mold is situated within a post-humanist framework that challenges anthropocentric world-views. Rather than thinking about humans as separate from other life systems, this project considers the intersections of different species' lives. Some of these overlaps are more apparent than others, especially when there are detrimental effects. In such cases, it is clear how critical it can be to consider our effects on and within other life systems. There are countless interspecies overlaps in which we take part, and it is not just about negative consequences. It is also about the reciprocal nature of these entanglements. We are affected by other life systems just as we enact effects on them. This project focuses on an interspecies overlap that tends to go unnoticed: the relationship between humans and the microscopic fungi with which we cohabitate. By highlighting such a minute entanglement, this project is intended to spark considerations of how many other life system intersections are happening without our knowing. In this way, the project is a simple call for thoughtfulness beyond human life.

The spores of the ubiquitous species of fungi that I am investigating are invisible to the naked eye, so it is easy to forget that they surround us at all times. Our effects on each other are similarly invisible and inaccessible, until there is a major problem like an overgrowth of black mold in moisture-ridden homes. As a result, the idea of mold in a home is equated with severe pathogenicity. True, an overgrowth of mold to the point

where it is visible can be problematic. What I would like to think about, however, is the typical state of cohabitation where the fungi are indeed invisible. In these standard conditions, we share a space and potentially have symbiotic relationships with one another. I think it is important to bring light to this reality in order to counter unfounded negative connotations with mold. By doing so, I can reveal the bigger picture of our natural entanglements with fungi and hopefully dispel any trepidation.

As an interdisciplinary practice-based project, *Multisensory Mold* is also part of a shift toward collaboration and innovation at the intersection of disciplines. The project uses methods and materials from mycology (the study of fungi), fiber arts, painting, sculpture, and sound art. The sciences inform the acquisition and cultivation of the fungal samples while the various art disciplines allow me to interpret the fungi and their growth in ways that allow audience interaction and manipulation of both temporal and physical qualities. Additionally, while there are some elements of design in this project, such as architectural design, my focus and perspective is artistic. Any element of design tends to function as a vehicle to organize and display the different modes of artwork in this project. *Multisensory Mold* brings aspects of the sciences and art together and exemplifies how we can communicate information in new ways when we merge seemingly disconnected methods and studies. This is accomplished through a multimodal methodology that approaches signification beyond just vision. With inviting, interactive tactile and auditory features, this exhibition plays with the conventions of communicating information. As a result, knowledge and ideas are not only shared, they also offer unique sensory engagement. This is beneficial to reaching a wider variety of individuals in the

community. People of all ages and different abilities can interact with the artwork, placing the project within a trajectory of more accessible art/research. This project is offered as means to communicate knowledge in a manner that is inclusive and community building.

1.1 Background and Context

It all started with a coffee cup. I had left it out in my studio for a few days. As it turns out, coffee is a wonderful substrate for fungal growth. When I looked into my mug a few days later, what I saw astounded me. An intricate microcosm lay within, with a fascinating variety of colors and textures. This accidental culture was almost reminiscent

Figure 1: Cup of coffee with mold and a close-up of the contents.

of outer space with its multitude of round shapes over a rich, dark background that had a mysterious, otherworldly essence (see figure 1). I decided in that moment that I must paint what I was seeing. This singular experience led me into a two-year exploration of growing and painting fungi. I found myself purposely leaving out coffee and other

organic substrates. I was learning through trial and error and was driven by the excitement and surprise of each new culture. I was enamored with mold. Before studying art, I was on the science track in college. The sciences were something I was always interested in, but as it tends to happen, my decided on a complete change in focus during my undergraduate pursuits. For a long time after, I kept my interest in the arts and science completely separate. Unbeknownst to me, however, my interaction with that old cup of coffee would eventually lead me to the realization that I could bring those two passions together into an interdisciplinary art practice.

In my first semesters of the Interdisciplinary Art, Media, and Design program at OCAD University, I continued with my focus on painting. I moved my practice forward by researching how I could cultivate fungi in Petri dishes and create a more controlled experiment. I learned about the environmental conditions that affect growth, like temperature and lighting, as well as what different substrates (agars) can afford. I also

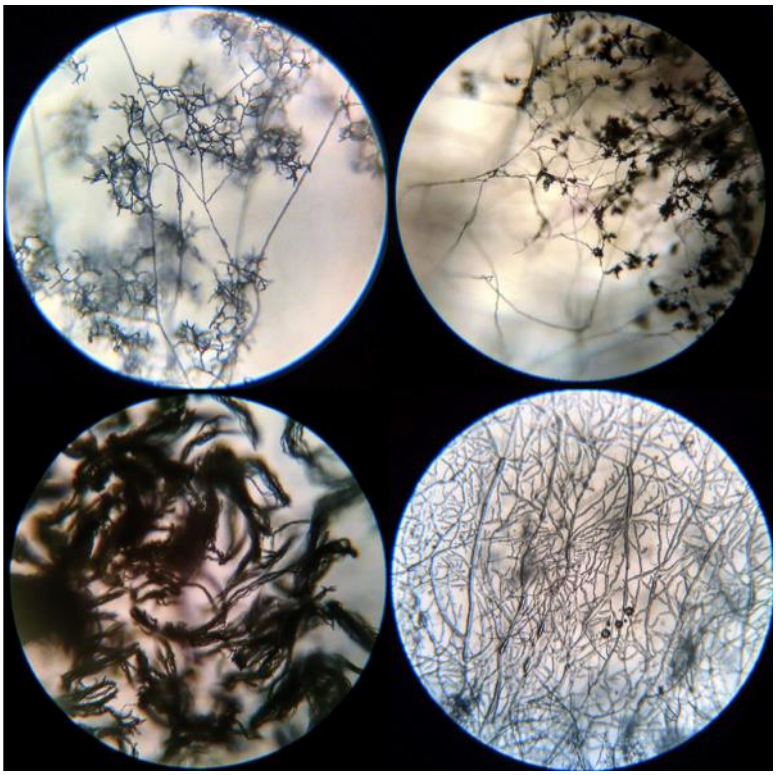

Figure 2: Examples of fungi as seen under a microscope.

made sure to research proper safety and sanitization precautions to ensure the best conditions for both my cultures and myself. I also decided to examine my cultures under a microscope and became even further captivated by the fungi. Their microscopic structures were a mesmerizing combination of geometric and organic forms (see figure 2). I began painting this imagery in addition to the macroscopic views (see figure 3). I was developing the science side of my studies to the best of my abilities, as a non-professional, but my painting practice essentially remained the same. I recognized that there was a lack but I was so caught up in identifying as a painter that it was difficult to step back and genuinely figure out "why".

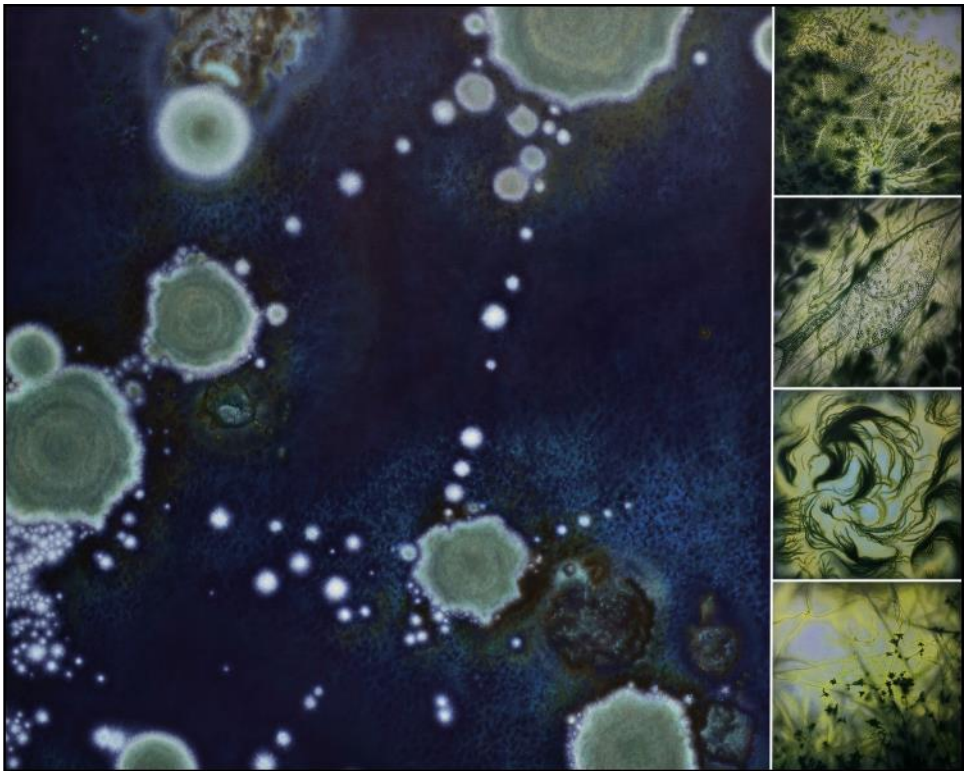

Figure 3: *Penicillium Perceptions*, oil painting of the macroscopic view of fungi (left) and the microscopic views (right).

