VULNERABILITY

AND INTERACTIVE EXPERIENCES

STEPHANIE DUDZIC

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BRIAN LUCID *Thesis Advisor*

Professor of Design
Dynamic Media Institute
Massachusetts College of Art and Design

GUNTA KAZA *Thesis Advisor*

Professor of Design
Dynamic Media Institute
Massachusetts College of Art and Design

JOSEPH QUACKENBUSH *Thesis Advisor*

Associate Professor of Design
Dynamic Media Institute
Massachusetts College of Art and Design

JAN KUBASIEWICZ

Coordinator of Graduate Program in Design
Professor of Design Dynamic Media Institute
Massachusetts College of Art and Design

Interactions are a core part of our experiences. We interact with each other, we interact with the world around us, and we interact with dynamic systems. Interactions are how we fulfill a need and desire to connect with others and the world around us. Across all interactions, we experience some level of vulnerability. I believe vulnerability presents a challenge as well as an opportunity to consider in design.

When participants encounter interactive systems, what underlying process is guiding their actions? When facing an interactive system, what is their emotional experience? What approaches and strategies do participants use to face situations where they feel vulnerable?

Using light, sound, and tactile interfaces, this thesis describes a series of encounters, centered around familiar to unfamiliar systems, to investigate the role vulnerability plays in interactive experiences. This thesis outlines an overall process for interactive experiences. This thesis also examines the role vulnerability plays in these encounters and suggests strategies participants use when facing vulnerable situations.

ICE CREAM

I was alone,

in a foreign city,

with only a handful of Czech phrases.

Signage from a bakery in Prague.

My first day in Prague, I walked down the street near my hotel in an attempt to figure out how I was going to survive on this trip. I could see letters and words everywhere, but I couldn't read any of them. I could see and hear people talking, but I couldn't understand what they were saying or talk to them myself. All this communication was around me, but I couldn't participate. How was I going to survive a week?

Then, I saw a girl behind a street cart selling ice cream. She smiled at me and looked like a genuinely nice person. In the few words of Czech I knew, I greeted her and asked if she knew English. I knew enough Czech to know her answer was no. I was vulnerable. We couldn't talk to each other, but we smiled at each other. Then, we worked together and had a intimate exchange around the simple task of purchasing one ice cream cone. I pointed to a random ice cream container in her cart, which looked like chocolate. I had no idea how much it cost, how to use the coins in my hand to pay her, or even if it was chocolate. So I opened my hand filled with strange coins. She picked two coins, put them on the counter for me, and placed a smaller coin next to them. This was my change. In this exchange, there was lots of pointing, gesturing, smiling, and communication even though we couldn't speak to each other. This single interaction gave me the confidence that at the very least I could survive off of ice cream from her cart for the rest of the trip, which wasn't bad at all. More importantly, this experience gave me peace of mind to try to interact with others in this foreign place.

Over the rest of the trip, I continued my attempts to communicate with others: buying food, tickets for a train, requesting a receipt, and other social situations. I had a variety of experiences with people and was grateful that many people knew English. At the end of each day, I felt an immense sense of gratitude for every interaction and each person that took on the extra work to communicate and help me with buying bread from a bakery, fruit from a market, or water from a grocery store.

This trip was a formative experience in remembering how to value even the smallest of interactions with others. What was it about these interactions that made them so important to me? It was because of the clear sense of vulnerability I felt in these exchanges. Vulnerability was a challenge, but also an opportunity to connect with others through the smallest of interactions. These experiences laid the foundation for my interest in researching the core of all interactions: vulnerability.

This remainder of this thesis feature a collection of designed experiences to research the role of vulnerability in interactive experiences. Using light, sound, and tactile interfaces, this thesis describes a series of encounters centered around familiar to increasingly unfamiliar systems and outlines an overall process for interactive experiences. This thesis examines the role vulnerability plays in these encounters and suggests archetypical strategies participants use when interacting with unfamiliar systems.

WHY DYNAMIC MEDIA

WALT WHITMAN

O ME! O LIFE!

Oh me! Oh life! of the questions of these recurring,

Of the endless trains of the faithless, of cities fill'd
    with the foolish,

Of myself forever reproaching myself, (for who more
    foolish than I, and who more faithless?)

Of eyes that vainly crave the light, of the objects
    mean, of the struggle ever renew'd,

Of the poor results of all, of the plodding and sordid
    crowds I see around me,

Of the empty and useless years of the rest, with the
    rest me intertwined,

The question, O me! so sad, recurring—What good
    amid these, O me, O life?

          Answer.

That you are here—that life exists and identity,

That the powerful play goes on, and you may con-
    tribute a verse.

As a child, I frequently was in trouble. My main offenders were secretly reading after bedtime and reading a not-so-hidden book under the dinner table. Books captivated me. I solved mysteries with Encyclopedia Brown, Nancy Drew, and the Hardy Boys. I was introduced to a special pig in *Charlotte's Web*. I traveled to incredible places in *The Phantom Tollbooth*. Through these and many other stories, I learned that adults needed help too, sometimes from a kid like me, and I encountered death for the first time. I also discovered the fun in word puns which became the basis for much laughter shared between me and my dad.

Books were how I learned about myself, others, and the world. As my parents divorced, I learned how to explain my then unusual family to other children by reading how one girl in the Babysitter's Club explained her own divorced parents to friends. One of the earliest and most impactful books was a short picture book I found by chance at the library called *The Wooden Doll*. This book was about a Polish girl, also named Stephanie, at her grandparents house. Through that story, I learned what it meant to have grandparents even though I hadn't met my own as they lived across the world. Later, this basic understanding from the story helped me connect with my grandmother when we first met, despite a thick language and culture barrier. Even now, as an adult, I feel that when I finally read my father's favorite book growing up, *Mysterious Island*, I will in some way have insight into what my father was like as a teenager.

The Wooden Doll, by Susan Bonners

Just as books have been to me, dynamic media is how I learn about myself, others, and the world. I did not choose to study dynamic media because "it's the future" or to learn about "where we are going." Dynamic media is here and has been pervasive across our culture for a while. Dynamic media builds on our history, explores and challenges the present, and informs the future. Wikipedia pushes us to think about the veracity of information as well as power of crowds. Facebook explores and challenges the traditional concept of friendships, created and forces the issue of formal definition of romantic relationships in online "public spaces", and does not allow us to easily "forget", a necessary and critical aspect of being human. Dynamic media is about how communication on something like Twitter either is a result of the evolution of communication or is an influence on our evolving towards short messages, or some combination of both. Dynamic media allows an individual to quickly influence a massive number of people. What does it mean to our society that students are no longer learning cursive and instead typing? What does it mean that we heavily rely on automated spellcheck so that we no longer worry when we don't know how to spell specific words? What do the social faux paus that result from the iPhone's auto complete say about our laziness and reliance on the feature to where we don't finish full words or even proof our texts before we send them out? These are example questions I think the field of dynamic media raises. I came to dynamic media to understand our human responses, resistance, and relationships. I am interested in using dynamic media to explore individual and group dynamics. Dynamic media is a lens into which we can observe the current context we live in and is also a reflection of aspects of our society. Finally, dynamic media has and will continue to impact culture and society. As a designer, I am studying dynamic media to better understand my role, abilities, and responsibilities with this field.

To me, dynamic media is about an entire experience, not just the interface. It explores information, presentation, form, and space. dynamic media is about the systems. The most compelling aspect of dynamic media design is the focus on people. As dynamic media designers, we move back and forth from the designer's perspective to the participant's perspective, and consider the experience of the system as a whole.

Dynamic media isn't limited to the quantitative and algorithmic aspects of human experience, but also includes qualitative ones. While interviewing for a job at high tech company, I spoke with a user interface designer about what made their job meaningful to them each day. His response was that he moved a submit button over some small number of pixels to the left. This move saved a small fraction of a second for each user. Due to the millions of users the company, this cumulated to a significant amount of time. From the designer's perspective, he felt that he literally "saved" a specific number of human lives with

that single decision. This is the exact opposite of why I am here. Not to improve efficiency in how we interact with technology, but to explore how we can mindfully improve the overall quality of human experience by learning about ourselves through dynamic media.

After my time formally researching dynamic media, I hope to have the opportunity to be an educator to others. I hope to teach other aspiring designers and enable them to think critically about the self, others, and the world we live in through the medium of dynamic media. I also hope to inspire designers to consider their impact and responsibilities within the context we live in. I also hope to continue my research in dynamic media and share my work with others outside of the classroom as well. To share, teach, and enable others is what I hope my contribution will be in the continuously evolving field of dynamic media.

THE EXPERIENCE OF DYNAMIC MEDIA

My days are filled with work on computers. I have continual access to high tech devices which are hundreds of thousands times more powerful than spacecraft at the edge of the solar system. Despite all of this, the interactive object that has most influenced me as a designer today is a monkey that belongs to my fiancé, Ryan. This monkey has a motion sensor that detects when someone walks by. When this happens, the monkey makes a ridiculous monkey noise and kicks its legs from left to right. Because of the monkey's ability to hang anywhere and surprise unsuspecting people, he is strategically placed in the coat closet to surprise my family on a visit, on my work chair before I sit down to work on an essay, or in the kitchen for an early morning surprise. It's a simple device, which we've used so many times to delight and create new memories among ourselves, friends, and family. However, it isn't the interactive monkey that makes these comical situations happen. It's me and Ryan. We craft the situations and overall experiences through careful thought, planning, and consideration of the other when we place this object in the next strategic spot in our home. This is what I mean when I say I am interested in researching the experience surrounding interactive systems.

ON INTERACTION

Much of the work that we as designers do today revolves around interactive experiences. This is especially true as more objects around us become interactive. However, I've noticed that interactions sometimes are taken for granted. I've also noticed that we may make things interactive for the sake of interaction. This bothers me. Why is this better? Is it better? What are the implications of all these experiences when they are designed this way? In this thesis, I am researching the experience of interactions. I explicitly call out the challenge of interactions as well as encourage gratitude when these interactions occur.

Interactions as two-way exchanges between two participants. In an interaction, each party gives and receives from the other. Frequently, I use the metaphor of "conversations" when describing interactive experiences. Just as there are two participating parties in a conversation, there are two participants in an interactive experience: the system and the person. I don't see the person as a *user* utilizing a tool, but instead as a *participant* in the two-way exchange (or "conversation") with the interactive system. Communication between the two participants happens through a designed language and occurs through the interface of the interactive system.

Interactions are critical to how we learn about ourselves and the world. According to psychoanalyst Donald Winnicott in *Playing and Reality,* infants initially learn about their self and the world through interactions with their mother. The infant first "sees" himself through his mother's face which acts in response to the infant's actions. The mother's face becomes a mirror on his existence. Through this first interaction with the mother, the child learns about his existence and the current state (happiness, fear, sadness, etc.). In summary, Winnicott states, "When I look I am seen, so I exist." Through interaction with another, we first learn about our own existence. Then, through continued interactions with the world that we learn about boundaries, relationships, environment, and culture.

In interactive experiences, there is an *initiation, an action,* and *a response.* Initiation occurs when there is a person or system that is available to interact with. This first action is a way of the participant asserting his self with the system. The participant can be affirmed through the systems response to his action or ignored by the system. Through this two-way exchange, or interaction, the participant has communicated and influenced the system and the system has communicated and influenced the participant.

Interactions are hard. In each interaction, the participant experiences some levels of vulnerability. For example, when we choose to interact and enter this possible two way exchange, we hope the other party will fulfill their end of the contract and respond. At the same time, we fear rejection. When we first perform the initial action, we are exposed and waiting for a response back. When we do receive a response, we may be grateful for this interactive experience.