My perspective was finally shifted when I came across the concept of inclusive design. I took a couple electives that were situated in this area of study and the result was a complete change in my art practice. In what felt like mere moments, I was suddenly aware that the majority of the art world is constructed around able bodies. Coming from the standpoint of a painter, I actually felt an overwhelming guilt that I had never considered the accessibility of my art. By only providing visually based artwork, I was unknowingly excluding entire communities of people. Self-assigned guilt aside, it also became apparent to me that this is an inherently systemic issue as well. Not only has the history of art been primarily ocular-centric, but my earlier education and experiences within the art world were too. Aside from audio tours within my local art museum, I had not seen accommodations for low-vision accessibility. Nobody was talking about it. Nobody was questioning it. At least, not anywhere in my vicinity at that time. And what that tells me is that the conversation was far from being widespread yet. I always considered art to be culture building and community building. When portions of the community are being excluded from those experiences, however, there is division happening. I envision a paradigm shift that allows art to be universal and not a privilege for only some. For this reason, my work now involves three sensory modes. I provide a visual aspect, an interactive tactile aspect, and well as an auditory one. Not only am I hoping to make my work more accessible, but I also now recognize the unique affordances these new sensory modes have for low-vision individuals and able-bodied individuals alike.

1.2 Purpose and Rationale

In addition to researching *how* to grow fungi in Petri dishes, I also began thinking about why. The first thing that I needed to establish was why was I growing the fungi that I was. The species that I was cultivating came from decaying organic substrates as well as the air. I was accumulating a collection from which I could sample and then "curate" my Petri dishes. I wanted diversity, but the randomness of my collection techniques had no meaning. Random was not enough. This led me to considering our relationship with microscopic fungi. I researched in what ways our lives overlap with microscopic fungi and discovered a wide array of instances that can sometimes even be beneficial. Fungi have been used to produce certain food and drinks, medicines, and probiotic supplements. The usage of microscopic fungi in food and beverage can actually be traced back to almost every ancient civilization. In fact, "humans have exploited the natural abilities of fungi to ferment fruits and grains to produce alcoholic beverages and bread since as early as 6000 BCE and for cheese since at least 7500 BCE" (Dupont 2017, 2). I was also delving into research regarding symbiotic relationships between human and fungi and what I found was a significant lack of research (particularly so, if you compare to the breadth of research on human-bacteria symbiosis). Further, the research that has been established mostly focuses on endosymbiosis and exosymbiosis (in and on our bodies). Instead of viewing this as a detriment to my interests, I saw this as an opportunity. I decided to build my project around fungi in our homes (rather than our bodies) in hopes of creating something that everyone could relate to. While not *completely* void of

scientific research on this subject, this is certainly a field where there is still so much knowledge to be discovered and built upon.

There are several artists making work that pertains to the research on endosymbiotic and exosymbiotic microbes. The artist Sasa Spacal is engaged in a variety of investigations of such biological entanglements. In her piece *Mycophone Unison*, for example, Spacal considers the microorganisms that constitute the human microbiome and how they indicate a "plurality of human body that can no longer be seen as one but as many" (Spacal 2013). This piece displays three unique microbiomes from the collaborative authors of the artwork (see figure 4). These cultures are interconnected to each other and to the participant as well. The viewer presses a button that sends a signal through a sound map that "processes it through the central celestial plate to the microbiomes that modulate it as a sound of unison" (Ibid.). In this instant, the individual and the "multiplicity of authors" are sonically interconnected. Another bioartist, Mellissa

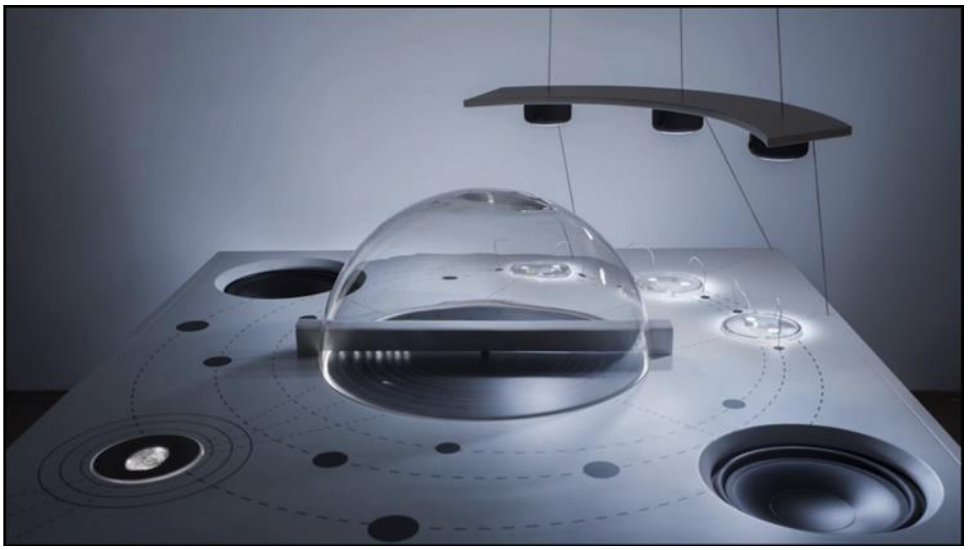

Figure 4: Spacal, Sasa. 2013. *Mycophone Unison.* Mixed media artwork. http://www.agapea.si/en/project/mychophone_unison. (Accessed Mar 14, 2019)

Fisher, researches the exosymbiotic microbiome of her skin and displays it on agar-based sculptures of her body (see figure 5). Fisher is similarly interested in the "unseen and the invisible" and how displaying her skin bacteria might allow the viewer to think about and connect with their own skin microbiome (Fisher 2013). Similarly interested in the skin as microbial habitat, Elaine Whittaker takes a mixed media approach in her piece *Skinscape*. Whittaker created a large, immersive installation hung on fish netting which is a "metaphor for the skin's matrix" (Whittaker 2019). The piece displays over 400 Petri dishes that contain microcopy images of her skin, paintings, and textile interpretations of microbes. Whittaker describes, "the microscopic becomes macroscopic as it flows from high above on a wall to overhead, putting the viewer deep inside the skin" (Ibid.). These artists are wonderful examples of how we can convey information about our intimate entanglements with microbes on and in our bodies through interdisciplinary art approaches. These bioartists exemplify how art and science can intersect and create a cohesive and innovative art concept. They each use different artistic

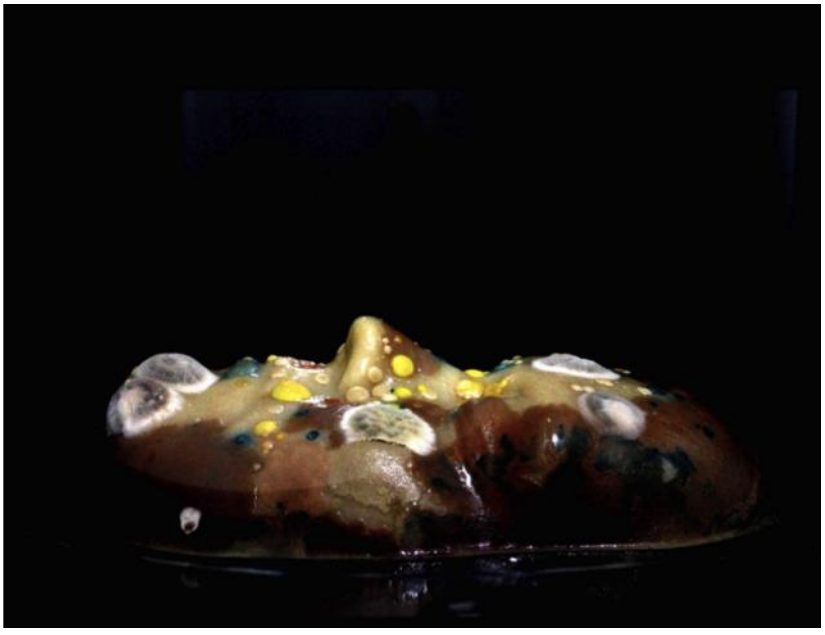

Figure 5: Fisher, Mellissa. 2013. *Microbial Me***.** Agar cast of artist's face and various microbes. http://www.mellissafisher.com/microbial-me. (Accessed Mar 14, 2019)

techniques that allow their artwork to be accessible and approachable to the public. In this way, these artists also demonstrate how bioart can also be educational in a social context. Through their artwork, they are able to both convey information about our microscopic entanglements and enable perception/interaction. Also situating myself within an educational bioart context, I intend for my work to enable similar artistic knowledge sharing pertaining to the microscopic fungi *around* us as well.

In thinking about the "why" of my artwork, I also found importance in recognizing the negative associations that many people have, especially with mold. Mold tends to be correlated with the unclean and rotten and as a result, elicits feelings of fear and disgust. I knew that I wanted to shift this common mindset. In order for the public to see the beauty that I see in fungi, I had make sure to address these connotations. One way to approach this is by dispelling misconceptions through education. Didactics within my exhibition carry much of this weight. It is important to me to explain the ubiquity of microscopic fungi and why fear is usually an unwarranted response. On the other side of the argument, I also find it imperative to explain what kinds of situations *do* lead to pathogenicity and other dangers. I believe in an honest, educational approach that helps build understanding regarding our relationship with these microorganisms. In addition to a didactic-based method to shift negative associations, the different sensory approaches also have roles. The visual component, fungi-filled terrariums, allows the visitors to see what is typically invisible and develop new associations that are inevitably affected by the art gallery context. That is, rather than happening upon something decaying that has mold, they will view something that was cultivated specifically for them. The

associations tied to an “art object” might include the pieces being safe, clean, and meaningful beyond appearance. The sonifications, as well, allow listeners to be audibly immersed in the growth process and to build on the idea that fungi can be art. Sonifications are data-based audio creations that can incorporate a wide variety of disciplines and methodologies. I will expand on this and my own methodological choices in section 3.3. Finally, the tactile interpretations of the species allow the viewers to be physically entangled with the fungi, using materials that are soft, inviting, and potentially draw connections back to the idea of home through familiar textile associations.