In this thesis, I am interested in the role vulnerability plays in interactive experiences. When a participant faces an unfamiliar interactive system, they are especially vulnerable. They are challenged to figure out the language of communication and the rules of the interface in addition to waiting for the response. Across my projects, I use this initial experience with unfamiliar systems to explore the role vulnerability places in interactions. In the *Tic Tac Toe* case study, I explore the role of context as well as how to reduce vulnerability during initial interactions. I define an overall interaction process based on my observations with the *Sound of Type* case study. This interaction process highlights the phases participants go through during interactive experiences. Through the *Tactile Diorama* case study, I define a set of strategies participants use when experiencing a sense of vulnerability with an interaction. In the *Sounds of Discovery* project, I explore the role of language and interface in interactive experiences through a visualization and sonification of nasa data. In the *Light Pipes* case study, I design an especially vulnerable interactive experience. Finally, I end with methods for how the results and conclusions in this thesis can be applied by designers today.

VULNERABILITY

INTERACTIONS & VULNERABILITY

"We're not primarily self-con-
tained individuals. We're social
animals, not rational animals.
We emerge out of relationships,
and we are deeply interpen-
etrated, one with another. "

DAVID BROOKS

We are social beings. We make these connections by interacting with others. Interactions help us fulfill our fundamental need and desire for connections.

I see interactions as a two-way exchange, or "conversation" with another participant, such as a person or an interactive system. In these "conversations" both participants are giving and receiving from each other. In an interaction, we acknowledge the other and assert ourselves by engaging the other. We wait for a response. In this moment, we are exposed, but open and ready to receive. We are vulnerable.

Vulnerability is a challenging emotion for us as it is inherently risky. We will either receive a response from the other participant or be ignored. Sometimes, the risk may be worth the reward. When we do get a response, we may be grateful, learn something new, make a connection, or gain confidence. However, some participants may not be able to face the level of vulnerability they experience and ultimately may not interact with the system. Vulnerability is challenge, but it is also an opportunity to create more meaningful experiences with participants.

Even at the smallest scale of interactions we are vulnerable at some level. When we save a text document on the computer, we hope that the document is saved and not lost. We trust photos we take will be on our mobile device until we decide otherwise. We follow our GPS to guide us through an unfamiliar city and trust it won't tell us to turn down a one-way street. When our computer freezes, we hope our data is not lost. As designers, we should consider the inherent vulnerability that exists across all scales of interactions.

DEFINITION

Traditional definitions of vulnerability speak to the possibility of pain, injury, or more specifically getting wounded. Vulnerability often suggests a negative connotation as it is associated with weakness. However, being vulnerable is being courageous. I see vulnerabil-ity as a unique state that can be formed around moments of exposure.

Brene Brown, a contemporary social psychologist and foundational researcher on vulnerability, declares that being vulnerable is "daring greatly". According to Dr. Brown, "vulnerability is the core, the heart, the center, of meaningful experiences." Just as vulnerability plays a key role in our interactions with each other, it also plays a role with interactive experiences with dynamic media.

> "Yes, we are totally exposed when we are vulnerable. Yes, we are in the torture chamber that we call uncertainty. And, yes, we're taking a huge emotional risk when we allow ourselves to be vulnerable. But there's no equation where taking risk, braving uncertainty, and opening up ourselves to emotional exposure equals weakness."
>
> **BRENE BROWN**

In a trip to Zion National Park I visited a rock formation named Weeping Rock. Weeping Rock was a large, porous, sandstone rock. Over time, this rock soaked in water and contained the water. As the internal water pressure built up, cracks formed to release the water. Beautiful waterfalls and botanical gardens formed in these water filled cracks. In the same way, we have built up defenses that act as a container for our emotional self. Over time our need and desire for connections or interactions with others can break through this metaphorical container resulting in a crack. These cracks are when we are vulnerable. Operating through these cracks is uncomfortable, and we feel exposed, but there is also opportunity connections and relationships can be created that provide meaning for our lives. Vulnerability is both an internal and external struggle; a universal experience that occurs across geographical boundaries, gender, age, digital and physical space, and ages.

In Professor Gunta Kaza's Design as Experience class , we were asked to design a response around a stimulus. One week, the stimulus was a tea towel. My tea towel was blue and white and tightly woven together. My response to the towel was an investigation of the holes. These holes were imperfect places where the towel was exposed and vulnerable. However, in these holes, I was able to glimpse the inside of the tightly woven towel. These vulnerable places gave me the opportunity to experience the towel in ways I couldn't have otherwise.

THE EXPERIENCE OF VULNERABILITY

I begin some mornings with a jog on the Minuteman bikeway near where I live. Over the years, these jogs have taken on different meanings to me. Some mornings these jogs were serious training runs for marathons. Other times, the jogs are way to peacefully enjoy feeling connected to the community of runners and walkers in the morning. Much of what makes these runs special is the small interactions I have with others. When someone is approaching me, there's always a choice. Do I look at the person and try to engage with them? This can be as simple as a smile or a good morning. Then, I wait to for a response, which may or may not come. I may get completely ignored or I may get a response.

Over the years, I've been fortunate to build up a sense of community with the people on the pathway through these small interactions. In particular, there's one older man who never fails to greet me. His walks are so consistently timed that I frequently can tell how much ahead or behind schedule based on when we approached each other on the bike path way. We've never had a significant conversation, but he's a staple part of many of my mornings. This is the case of many of the interactions I've had on the bike path way and the reason why the morning community is a special start to my day.

These interactions clearly highlight the experience of vulnerability. In these interactions, I have a *pre-condition.* Are my defenses down? Am I willing to engage with someone else? Am I in the right mental space for this? Or am I too focused on this serious run? After the preconditions there's the actual *state of vulnerability* in this interaction. This is the moment when I've engaged with someone else (usually through a greeting) and am waiting for a response. I am open and waiting. However, I have no guarantees whether I'll be acknowledged or responded too by the other person. Then, a *result* will happen. Either the person will acknowledge my presences and return the greeting or not.

VULNERABILITY & UNFAMILIAR SYSTEMS

Over time and experience, we build trust with people and the systems we interact with which reduces the level of vulnerability we experience. We trust that close friends will listen to us without judgment and give us advice. With interactive systems, we trust that the traffic map is accurate, that the best route is given to us, and that sending information to our bank account is secure.