Multisensory Mold intends to build on ideas of symbiotic entanglements between humans and microscopic life. Rather than focusing on the human body, the project focuses externally on the home environment. On the one hand, the purpose is to build on existing research and create knowledge in an area that is still in its infancy. Approaching from an art-based research methodology, too, creates entirely new avenues for communicating results within the public domain. The human-fungi entanglement within the home environment is also something that every person takes part in. In this way, the project is built upon a base of relatability that can help shift the public’s perception and misconceptions of mold and yeasts.

1.3 Objectives

The first objective of this research project is to investigate the ubiquitous fungi that cohabitate with humans in living spaces. The samples are derived from households that have a balanced indoor ecosystem (i.e. no visible mold growth or moisture issues)

and from different geographical locations. The results of this research are displayed visually as evidence of a natural cohabitation with microscopic fungi. The second objective of this research project is to alter the perception of mold and counter the negative connotations associated with it. The average home environment will always have ubiquitous fungi present. This reality will be conveyed visually and didactically with careful consideration to addressing common misconceptions. The auditory and haptic components of the exhibition help to provide approachability, accessibility, and creative immersion. These attributes are integral to achieving this objective. Both of these objectives draw on ideas of interspecies entanglements and bringing light to our invisible relationship with fungi. The research reveals the realities of our entanglements and the art practice brings the public into the conversation. The exhibition is intended to be knowledge building and community building. This includes the idea of community between humans and other life systems.

1.4 Scope and Limitations

Through this research, I hope to unveil several species of ubiquitous fungi that humans cohabitate with around the world. The number of samples I can retrieve and display will limit the results of this research, however. The scope of this project will extend to different continents, but will likely exhibit only six total cultures. While I find this amount to be significant to achieving my objectives with the public, this will limit the knowledge this arts-based research can offer the science community. Beyond the timeline of this thesis, however, I plan to accumulate many more samples. Additionally, I am

limited by my inability to identify the fungi down to the species level. I am not a professional in the sciences nor do I have access to the equipment and resources to do so. This venture would absolutely necessitate collaboration within the science community. I am a proponent of interdisciplinary collaboration, but this is well out of the scope of this project for now. Identifying microscopic fungi is no easy task and would require an extended budget to accommodate a mycologist and the time that I would ask of them. This project will continue outside of this thesis, however, so there is a possibility of this collaboration in the future.

All the above being said, I do not take issue with my inability to identify species within this research project. While it would aid the knowledge I can offer to indoor fungi research, I do not believe it detracts from the public's reception of my artwork. It means something different to approach this research through an art practice. The artwork can communicate the ubiquity of mold and yeast without listing the species names. It can make it visible, audible, and touchable. I would argue this is entirely more immersive and engaging to the average person than a list of species names. The art-based research approach brings the public into the conversation and breaks down those disciplinary barriers. Public engagement is integral to this project's objectives. Research for research's sake is good, but it is not quite enough in this case.

As I have situated this project within the emerging paradigm shift toward accessible art, I must also recognize the limitations in this area. First, I would like to acknowledge that I am an able bodied individual. I am compelled to work toward a more accessible art

world, but in no way can I speak for a community of people with which I do not belong. This is all to say that collaboration is vital. Unlike the aforementioned collaboration with scientists, this type of cooperation is immediately feasible and very necessary along the way. I am fortunate to have made several connections within the low vision community in Toronto (many of which are thanks to OCAD's Inclusive Design program). I have also been fortunate to be in conversation with other people involved in arts accessibility at the Art Gallery of Ontario and the Canadian Broadcasting Corporation. The conversations and opportunities that I have had have influenced this project in significant ways. I place all these acknowledgements in this section, however, because there is always more to learn and more collaborations to be had. I am very new to this movement and am far from having all the answers or the best accessible art methodologies. I look forward to more feedback and collaboration from underserved communities as this project moves forward.

Chapter 2

THEORETICAL FRAMEWORK

Multisensory Mold is contextualized with theoretical literature that helps answer the "why" and the "how" of this project. Why do I think it is important to investigate and experience the microscopic fungi with which we cohabitate? In thinking about our relationship to microscopic fungi, I am drawing ideas about symbiosis and interspecies entanglements from Donna Haraway (2016) and Anna Tsing (2015). It is apparent to me that humankind must acknowledge the other species that we share this earth with. We have always already been entangled with numerous non-human life systems and in turn have significant effects on them, as they do us. As I seek to reveal this invisible relationship with fungi to the public, I do so to not only educate but to also destigmatize mold. This is where I must think about *how* I intend to do so. To answer this question, I am utilizing a phenomenological perspective on the experience of art. Referencing the writing of Maurice Merleau-Ponty (1962), I identify how approaching this research through an art practice creates a uniquely immersive and approachable sensibility for a subject that can otherwise be off-putting and inaccessible. In this way, I find the art-based methodology to be of utmost importance to the goals of this research and exhibition.

2.1 Phenomenology of Perception

In my goal to actually change the perception of mold, and the related negative associations, I take a phenomenological approach. Phenomenology is the study of

experiences and consciousness through both sensory perception and less tangible phenomena like memory and emotions. Phenomenology focuses on this conscious experience from a personal, first-person point of view (Smith 2018). Drawing from Maurice Merleau-Ponty's view of phenomenological perception, I am looking at the ability of the art object to not only enable physiological perception of fungi but to provide a unique experience of it as well. Merleau-Ponty emphasizes that a person's perception of a thing is dependent on a certain point of view as an observer in a body. He asserts that the system of experiences is not laid out for our perception alone, but is simply facilitated by a certain point of view. The limitations of the body, therefore, outline the finiteness of perception (Merleau-Ponty 1962). I relate this directly to the perceptual inaccessibility of microscopic mold. While some indoor spaces may have atypical conditions that are conducive to the perceivable overgrowth of mold, like a leaking foundation for example, I am more interested in the typical indoor living space. The atypical conditions, where the fungal spores are allowed to multiply and the colonies become visible, are where most of the negative associations with mold are born (see figure 6). When in excess, it is certainly true that certain species of mold can become a dangerous issue. The majority of indoor environments, however, do not exhibit such conditions. Rather, we simply have our benign, undetectable, microscopic fungi that are truly ubiquitous. Our perception of these microscopic roommates is inhibited by our bodily affordances, yet the cultivation of the microbes in a laboratory setting reveals their existence. Our understanding and perception of the ubiquitous mold from various scientific studies is of a very different nature than direct perception, however. For this, I am considering an average individual (not directly

involved in the sciences) conducting a curious Internet search. Such a distinction is outlined by Merleau-Ponty when he states, “For science and objective thought, an apparently small object seen a hundred yards away is indistinguishable from the same object seen ten yards away at a greater angle…But for me the perceiver, the object seen a hundred yards away is not real and present in the sense in which is at ten yards, and I identify the object in all positions, at all distances, in all appearances, in so far as all the perspectives converge towards the perception which I obtain at a certain distance and with a certain typical orientation” (Merleau-Ponty 1962, 270). The perception of the ubiquity of mold is much different from a purely scientific lens than as a perceivable art object. Understanding the presence of this invisible mold via data or even images outlined in a scientific text is like observing Merleau-Ponty’s object from a

Figure 6: Example of a severe overgrowth of black mold in a home. (Photo source: Wikimedia Commons http://upload.wikimedia.org/commons/b/b9/westendmoldylivingroom.jpg [Accessed Mar 17, 2019]).

hundred yards away. The existence of the microscopic mold is apparent only in so far as it is relayed to me via data. Having this ubiquitous mold grown, multiplied, and presented to me, however, is more like perceiving Merleau-Ponty's object at ten yards away. It allows the invisible fungi to become physiologically perceivable and therefore phenomenologically real and present in the moment. This is a significant difference in perception and is integral to my proposition that our regards toward mold can be altered through a multisensory art-experience of it. Presenting the cultivated mold itself in the glass terrarium is only one aspect. The phenomenological perception of mold is further expanded when the audience is presented with alternate modalities that are interactive. The experience is much different when the user can get close to art piece and tactilely explore its properties. I theorize that by presenting the audience with the object itself (the mold) and immersive interpretations (tactile and auditory) that the perception of ubiquitous mold is completely transformed. Where there was once a limited perception due to our bodily limitations, there is now a multisensory perception that is accessible to a wide array of individuals.

2.2 Interspecies Entanglements

Our coexistence with other species is not without importance or meaning. As humans manipulate the environment to produce their living spaces, our effect on other living beings is inevitable. Haraway uses the term sympoieisis, which she explains as meaning "making-with" as opposed to self-organizing autopoietic living systems (Haraway 2016, 58). Human and non-human species thrive with and amongst each other.

They make-with their environment and their cohabitants in that environment. Living systems are interwoven and these cohabitation entanglements between human and non-human species exist in a sensitive balance. In *Staying with the Trouble: Making Kin in the Cthulucene* Haraway states, "critters-human and not-become-with each other, compose and decompose each other, in every scale and register of time and stuff in sympoietic tangling, in ecological evolutionary developmental earthly worlding and unworlding" (Ibid., 97). I align my research with these principles in that I see an importance in being aware of our own sympoietic entanglements. It is crucial to consider the living systems around us and our imprint on them.

Tsing dubs these interrelationships as "living space entanglements" (Tsing 2015, 5). In her book *The Mushroom at the End of the World,* Tsing uses a certain species of mushroom, the matsutake, as a thread to weave together the discussion of multispecies assemblages and the role of capitalism on ecology and interspecies cohabitation. While human activity can certainly be harmful to other species, Tsing also identifies how human intervention can in some ways be beneficial. For example, both pine trees and matsutake mushrooms only grow in forests that have been deeply affected by human activity. The matsutake seek out the root systems of pines and not only derive nourishment from them, but also provide the pine tree with minerals and nutrients that otherwise would be unavailable in the damaged soils. The pine tree evolved with fungi and both come into being through interspecies relations with not only each other but with human intervention as well. This multispecies give-and-take is representative of how intertwined living

systems can become over time. Human presence has influenced, both positively and negatively, the histories of living systems.

In thinking about microscopic fungi, one can imagine the many instances of coevolution and interspecies entanglements that have occurred, unseen, over time. Coevolution is when two or more different species are in some way associated and over time, they each affect each other's evolution. Some instances of coevolution are more apparent, like the relationships between predators and prey. In the case of microscopic organisms, instances of coevolution may be less obvious or macroscopically unobservable. This is what I find fascinating about the human-mold relationship: the invisible nature of it. Only with science and technology can we view, study, and hypothesize about our microscopic roommates. Nevertheless, size and visibility do not correlate with importance.

2.2.1 Fungi Inside Our Bodies

As we know, microscopic organisms can have vast influence on and in our own bodies. Bacteria inhabit humans, for example, from the moment we are born (Yang *et al.* 2016, 76). These various species of bacteria form a vitally beneficial component of our digestive system. This is one common example of our own coevolution with microscopic organisms, but what I aim to highlight is the lesser-known role of microscopic fungi with humans. Interestingly, the research involving human-fungi symbiosis is in its infancy compared to bacteria. There is no shortage of fungi inside of our bodies, however. According to Rebecca A. Hall *et al*., "over 75 genera of fungi have been identified in the

oral cavity alone" (Hall *et al*. 2017, 59). These fungi, in turn, can also make their way into the GI tract and become part of our internal mycobiome. The potential benefit of having each of these species in our gut is not comprehensively known, but there are emerging studies slowly uncovering this mystery. One known example of a mutualistic fungal symbiont in our digestive system is *Saccharomyces boulardii*. This yeast is actually used as a probiotic treatment for gastroenteritis (Ibid., 59). In addition to our mouth and GI tract, fungi inhabit other mucosal surfaces of our bodies as well. For example, the fungus *Candida albicans* is widely known for inhabiting the vagina. When in an imbalanced state of overgrowth, this yeast can of course cause uncomfortable infections. What is interesting, though, is that in healthy, balanced individuals this fungus is still present. Hall *et al.* hypothesizes that there is a mutually symbiotic reason for this. They propose that because of the vagina's proximity to the anus, and therefore a source of bacteria, that the *C. albicans* actually protects from bacterial urinary tract infections (Ibid., 60). It is all about balance versus overgrowth. In an imbalanced environment, this fungus becomes a pathogen, but just as easily, it may be working in our favor. These are a couple examples of how fungi that colonize our bodies can form beneficial symbiotic relationships with us. As research continues, we may recognize countless more examples of how, like some bacteria, some fungi are friends to us.

2.2.2 Fungi Inside Our Home

Even more elusive, and what is of specific interest to my research project, is our relationship to microscopic fungi in our homes. Identifying the role of fungi on and in our

bodies is one thing, but outside of our bodies and in cohabitation is a different question entirely. It is not a question of whether we are surrounded by mold spores or not. This is something we already know and that which I am exploring and exhibiting with my work. Indeed, in every single home and building, we live with various microscopic fungi. On average, one can expect approximately 1000 spores/m^3 in any given building (Baxter 2005, 17). This number can vary quite a bit depending on the circumstances. Due to the significantly higher concentration of mold spores outside, a building with natural ventilation (like windows open) can bring that up to 9,000 spores/m^3 (Macintosh 2006, 382). As well, this concentration can include over 400 different species, most typically from the Aspergillus, Cladosporidium, Penicillium and Fusarium genera (Lukaszuk 2011, 158). Somehow we have been convinced that these invisible microbes are "dirty", "dangerous", and in need of elimination. We have been given every antimicrobial cleaning agent we could possibly want at home and on-the-go. True, too much of anything can potentially be bad but we must consider why and how we have become surrounded by these microscopic species. Like the many interspecies entanglements that have already been identified by theorists like Tsing and Haraway and scientists alike, we have coevolved to live together. It is clear to me that there is some kind of non-threatening harmony in which we unknowingly participate. Given the reality that these ubiquitous fungi surround us, if they lived up to their hazardous reputation, surely not one of us would be healthy right now. In fact, "current scientific evidence does not support the proposition that human health has been adversely affected by inhaled mycotoxins in the home, school, or office environment" (Hardin 2003, 470). Further, "levels of

exposure in the indoor environment suggest that delivery by the inhalation route of a toxic dose of mycotoxins in the indoor environment is highly unlikely at best, even for the hypothetically most vulnerable subpopulations" (Ibid., 476). This asserts that death by mycotoxins is far from a realistic concern, but one might argue that fatality is not the only concern. True, one might experience other symptoms before reaching that end of the spectrum. Most commonly, these conditions are allergic rhinitis ("hay fever") and allergic asthma. Interestingly, only about "5% of the population is predicted to have, at some time, allergic symptoms from molds" (Ibid., 471). As previously mentioned, too, the concentration of mold spores is much higher outdoors than indoors. While one can expect around 1000 spores/m^3 indoors, the average outdoors is closer to 6000 spores/m^3 (Baxter 2005, 12). In other words, the allergic concerns pertaining to microscopic fungal spores are at least six times higher outdoors. For this and the aforementioned reasons, my position is against perpetuating unfounded fears of ubiquitous fungi in our homes. Our entanglement is quite normal and non-threatening under the usual circumstances. I hope my work will not only reveal these ubiquitous fungi, but to also move us away from unnecessary trepidation.

One way in which my work aims to achieve this is through the variety of samples I will be displaying. The viewers will be able to connect to the culture derived from a Toronto home while also seeing the existence of fungi in homes all around the world. This will help emphasize the ubiquity and normality of living with mold spores. The house-shaped terrariums also help visually connect the cultures with the indoor home environment. The terrarium does separate us from the actual fungi, but one must keep in

mind the fungi do not exist like this in our homes. I have cultivated them to a state of overgrowth so to make them visible. In that way, I do need to keep the cultures contained. I hope to mediate this with informational didactics. It is important for the viewers to have the context they need in order to overcome the stigmatized view of mold. Another way in which the work will emphasize the non-threat is through the tactile pieces. I hope that the inviting materials and interactive nature of the wall-hung pieces will allow the participants to feel comfortable exploring the fungal species. Some of the materials I use are cotton (both spun and embroidered into a soft, carpet-like texture), wool, velvet, and fluffy bird feathers. I intend the tactile pieces to help form less-threatening associations and physically allude to our entanglements with fungi as the participants run their fingers through the work.

While both of these bodies of theory apply to different aspects of the work, there is a unification that occurs within the interactive space of the exhibition. One may consider the entanglement of the senses themselves. The different senses are always interacting with one another as we explore our surroundings. Different modes of sensory perception affect and enhance one another. Not only does this happen naturally, but a multi-modal presentation of information contains intentional entanglements. I utilize methodologies that aim to create experiences that parallel synesthesia. A multisensory approach is indeed an entanglement of the senses. Further, one may argue that our different engagements with the artwork are entangled with each other. It is not just that we share the same space simultaneously, but we also observe others' interactions with the artwork. Here, the role of the audience becomes an important factor beyond one's own

perceptual engagement with the artwork. In the exhibition space, an individual's engagement with the artwork is perceivable to others. As a result, one's perception of another may affect their own experience with the pieces. An individual's interest in engaging with a piece may ignite similar interest in another. The way in which one engages may affect how another chooses to engage. The responses that the audience has to the artwork, whether it is verbal or physically perceivable, affect how others regard the work. Every type of engagement that occurs in the gallery space is entangled when direct perception is possible. This interaction could be beneficial, as with a chain reaction of curious and excited interest, for example. This could also be disadvantageous, however, if a user exhibits an expression of disgust when viewing the fungi and another individual perceives this reaction and adopts a similar disposition based solely on that interaction. What becomes important for me, then, is observing these entangled and varied responses to the work as they unfold before me. My perception of the audience is key in understanding how the work functions. Their responses, even in body language, can tell me whether my intent to incite interest, dispel trepidation, and encourage physical engagement is successful or not.

Chapter 3

RESEARCH METHODOLOGY

This research project utilizes an interdisciplinary mixed methods research methodology. The project entails data collection, analysis, and art-making that ultimately requires a combination of quantitative and qualitative methods. My data collection consists of acquiring dust samples and cultivating the samples in Petri dishes. The specific methods used to achieve this are derived from scientific research and applied to the best of my abilities (as I am not a scientist nor working within a typical laboratory setting). The analysis of the resulting cultures is empirically investigated. This involves measuring and recording the variables of change over a set period and morphological observation. The practice-based methods that proceed after data collection and analysis employ interdisciplinary techniques and theoretical considerations. This includes the application of scientific techniques into a more artistic manifestation, interpretation of visual observations into different physical modalities, and utilization of cross-modal correspondence theory to interpret visual observation to auditory modalities. Detailed descriptions of the research designs within this mixed-methodology approach follow.