How can we better support interactions knowing that the participant is experiencing some level of vulnerability? Can we improve the space or context the interaction is happening? How can the interface itself support vulnerable participants?

VULNERABILITY SURVEY

I was curious about vulnerability and the perceptions of vulnerability. To explore this notion, I created a survey online to better understand the perception of the experience of being vulnerable with these questions:

> 1. When have you felt vulnerable?
> 2. What does being vulnerable feel like?
> 3. How do you cope when you are in a vulnerable situation?

Then, I had a separate page where I had one question:

> 4. Have you ever felt vulnerable when using technology? When?

One thing I learned from the survey is how uncomfortable it is to talk about vulnerability. After about an hour of leaving the survey up, I received an alarm from Survey Monkey that my survey was inherently risky as it had a high rate of people starting and stopping the survey. Over 49% of the people started the survey and didn't finish it.

I was also surprised at the answers, especially the rawness of the emotions and humanness of the answer through the anonymous survey. Some people recognized when they felt vulnerable, others didn't explicitly. There were a variety of strategies for dealing with vulnerability.

Reading through the answers, I was surprised at the 50 responses across all geographical locations, age groups, income, and gender. There were a few responses I immediately identified as female, but were male. Surprisingly, leaving the survey up I felt a deep sense of vulnerability as the designer of the survey. When people responded honestly, I was touched and grateful. When people ignored my survey with false answers or didn't respond at all, I was hurt.

My response in reading these responses was compassion. I also felt a sense of awe at the bravery for the personal challenges people faced and shared. Many of the times reading other people's emotions, I could relate to similar emotions and feelings even without experiencing the specific situation. As designers, we can and should draw on our own experiences of vulnerability when designing for others. Most of all, we should have gratitude when a participant is brave enough and an interaction has happened.

When have you felt vulnerable? Alone. Away from civilization. Parking lots. daughter was raped. Being alone in a place full of strangers. o. During apt ins to another and risked being rejected. Couple of times. Jim's death, auto acci cently. When I have no money. When I can't do nothing to improve my paren transit late at night. Hundreds. Not knowing where I am or where I am going someone I did not know well act as if we were best friends. Being at the wror play football. When someone tries to catch me up in a lie. When I couldn't understand the question. N/A. I haven't in a long time. When married to me vulnerability...so the only time I'm willing to report to you is this survey que Daily !! When I am shopping. I don't. When I was in an unruly cord. When When in a bad part of town at night. When being pressured by a salesperso change my service. When I was unemployed. During my divorced. When figl tionships, doctors. When hoping a guy would like me. When institutionalize a job that I don't feel I will be able to handle. Almost all the time. Yesterday. and having an audience. After having a baby. After a death of a loved one. Wl be a few times in my life I am sure. When I less confident. When I'm depress in the house. None. Never. What does it feel like? Scared, weak, defenseless, past, present, or the future. Inability to shield oneself from an onslaught. Lot tective masks & showing up as myself. Hurt and upset. Loss of security, u know. Exposed. Lack of control. Being judged of evaluated by other people. Ir kind of like a hurt feeling. Scared. See above. N/a. Not in control. Horrible. C ious. Like being taking advantage of. Exposed. Fearful, defenseless, unsafe. \ out choice, powerless, exposed. Insecurity nervousness. Cautious, timid. H field. I feel I must walk softly at all times, lest I be noticed. Uneasy. It feels guard. Not caring who knows how you feel. Scared, adrenaline pump........I c like with keys or some object. Try to be positive and work my way out of it. I control of every circumstance, who has planned all things in theca retain of t do as quickly as possible and get out. Look for a way out. I used to have dog spouse or talking to someone I know. I allow myself to feel the discomfort don't feel better about it until I confront the person that made met eel that w to my sister. Stayc alm. Try to ground myself. Stick to the facts. Focus on my tunity to connect with people and change if need be. By taking the p. I think fident. Sleep or talk to someone. Make sure that I am away or my surroundir Get out of the situation that caused my vulnerable state. I stay away from th scripture, think positively, be purposeful about guarding myself — mentally, es. Cry and pray. Seek advice from the people I trust. Breathing, friends, wal positive and know my surroundings. Cry. Trust family. Pray, motivate myself for ways to fix and overcome. I try to remember that when other people are.

Alone with a male in an elevator. Last week. I don't know. Never. When my
spections, fire alarms, unknown people at the door. When I exposed my truth
dent, after darkness in August 4, in NYC once, and many more especially re-
nt's health. o. Among a crowd of strangers. Starting a new job. Riding public
. Not knowing what to do at work when something new is presented. Having
ng place at the wrong time. When a girl doesn't like me. When I didn't get to
run as fast as I wanted. Alone in a parking garage at night downtown. Don't
ex. This is weird into a survey...No info on who is requesting this info about
estion. This survey question makes me feel vulnerable and a little pissed off.
I was around someone angry. When I was sick or otherwise incapacitated.
. When someone claiming to be with my phone company tries to get me to
hting with my current husband. When I can't help my children. Driving, rela-
ed. When hearing voices and voice critizing me. 3. Alot. 6. When asked to do
Being in a relationship, giving a presentation for work/class, playing a sport
en my husband lost his job. When my job tasks at work were changed. May-
ed. When I'm totally out of money. When I was afraid someone was breaking
helps. Crap. I don't know. Don't know. Inability to do anything to change the
ts of anxiety and nervousness. Fearful. Anxiety, uncertainty. Taking off all pro-
nable to handle a situation. It feels like a desperation and madness. Don't
nsecure. Helpless, hopeless, not knowing that is going to happen to me. Ehh
On edge. Questioning the motives of the man behind the curtain. Fearful anx-
Weak, open to attack, exposed, unguarded, defenseless. Out of control. With-
Horrible. Helpless, depressing. Not in control. Like being naked in an open
very exposing. No control, scared, unsure. Scary? You are unable to stand
on't know. I don't know. How do you cope? Pray, get ready to protect myself
don't know. Not in that situation. I lift the situation up to the God who is in
ime and space, who is my shield, my defender and friend. Do what I came to
gs, but apt mgr forced me to get rid of them, so now I sometimes rely on my
& accept myself & love myself regardless of the outcome. I feel upset and I
 way. Hope it yes over with as soon as possible — I keep moving forward. Talk
strengths and realize that vulnerability is not always bad - It can be an oppor-
of alternative escapes, routes, or how to get myself back on track and be con-
gs. ? N/A. Fix the situation that causes it. I don't. Defensive. Prayer self talk.
ose situations. I try to get out as fast as I can. Remain productive; pray, read
emotionally and physically, work to be consciously away of my circumstanc-
away. Sleep try to think of other things talk about it with the voice. Try to be
. I just do. You get on with your shit and move forward. I address it and look
n the same situation that I am in, I do not judge them so I know they are not