3.1 Data Collection

In order to sample and cultivate fungal spores, I am adopting techniques and processes from the sciences. The method I am using to retrieve mold samples from various households is a dust sampling method outlined by Anthony Amend *et al.* in their

study *Indoor Fungal Composition is Geographically Pattered and More Diverse in Temperate Zones Than in the Tropics.* There are two important reasons for adopting this method. On one the hand, the fungal spores in settled dust provides an array of species throughout several seasons. An air-sampling method, by contrast, only reveals fungal spores from the present season. The second reason to utilize this method is to facilitate the safe and legal transport of the biological specimen overseas. An air-sampling method uses a prepared Petri dish and requires the transport of live cultures through the mail. This poses several problems, including legal ones. With the dust sampling method, however, the dust can be sent with no problems and cultivation can occur only once the samples arrive in my possession. A related methodological choice, where the samples are derived from, also comes from this study. Amend *et al.* found that the greatest diversity of indoor mold species is directly correlated to geographical location. This correlation can be further attributed to distance from the equator (Amend *et al.* 2010, 13750). For this reason, the samples will be derived from a variety of geographical locations using the dust sampling method.

Once the samples are retrieved, they are cultivated in Petri dishes prepared with three different agars. I use malt extract agar (MEA), Sabouraud's agar (SA), and potato dextrose agar (PDA). Each of these agars are particularly suitable for a wide variety of fungi. As well, they each have an acidic pH (MEA 5.0, SA and PDA 5.6), which helps to avoid bacterial contamination (Pitt *et al.* 1985, 43). Each of the agars has different constituents and nutrient concentrations that benefit different species (see figure 7). This is largely the reason that I am choosing to swab my dust samples on different media. I

Figure 7: The same culture swabbed on different media. Sample from Port Washingon, Wisconsin, U.S.A. Malt extract agar (left), Saboraud's agar (center), and potato dextrose agar (right) photographed on day six of growth.

want to reveal as many species that are present in homes as I can in order to provide a comprehensive look at the invisible indoor mycobiome. I am also interested in the formal qualities of having a variety of species. I believe cultures with a wide variety of colors and textures will be more exciting and intriguing for the viewers of the exhibition. In the same vein, the mixed media interpretation I make of the cultures will be much more haptically diverse and exciting with more species to represent. In order to keep my cultures free from unwelcome contamination, I order Petri dishes that are pre-prepared with each of these agars and sterile[1]. The method I use to transfer the microscopic fungi from the dust to the Petri dishes is a direct plating method. This is a simple technique in which I use sterile cotton swabs to pick up fungi from the dust samples and transfer them to the surface of the agar. I then place the lids back on the Petri dishes and seal the edges

[1] Petri dishes sourced from Salomon's Greenhouse in Lebanon, Tennessee. https://www.salomonsgreenhouse.com, https://www.ebay.com/str/Salomons-Greenhouse.

with Parafilm®[2] to keep out contamination as well as to prevent the evaporation of moisture from the agar. I also place the Petri dishes in sterilized, plastic containers with lids to further prevent loss of moisture. The dishes are then left to grow at room temperature (approximately 21ºC).

3.2 Data Analysis

Following the process of swabbing my Petri dishes, the next step is observing and documenting the growth that occurs. I utilize the same schedule of documentation for each of the cultures. Over the course of seven days, I open the Petri dishes and photograph them at the same time twice per day. This entire process is completed in a sanitized, semi-enclosed area that has been fitted with ventilation. As well, I am using gloves and protecting myself with a P100 fine particulate respirator that is recommended by the EPA for use around mold. I choose to stop at the seven-day mark because growth

Figure 8: Example of early growth on day two (left), growth on day four (center), and a state of overgrowth on day seven (right). Sample from Kraków, Poland grown on malt extract agar.

[2] Parafilm® is a stretchy self-sealing film commonly used to seal labware. https://www.bemis.com/na/products/parafilm-floratape/parafilm-lab.

tends to slow at this point and colonies become crowded and/or take over one another. Observation becomes difficult at this point and the formal qualities of the culture are no longer desirable from an artistic standpoint (see figure 8).

Next, I edit the photos so that they line up perfectly on top of one another to prepare for measurements and visual analysis. At this stage, of the three Petri dishes used for each dust sample, I choose one that will directly inform my art pieces. I make this decision based on which agar was favorable to the most diversity. In cases where the same species were present on two or more different agars, I simply choose one that has the best composition, artistically speaking. Using the photo editing application, I label

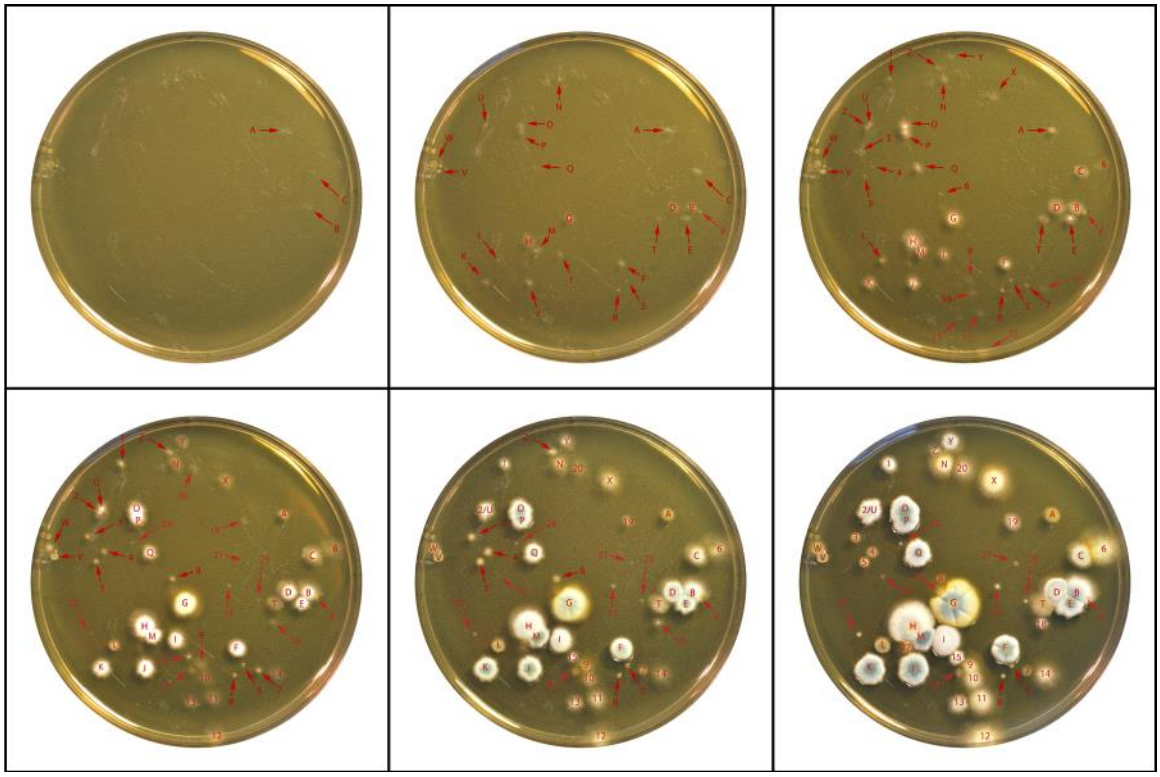

Figure 9: Example of how fungal colonies are labeled with numbers and letters as growth emerges and progresses. Shown are the first six documentation photos of the sample obtained from Toronto, Ontario and grown on Saboraud's agar.

each colony with a letter or number. As I proceed through the documentation, I continue to label new emerging colonies on each photo and record when and where their emergence occurred (see figure 9). I record the location of emergence by bisecting the Petri dish into left and right sections. I also denote the location of colonies that occur in the center. After this step, I return to the first documentation photo and using my labels, follow each individual colony's growth throughout the documentation. Using the photo editing application, I digitally measure the size of the colony and record this information for each documentation photo. If a colony is not circular, I measure the diameter of the shape from multiple directions and take the average of each of these measurements. Once I have recorded the growth changes for each colony, I calculate the percent change from one photo to the next. Each of these measurements is put into a spreadsheet so that I can reference them quickly and inform the creation of the sonifications. In this way, I can look at percent change, location, time of emergence, as well as instances where colonies stop growing, merge with another colony of the same species, or are taken over by a different species.

3.3 Cross-Modal Correspondences

As briefly discussed, the type of auditory modality I am employing to convey information about the fungi is sonification. This data-based method is described as "the transformation of data relations into perceived relations in an acoustic signal for the purposes of facilitating communication or interpretation" (Kramer *et al.* 2010, 4). The theoretical underpinnings of sonification can come from a wide variety of fields and

disciplines such as psychology, mathematics, linguistics, semiotics, music, etc. For this reason, there is not necessarily any one methodology or set of guidelines for sonification. The creation of sonifications is in and of itself a process of interdisciplinary collaboration. This provides a unique opportunity for artists, too, to consider methods of signification and representation that traditionally reside outside of the visual arts. My methodological choice for sonification comes from cross-modal correspondence theory. This references neurological studies that identify correlations that the brain makes between seemingly unrelated sensory modes. I am intrigued by the theoretical possibility of inducing synesthetic connections in my participants that may be able to convey information about fungal growth (i.e.: size variance, number of colonies, etc). I am aware that even if these correlations were achieved that they would not necessarily be obvious or conscious, but it would still provide a unique sensory interaction that is not otherwise available. It is an atypical engagement with fungi that I see as building on our entanglements.