TIC TAC TOE

Tic Tac Toe was a collaborative project with my classmate Maria Stangel. We had seen similarities across our projects and wanted to work together. In this project, we wanted to design a system that facilitates interaction between participants. We quickly settled on the idea of a game as a way to encourage participants to interact with each other. Because of the universality, simplicity, and accessibility, we chose tic tac toe as the game for our project.

One challenge of using a game was the inherent competition. We wanted to change competitive interactions between players into collaborative interactions. To address this challenge, we introduced sound as an additional layer on top of the game. Each square in the *Tic Tac Toe* game would have a unique pitch assigned to it. When a piece was placed in that square, the corresponding pitch would be played. As other pieces were placed on squares, each newly played piece's note is combined with the previous note to form a
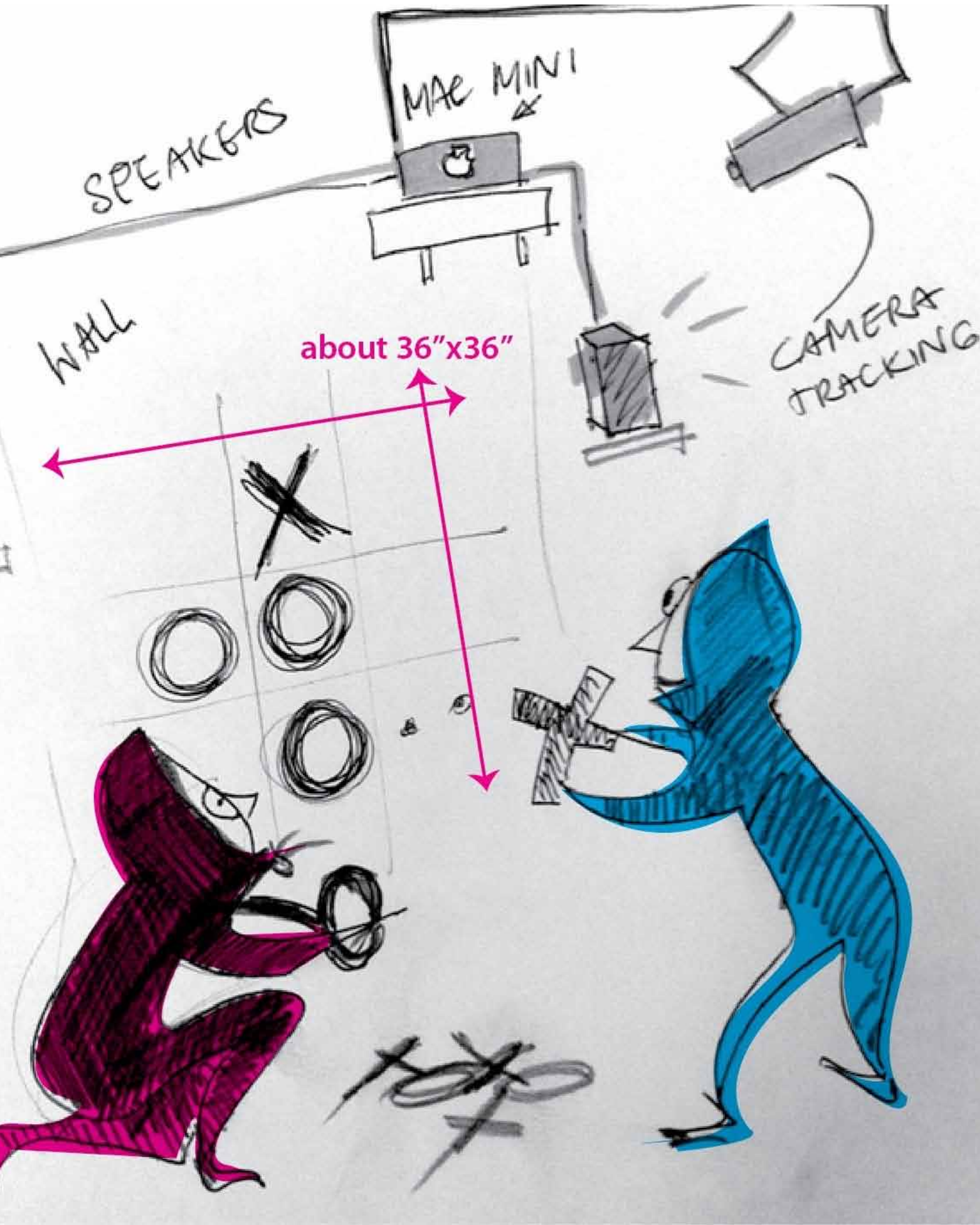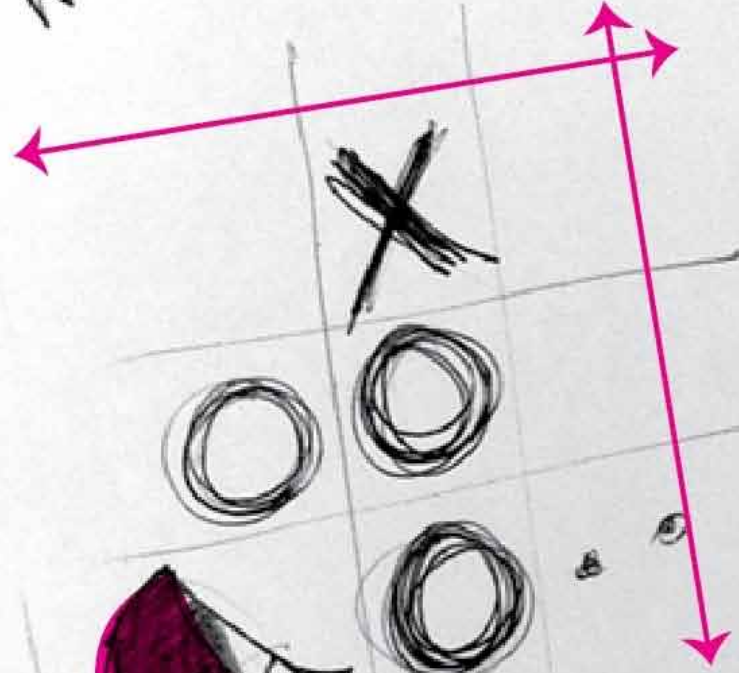
How would participants respond to interacting with a familiar game with this new, unfamiliar sound layer? We hoped people would use the metaphor of taking turns from the game to collaborate to make sounds. Would adding sound to the well-known game of *Tic Tac Toe* change how the pieces were played? How does adding sound change our relationship and interaction across the participants? Most importantly, how could we use sounds to encourage interaction between participants in the game? If participants learned the underlying rules for the sound, would they continue playing as a traditional game or would they use the pieces and squares as a way to create sound compositions together?

PROCESS

In choosing the familiar tic tac toe game as the basis for our project, we hoped that participants would feel comfortable interacting with the system and each other. We also considered how the scale of the game would affect the way participants would approach the game. For small napkin-sized games, we hypothesized that the game would be intimate and personal. For large table-size games, we hypothesized that there would be more freedom and would better support exploration and non-serious play. We wanted the game to feel larger than life in the hope it would support the exploration of the sound element in addition to the game.

Then, we considered the participants physical relationship to the game. Would the game exist on a wall? Or would the game exist on a table? How does the game change depending on its relationship to the participants in space? With a wall-based game, it would be challenging to determine the most accessible height. For example, children may have a difficult time placing pieces if the game is placed too high on the wall, and adults may be uncomfortable leaning down low to place the piece. Also, a wall-based game would broadcast the game to the entire room. This might put pressure and anxiety on the participants to perform well for observers. We settled on a table-top game with large pieces to keep the game accessible and fun while removing possible performance anxiety.

PROTOTYPING & TESTING

To test out our hypothesis about the scale factors, we prototyped some small laser cut "X" and "O" pieces and played games ourselves. While this was fun, the small-scale games felt intimate and fragile. We wanted the project to be more inviting to participants to play, so we continued to explore the large scale option.

We made a software prototype in Processing to explore the interaction between gameplay

switch
speaker
light
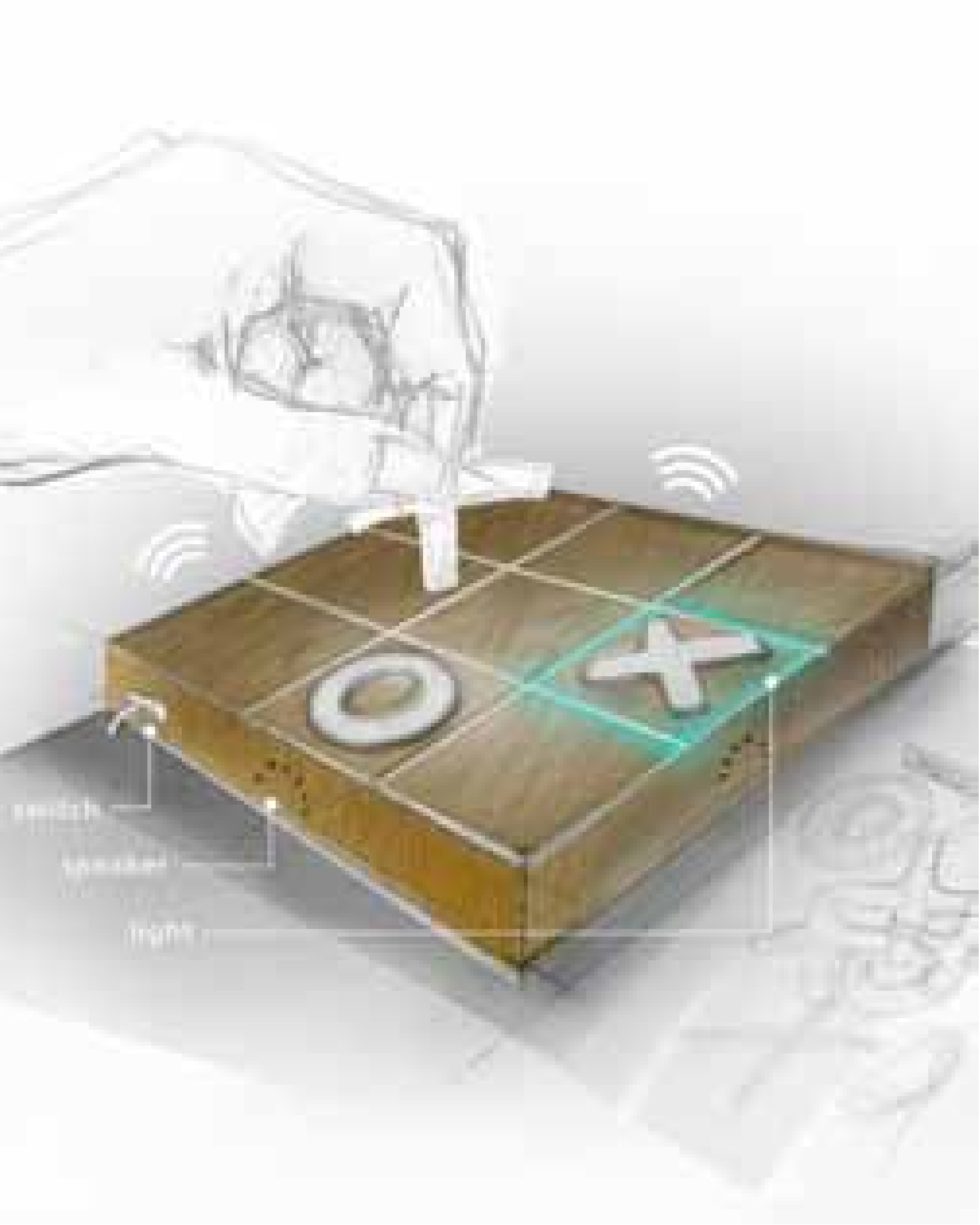
and sound. This software prototype modeled a full game including the detection for who's turn it was, what shape was next to be played, logic for detecting wins and stalemates, and the visual rendering of the game pieces and board. In addition, each square on the board was mapped to a specific pitch from a C scale. Initially, only the associated note with the square the "X" or "O" was placed in was played. While this made the game seem more "alive" and reactive, the sound seemed like an effect. If a player won the game, a chord of notes would be played. The game experience was the same and there was little change.