There have been numerous studies investigating phenomena of synesthesia between the senses. This "classical synesthesia" occurs when one sense is experienced and a second, unrelated sense is involuntarily triggered. It is hypothesized, however, that synesthetic experiences resulting from cross-modal correspondences (like my sonifications) are not arbitrary or idiosyncratic (Lacey *et al*. 2016, 2716). That is, artists can theoretically induce synesthetic responses by means of multisensory approaches that utilize demonstrated cross-modal correspondence techniques. It is notable that these synesthetic connections are not necessarily the same as true, classical synesthesia but the

similarities are fascinating and have a great deal of potential for use. In a study by Parise *et al.*, for example, there is evidence that there is a correspondence between visual size increase and audio pitch decrease. In other words, bigger objects are correlated with lower sounds. This study provided "the first psychophysical evidence that synesthetic congruency can actually promote multisensory integration" (Parise *et al.* 2009, 6). These types of correlations are what inform my decisions while creating the sonfications. The following growth variables are used for this technique: emergence/number of colonies, colony size increase/decrease, location of colonies on the Petri dish, different species types, rate of growth, and the overall time span over which this growth occurs. Each of these variables will be assigned audio correlations based on cross-modal correspondence literature as well as some creative choices. The emergence/number of colonies are each represented by individual sound clips. Colony size variance is correlated inversely with change in pitch. The location of colonies is correlated with stereo sound (i.e.: which ear the sound is played in) and the rate of growth is correlated with changes in volume. The time span of growth is associated with the length of sonification and the relational placement of colonies along that segment of audio (of course not a 1:1 correlation). Finally, the species types are represented using creative choices in sound clips. This is based on instinctual associations between visual shape/texture and sound.

The data that I recorded into spreadsheets during the documentation analysis stage are referenced throughout the creation of the sonifications. While this technique primarily uses data, there is still the one aspect of the sonifications that is interpretive and artistic. Before I can manipulate the sound clips according to the variations in growth, I must first

decide what the sound clips will be. I decided against sonifications that would be unpleasant, overwhelmingly chaotic, or even too digital sounding. Using computer-generated tones were not something I was interested in, for example. I believe in order to represent something natural, organically produced sounds are more appropriate and enjoyable. What I did was explore my living space and create sounds with various objects. I would tap them, shake them, run my hands along them, etc. Meanwhile, I would keep in mind the morphology of the species that were growing in my Petri dishes and think about what sounds I naturally correlate with those shapes and textures. For example, a species that is very filamentous or "fluffy" might have a sound that is fizzy or static-like. In contrast, yeast colonies appear smooth and gel-like and may be represented using liquid sounds.

Part of my sonification technique, too, is attributing not one but two sounds to each species. The first sound represents the initial emergence of the colony. I found this to be the easiest way to recognize the emergence of new colonies amongst the other sounds being played. The morphology of the colonies is also very different from the beginning of the growth to the later stages. In this way, I am able to represent those differences in appearance. The second sound that is attributed to a colony is what I deem the "persistence sound". This sound is carried throughout the growth process and fluctuates according to the colony's growth. This secondary sound clip tends to be a softer sound that layers well over the others without becoming too overwhelming. In contrast, the emergent noise stands out as more of a distinct "click" or "pop", but only lasts a moment before transitioning into the persistent sound clip. Some examples of the

sounds I used for both emergence and persistence include: tapping Styrofoam, wood, and a ukulele, light switch clicks, stepping on a creaky floor, pouring a carbonated beverage, mouth "pops", dragging wooden beads, rustling straw, fingernails on corduroy, drops of liquid, a running faucet, blowing air, shaking a bottle of viscous liquid, snapping fingers, crunching plastic bags and leaves, and many more.

Once I have chosen two sound clips based on the morphology of a colony throughout its growth process, I then begin the cross-modal sonification process. I assess one colony at a time. I take the emergence sound clip and place it according to which documentation photo the colony emerged in. This is why documenting the Petri dishes according to the same schedules is important, as I would like my sonifications to be consistent in their creation. Each sonification is one minute in length. I divide that minute

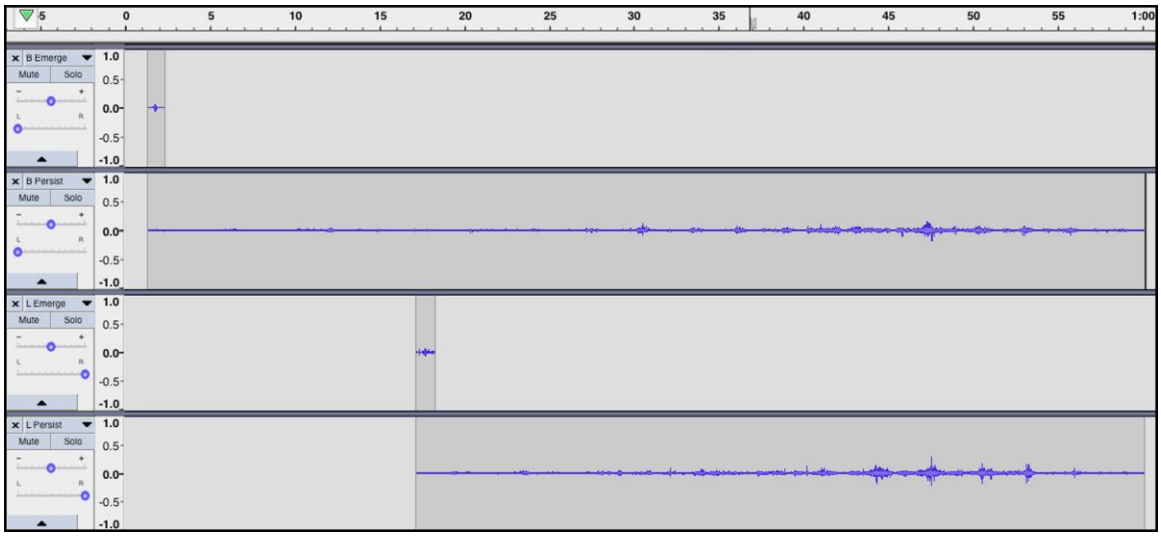

Figure 10: Example of audio layers for two colonies. The top row indicates colony B's emergence at 1 sec. and is followed by the sound clip that persists and changes according to colony B's growth. The third row indicates colony L's emergence at 17 sec. and is followed by a persistence layer of audio for colony L.

according to the number of documentation photos from the growth process. Subsequently, the growth variation from one photo to the next is assigned to a specific place along the full length of audio (see figure 10). In addition to when the colony emerges, I also signify where it emerges. As stated earlier, my spreadsheets include where the colony emerges on the Petri dish according to “left”, “right”, and “center”. This is directly correlated to stereo audio. In other words, it informs whether it will be played in the left ear, right ear, or both simultaneously. Next, I layer the persistence sound for the colony. I take the sound clip and manipulate it to be the appropriate length. This will either be the one-minute length of the sonification or less if the colony was overtaken by another and was no longer visible. Then I assess the percent change in size from one photo to the next. This is inversely correlated to pitch. For example, if a colony increases in size by 23.4% from emergence to the second photo, I will apply a 23.4% decrease in pitch for the appropriate section of that audio clip. I decided not to utilize a different sound variable for variance in height of the colonies. As this is another form of size increase/decrease, pitch would also be the appropriate correspondence. As well, it is difficult to measure the height of the colonies accurately. Finally, I also manipulate the volume levels for each colony’s growth. This I correlate with the rapidity of growth. Typically, the growth of fungi starts a little slow until it hits a very rapid stride and then slows back down again, sometimes not changing at all. I reference the percentage change data to surmise this correlation. In this case, my correspondence cannot follow a 1:1 ratio like size and pitch. The percentage change for many colonies is far too high and the volume would be absurdly loud. Instead, I figure out an appropriate ratio of

correspondence that still adheres to the change in data but is not overwhelming to listen to. Once I find that sweet spot, I make sure to keep that ratio consistent throughout that sonification. Depending on the culture and unique growth in each Petri dish, this ratio varies. I repeat this process for every single colony on a Petri dish. Sometimes this means around 50 different layers of audio. This is why attention to the type of clips I use and the volume are integral to creating a pleasant experience. I determine which species are different primarily based on morphological examination. Sometimes different species will appear morphologically similar, so periodically I will examine the colonies under a microscope to see if their structures differ. This is simply to decide whether I will be using a different sound clip or not. If two colonies are seemingly the same species, I will manipulate the same clips according to their individual growth variables.