On a second iteration of the software prototype, I stored each piece that had been played and the order the notes had been played to capture the evolution of the gameplay over time. As a new piece was placed on the board, the prototype would play a sequence of notes representing all the previously placed pieces in the order the pieces were played, resulting in a musical representation of the game. This simple addition slowed down the pace of the gameplay from the rapid games we had been playing. As the gameplay slowed down due to the sounds, it was easier to focus on the sound aspect of the game instead of trying to win the game. This brought attention to the sound. We hoped participants would be more willing to see each "move" in the game as a way to influence the evolving sound representation that they were creating *with* the other player instead of trying to beat the other player and win the game.

After testing the logic and game mechanics, I moved off screen to see how to prototype a system to recognize physical "X" and "O" shapes on a table-top surface. The cheapest and quickest way to do this was to write an algorithm and use computer vision. Computer vision was not only a low-cost way to prototype this system but also a way for us to keep our technology hidden as the physical pieces themselves did not require specific sensors. The Kinect camera sensor allowed us a way to rapidly detect shapes in space within a specific range of the system.

To test out the software, I used sample "X" and "O"s printed from a computer in the first iteration of the off-screen prototype system. This allowed me to define programmatically what an "X" looked like from the Kinect's point of view as well as the "O" shape. I created metrics for each shape based on parameters such as the circumference, ratios of width to height, and overall area of the detected shape.

In designing the physical form of this prototype, we thought that approaching a physical table was more preferable and accessible to participants than a computer screen. This was

especially important as the project was going to be shown in a social setting such as the 2012 Fresh Media exhibition in Boston. Since we were more interested in interactions between participants, we wanted as much of this game to be in real space as possible. We found the perfect table in the DMI studio to use as the basis for an interactive table-top *Tic Tac Toe* game. At the bottom of this table we hid a Kinect camera, speakers, and computer to read in the shapes placed at the top of the table and play the associated sounds.

We continued to work on the design of the physical pieces themselves. We laser cut pieces out of thick, black board. These oversized pieces were lightweight, making the game feel

TIC TAC TOE

One challenge of working with this table was finding a material that allowed the Kinect and computer at the bottom to detect the shapes of the "X" and "O" pieces, but not the shadows of the people leaning over the table. We found a milky plastic material that was able to filter out these shadows but still allowed the shape of the pieces to be filtered. We also leveraged the Kinect's ability to detect range and adapted the software to filter out and only analyze visual information within a couple of feet of the camera, like the pieces.

CONCLUSION

In observing participants, I saw that the familiarity of the game lowered the threshold for people to interact with the system. At the same show, I had a prototype for the *Sound of Type* project, which had significantly less traffic due to the abstract and unfamiliar interface (see *Sound of Type* case study). I believe that the familiarity with the game and the form of the prototype lowered the vulnerability participants experienced with the system. The large scale game and lightweight pieces, also created a positive context for interaction.

Surprisingly, I saw the number of people "playing" the game change throughout the night. While pairs of people frequently played the game, I sometimes observed one person trying it by themselves and exploring the sound elements. This was a surprise to me to see individuals feeling confident enough to explore this system that was traditionally a game for multiple people. Other times I saw three or four people playing the game together and exploring the sound combinations. For the participants who noticed the sound and explored the sound layer, some "played" the notes alone and ignored the gameplay while others played the game and ignored the sounds. When there were multiple participants playing the game together, the participants took the metaphor from the game and took turns "playing" the sounds.

Through the simple addition of sound on top of the game where each move added note to the sound representation of the game, we were able to alter a competitive game into a collaborative exploration of sound for both participants. While the sound compositions were simple, there were a large number of possible sound combinations. I believe because of the simplicity of the sounds and the system itself, participants were willing to explore the large range of possibilities because the system was so accessible. If it was more complex to create sounds, I believe more participants would have been turned off by the system.

With this project, the sound altered how the game was played for some participants. I observed some participants systematically trying each square to decipher the sound mapping as well as some unusual placements for "X" and "O" pieces that did not make sense for someone attempting to win a tic tac toe game. Other participants completely ignored the sound aspect and continued playing the game as usual. This is consistent with observations across other projects. I observed similar approaches and interaction styles and discuss them further in the participant strategies section in the *Tactile Diorama*.

The most frequent feedback we received was that we should use light to highlight the associated square when each note is played. This was especially true at the Fresh Media exhibition when this project was competing for sound with other projects. Using light to highlight the square would definitely improve the experience of the game as it would provide a visual cue to help participants understand the underlying mapping for sounds. In addition, I think that having the table respond to a participant's presence, through sound and light cues, would more clearly indicate to the participant that the table was interactive.