My goal for the sonifications is to communicate how the fungi visually and spatially exist and change using only audio. Using instinctual choices for audio clips as well as cross-modal correspondences, I intend the listener to be able to pick out different species, where/when they emerge, and get at least a vague idea of the size and textures of the fungi. Inevitably, these visual-audio correspondences can get a little abstract. Especially so, when I am changing the pitch in extreme quantities. Still, I find this data-based methodology for audio creation to be a very unique approach for an artist to be able convey visual information in a different sensory mode. I also find it to be complimentary to the other aspects of my exhibition, like the tactile pieces, which instead rely on artistic interpretation. As there is an extensive variety of interdisciplinary methodologies for sonification, there is an equally extensive history of sonification applications across an

array of fields. Music technology expert, Mark Ballora, for example has worked on sonifications of solar wind, deep sea data, earth's electromagnetic resonances, heart rate variability, and the motion of planets in the solar system, to name a few. Ballora similarly makes artistic choices for sounds clips that he deems appropriate to represent phenomena that may not have any obvious sonic associations. Ballora thinks sonification "makes it a much more visceral phenomenon" and that "we all respond to music: if we can leverage that with science, there's a real chance of giving students a much more intuitive understanding of the material than they would get from a visual presentation alone" (Gugliemi 2017). Ballora also worked with astrophysicist Wanda Diaz Merced who lost her sight and wanted a way to work with and listen to her data. Interestingly, many of her sighted colleagues ended up utilizing the sonification software that Ballora developed because it afforded the ability to detect patterns that could not readily be seen from the data (Ibid.). This is a wonderful example of how sonification can transform the way we perceive information and afford new avenues of understanding. Another researcher/composer, Eduardo Reck Miranda, developed a fascinating sonification technique that allows him to play music in collaboration with the slime mold *Physarum polycephalum*. Miranda developed a "biocomputer", which uses components grown out of living material. He utilized *P. polycephalum* to begin the designs for this biocomputer. This slime mold actively searches for nutrient sources and in doing so expands and contracts a network of protoplasmic tubes (see figure 11). For this reason, this species is somewhat easy to observe and manipulate in the lab. Additionally, Miranda and colleagues discovered that "electrical current can be relayed through its protoplasmic

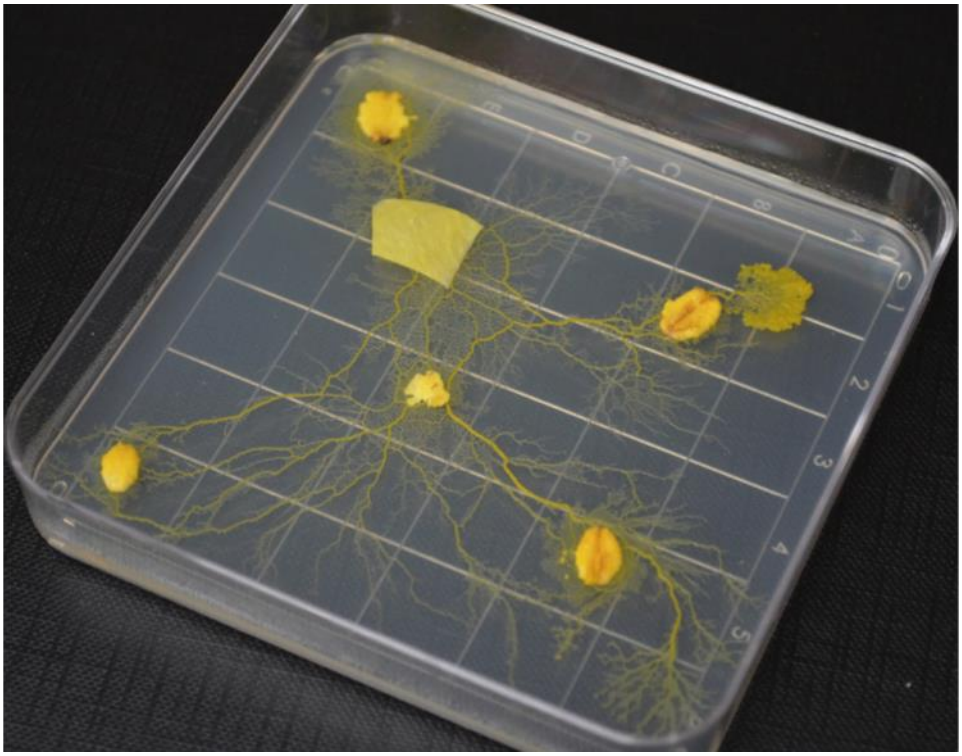

Figure 11: Slime mold *Physarum polycephalum* searching for food sources (oats). (Image by E.R. Miranda and E. Braund. From "A Method for Growing Bio-memristors from Slime Mold". J. Vis. Exp. 129 (2017): e56076.)

tube, and this prompts it to behave like an electronic component called the memristor" (Miranda *et al.* 2018, 30). Miranda *et al.* developed a mechanism by which audio can be input, relayed through *P. polycephalum* as memristor, and subsequently a responsive audio is outputted. This biocomputer setup allowed Miranda to play piano (the input) in collaboration with the unique slime mold output. Research continues as they look at other biological materials that act as memristors and that can eventually be used to create reliable bioelectrical components. I find this to be an impressive example of how we can work in collaboration with other species using an interdisciplinary approach. There is a husband and wife team, Jacques and Fran Soddell, who have worked on the task of

sonifying yeast and filamentous fungi as well. Their approach is vastly different from my own, demonstrating how diverse the process of sonification can be. The Soddells base their sonification off L-systems, or Lindenmayer Systems. This is a type of rewriting system that uses symbols to construct strings of code that are used to assemble a geometric model that is used to describe/interpret complex growth processes of organisms (Soddell). The results are an interesting array of atmospheric and musical tones that have a distinct digital essence. It is quite amazing how many different techniques and fields of study can come together to form unique methodologies for sonification. I agree with the sentiments of Mark Ballora in recognizing how sonification can create a platform for more intuitive and engaging education. I think it can benefit a wide range of individuals in the community, including professionals, families, students, and those with sensory impairments.

3.4 Interpretation and Art-Making

The second sensory modality that I utilize in this project is touch. For this, I create a mixed media tactile art piece for each culture. I begin with a stretched piece of linen that allows me a circular workspace of 24 inches in diameter. I chose a circular composition to mimic the Petri dishes. I use several different materials and techniques that I find appropriate to represent the differing morphologies of each mold or yeast that I observe (see figure 12). One of the more straightforward interpretations is the yeast colonies. Yeasts appear smooth and almost have a wet or gel-like texture. Their colors are neutral, ranging from white to cream tones. My tactile interpretation of the yeasts uses

Figure 12: Examples of real fungi (left) and their interpretive tactile counterparts (right).

silicone. The silicone I use is neutral toned (despite the focus on tactile properties I do consider visual qualities on my tactile pieces as well) and cures to a rubbery gel-like consistency (see figure 13). For the more filamentous species of fungi, I use materials and techniques that help me achieve those soft, fuzzy, and fluffy textures. One technique I use is punch needle embroidery with cotton embroidery thread. I then trim the loops that are deposited in between the linen fibers in order to shape the tactile colony and produce a soft shag-like effect (see figure 14). I also use needle felting on these tactile pieces. I use the traditional material, wool roving, as well as spun cotton (see figure 14). The cotton allows me to twist some of the fibers with my fingers to create some of the spindly branch like textures of certain species' mycelium. I also use upholstery foam to build up

Figure 13: Example of a silicone interpretation of a yeast colony.

the shape of some colonies. Some have very soft fluffy bird feathers sewn into them and others are covered with various fabrics like velvet (see figure 12). I also use some beading techniques to represent the droplets of liquid that form on some fungi as a result of nutrient digestion.

Each of these technique and material choices are made in reference to how the actual fungal colonies appear and how I personally imagine them to feel or how I think I can convey those visual textures through touch. I arrange the colonies on the fabric according to their position on the original Petri dish, while sometimes adjusting spacing to allow for easier haptic exploration. The base fabric is then stretched over a 24 inch circular piece of wood and secured on the back. I use the wood in order for the tactile pieces to sufficiently stand out from the surface of the wall where they will be hung and

Figure 14: Additional examples of fiber techniques. Trimmed punch needle embroidery (left), needle felted cotton (center), and needle felted wool roving (right).

to emphasize the edges of the circular composition. This is not only to reference the shape of the Petri dish, but also to help tactiley orient participants who are not using vision to explore the pieces. My hope with these artworks is to haptically convey different species types by use of the different techniques and materials. I also want to convey visual textures as well as the shape, size and general positioning of the colonies.

The third sensory modality that I include in this project is the visual. These bioart pieces are displayed alongside their tactile and sonic counterparts. They are glass terrariums built in the image of the house from which the individual fungal samples are derived (see figure 15). I not only ask for dust samples, but I ask my suppliers for a snapshot of the outside of their home. I sketch out a simplified version of their house that I can construct using glass. I simplify it so that it is not too complicated to make (there is only so much detail I can achieve with glass) and so that it does not include curved architecture (curves are too difficult to break out of glass successfully). This is also done to ensure that I can seal and sanitize every bit of the inside of the terrarium, because I eventually fill it with agar and fungi. I have chosen to build these terrarium displays in

the shape of the homes in order to directly allude to the type of fungi being shown. That is, the fungi are not random but representative of at least part of that specific home's indoor mycobiome. The methods I use to construct these glass terrariums are primarily derived from stained glass techniques. After measuring and marking out the necessary pieces based off my simplified designs, I score the glass and break the scored pieces by hand. Scoring involves cutting oil so I must then wash all of the pieces thoroughly afterward. I then place 7/32" copper tape along all the edges of the glass (see figure 16). This is so that in the next step, soldering, I can fuse the glass pieces together and begin building the house. Solder does not fuse to glass alone. I use a soldering iron and 1/8" 60/40 tin lead solder to coat the copper tape and bring the pieces together. I use flux, an aqueous solution of zinc chloride, which allows the solder to flow smoothly throughout this process[3]. This, too, can get messy so I give the terrarium a good wash after I am done soldering it together. I also leave a roof

Figure 15: Example of a *Multisensory Mold* terrarium. This terrarium is based off a home in Wisconsin, U.S.A.

[3] The flux used is the Novacan® Old Master's Flux https://www.novacan.net

piece separate so that I can access the inside of the terrarium through it like a door. I connect it to the rest of the roof with two hinges that I solder on as well. The final step in construction is applying a chemical copper patina to the tin/lead solder (an aqueous solution of copper sulphate pentahydrate and sulfuric acid)[4]. This transforms the silver toned finish of the solder to an orange copper-like finish. I find this tone to be more complimentary to the colors of the various fungi. Once again, I wash the terrarium to remove any excess chemical residue. Finally, I seal every edge of the inside of the terrarium with silicone. Once the silicone is cured, I fill the terrarium with water and carefully inspect it to ensure that it is completely sealed.

Figure 16: Example of copper tape application on pieces of glass.

Next, the terrarium is readied for the insertion of agar and the fungal spores. Before doing so, I must ensure that the terrarium is properly sanitized. There are a few steps I take to complete this process. First, I sanitize it with bleach (dilute sodium hypochlorite and sodium hydroxide)[5]. This helps eliminate any microbes that will contaminate my cultures. I then rinse the terrarium very thoroughly to remove any

[4] Copper patina used is the Novacan® Superbrite Copper Patina https://www.novacan.net
[5] The bleach used was Clorox® High Efficiency Regular Bleach. https://www.thecloroxcompany.com

remaining chemicals. Once dry, I then wipe down the inside of the terrarium with a glass cleaning solution[6] in order to ensure optimal clarity. Glass cleaning solutions often contain ammonia (reactive with bleach) so thorough rinsing of the bleach is imperative. Next, I prepare the agar to be poured into the terrarium. For this, I use dehydrated agar[7] and mix the proper amount (depends on the size of each terrarium) into boiling water. The type of agar used is the same as the Petri dish I choose to base my tactile interpretations from. The amount prepared is relative to my intention to fill the bottom of the terrarium approximately 3/4". I also mix food coloring into the agar in order to make the display more visually appealing and to create visual contrast between the agar and the colonies that grow (see figure 17).

Figure 17: Example of blue-tinted agar with contrasting fungal colonies growing on it.

[6] The glass cleaning solution was Windex® Original Glass Cleaner https://www.scjohnson.ca

[7] Powder agars sourced from Seaweed Solution Laboratories™

The color choices are based on the growth that already occurred in the Petri dishes from each sample, and therefore the expected fungal morphologies. I also brush some of the liquid agar up onto other parts of the inside of the terrarium like the walls. This aesthetic choice allows the fungi to grow on more surfaces than just the bottom of the terrarium. The agar is then left to cool down and set. Once this is completed, I can transfer the fungal spores to the agar. I use the exact same methods as outlined in section 3.1 (direct plating from the dust samples). Finally, the hinged roof piece of the terrarium is closed and I seal this piece with silicone from the outside. This ensures that the terrarium is sealed from outside contamination as well as the outside being safe from the fungi that will reside within. This process is completed approximately seven days before exhibition in order to ensure sufficient growth and visual appeal of the species.

Chapter 4

CONCLUSION

The exhibition of this project was set up as four multisensory groupings. Each dust/fungi sample had its respective visual, tactile, and sonic components. These groupings were arranged around the perimeter of the gallery space. The tactile pieces were hung on the wall at equal heights. A pair of Bluetooth-enabled headphones was hung on the wall to the right of each tactile artwork. They were wirelessly connected to media players that were readied with the appropriate sonification for each multisensory grouping. The sonification was played on a continuous loop so that users would not have to locate any buttons on the headphones or media player. The participants were able to explore the tactile artwork with their hands or view the terrarium as they listened to the sonification. The Bluetooth connection was a mindful choice for this reason. I wanted the public to be able to move around, interact with the other pieces in the group, and think about how what they were hearing was related to what they were seeing or feeling. The terrariums were placed on plinths that were situated directly in front of the tactile piece and headphones, but with enough space to circumnavigate (approximately 4.5 feet). The plinths were weighted on the inside near the bottom to ensure their stability if bumped into. The terrariums, as well, were adhered to the top of the plinths for added security. As one of my objectives is dispelling trepidation, the gallery space also had an informational didactic explaining the purpose of the exhibition and how it is related to our own homes' mycobiomes. Each multisensory grouping also had smaller didactics that described

material choices, geographical location of the fungal samples, and a blatant invitation to engage with the tactile and sonification pieces. Finally, I also included “fun facts” related to microscopic molds; such as the average number of spores that a person inhales daily. I intended this to further incite interest, engagement, and set the tone for an educational art experience.

While setting up this exhibition, I also considered conventions of accessible design. I included Braille versions of each didactic and fun fact on the walls. For the main exhibition didactic that is longer and descriptive, I included an audio version that was playing through headphones. I also utilized tactile grip tape on the floor of the gallery. I created perimeters on the floor around the plinths to help notify users with canes that there was something there that they could bump into. I also used this tactile tape to mark areas on the floor to indicate the presence of a tactile work and headphones on the wall above. I placed these pieces of tape perpendicular to the wall so that they could be easily identified as an individual passed by. This particular choice was not based on a convention, but rather was an experimental choice to try to indicate the presence of interactive artwork. Finally, I also considered AODA (Accessibility for Ontarians with Disabilities Act) guidelines for plinth height, space required between objects, and the height at which artwork was hung on the wall.

4.1 Discussion and Future Considerations

The first objective of this project was to visually investigate the ubiquitous fungi that reside in various indoor environments. The six samples that I was able to obtain

originated from different locations in North America, Europe, Asia, and Oceania (only four were exhibited and artistically interpreted). As expected from what is known about microscopic fungi, the dust samples from these regions were each rich with several different species of fungi. While the identification each species is not known, the morphological diversity is visually perceivable. Many of the samples showed what seemed to be the same or closely related species. A few of the samples also grew some unique fungi that I did not observe on other plates. I am pleased that I was able to find this kind of diversity amongst the chosen geographical locations. The shared species, too, make me think about the universality of our human-fungi entanglements. The goal to make the invisible visible and prove the ubiquity of fungi in our homes, no matter where we reside, was achieved. Unfortunately, not every continent was represented in this sample size, but the project serves as a start to a larger body of work. I also wanted my audience to be able to connect to the exhibition by thinking about their own in-home entanglements. Since the fungi one can expect in their home relates directly to geographical location, many of the audience members may have been able to view/interact with a similar indoor mycobiome as their own (samples from the United States and Ontario, Canada were exhibited). My second objective, to shift the public's perception of mold, is difficult to assess in its entirety. Each individual inevitably receives the content of the exhibition differently. By having conversations with the public, I can begin to surmise the difficulties and successes of my approach to this issue. As mentioned previously, observation in the exhibition setting is also key. The audience plays an important role as they engage with the artwork. Observing their reactions and

their manner of interacting with the pieces tells me vital things about the successes and failures of my methods. I was able to observe whether my exhibition set-up functioned as intended. I was also able to observe whether the users felt invited to engage without additional instruction. Perhaps most importantly, I was also able to observe and discuss with the audience how it felt to explore the tactile materials and whether they were able to connect the sonification to these material choices. This kind of observational and conversational feedback is helping inform future artistic choices like materials and techniques. What is also of the utmost importance is continuing to share this artwork and information. The conversation needs to continue outside of this exhibition and even outside of myself to begin erasing the misconceptions about mold that have been ingrained in us.

Since the number of samples acquired and displayed limited the scope of this project, there is certainly potential for expansion of this project in the future. Time constraints are one aspect, but the available area in the gallery space is also a limiting factor. I plan to continue the acquisition of dust samples to provide a much wider array of fungal diversity and geographical representation. I aim to display them in a larger area that allows the concurrent display of the existing and new multisensory groupings while still being mindful of the spacing as per AODA guidelines. Another future consideration that relates to available space is the manner in which I display the tactile works. In discussion with some individuals from the low-vision community, I was informed that optimal comfort for haptic exploration is better achieved with a horizontal display. The wall-hanging method causes some wrist discomfort and a tabletop display or even an

angled display would be superior. This is a good example of how collaboration is vital to finding the best solutions for accessibility. The choice to display the tactile works on the wall (as I would my paintings) is very much evident of my being stuck in the ocular-centric paradigm. For future exhibition of this work, I will certainly consider this informative feedback. As well, after conversations with some participants, I was able to learn which aspects of my sonifications are more successful than others. Interpreting aspects of visual growth into the auditory modality is difficult even when using data-based correlations to inform my decisions. The creative choices that I make, too, are not always necessarily clear. Moving forward, I can use this feedback to adjust my sonifications and subsequently find out what choices may work better to convey certain textures and shapes sonically.

This research project does not conclude here, but rather moves forward. I have consistently deduced that collaboration and feedback is fundamental. The success of a project that not only lies at the intersection of different disciplines, but that also aims to shift the inaccessible standards of art can only do so through cooperation. This realization has completely transformed my practice. While I was once a traditional oil painter, I am now open to a variety of methods and disciplines that appeal to more than just one sense. Instead of making artistic choices that rely on aesthetics, I am now driven by user experience, observation, and feedback. As an interdisciplinary artist, I aim to continue blurring the boundaries between disciplines, techniques, and traditional sensory modalities. There may not be any one *best* methodology to convey information across different sensory modes, but I am sure that it would never be found without continued

community and interdisciplinary collaboration. Each new individual that is consulted has their own unique perspective and expertise. There is no hierarchy of perspective when making art accessible to all.

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