Finally, I unexpectedly saw how an object was able to create a space around it. By designing a game table that people could gather around, there was an implicit "space" created. This space was light and social due to the form of the table and the pieces. I observed people talking and interacting regardless of whether they were playing the game. This was a surprising and unintended way we achieved the original goals of the project, facilitating interactions across participants. We observed participants talking, drinking, laughing, exchanging stories. Sometimes the pieces were moved during these conversations as almost a focus point or distraction for any awkwardness. It appeared that the *Tic Tac Toe* game became a container for any social awkwardness. In contrast, for the *Sound of Type* project which was also installed at the same exhibition, I had a seemingly serious space around the piece as it was very small and participants had to crouch and lean in. The close proximity, physical awkwardness resulting form the sound constraint and abstract interface asked more from participants. We, as designers, should also consider the space that the system exists in and how that contributes to the vulnerability participants feel when interacting with systems.
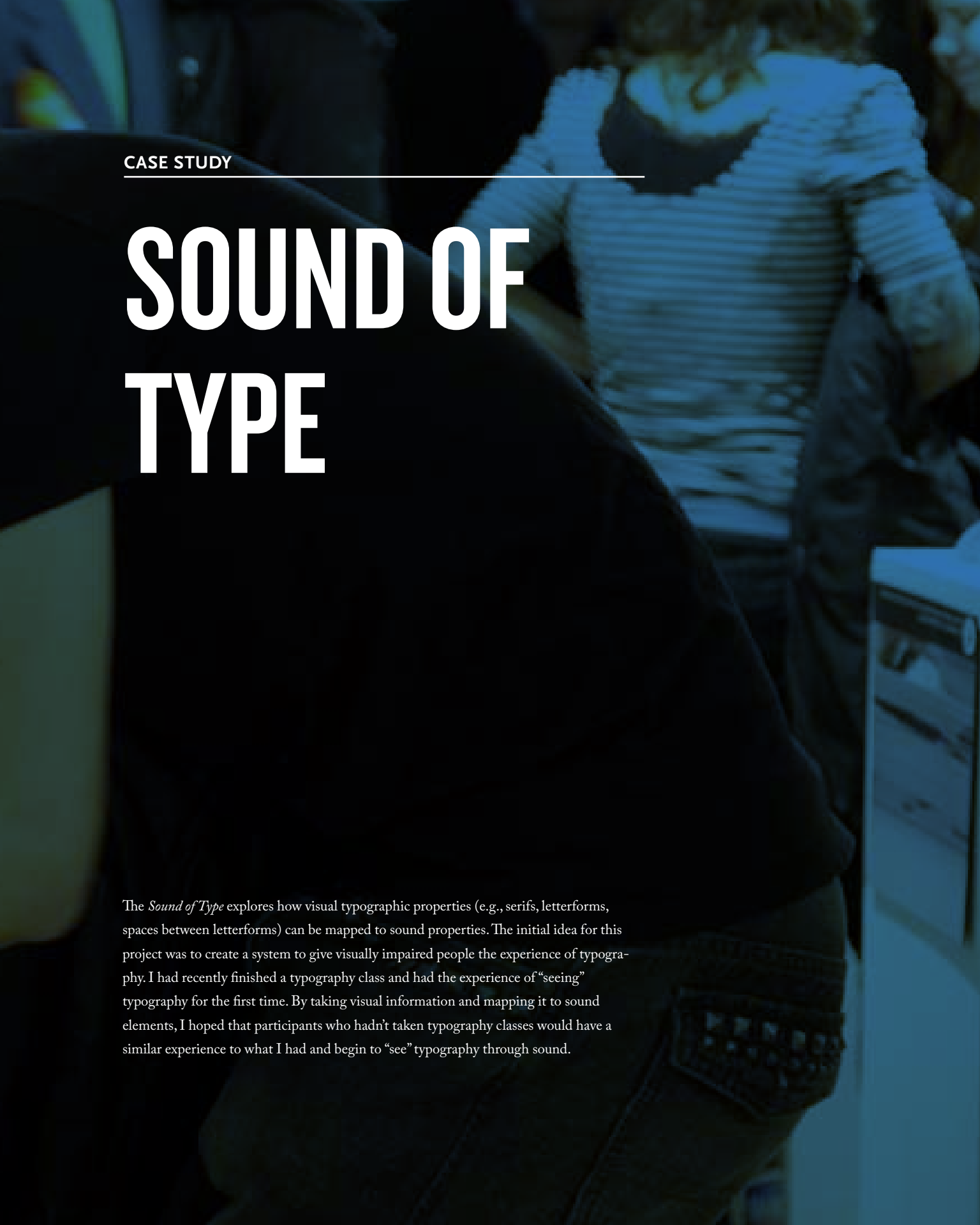
SOUND OF TYPE

The *Sound of Type* explores how visual typographic properties (e.g., serifs, letterforms, spaces between letterforms) can be mapped to sound properties. The initial idea for this project was to create a system to give visually impaired people the experience of typography. I had recently finished a typography class and had the experience of "seeing" typography for the first time. By taking visual information and mapping it to sound elements, I hoped that participants who hadn't taken typography classes would have a similar experience to what I had and begin to "see" typography through sound.
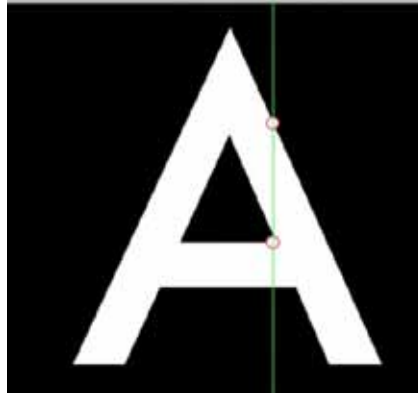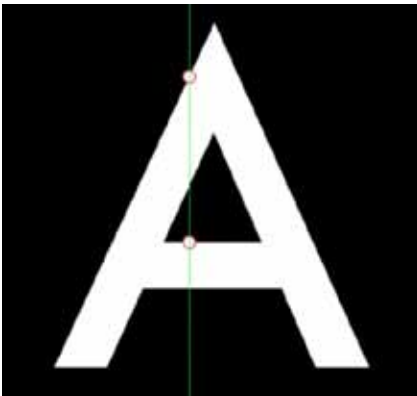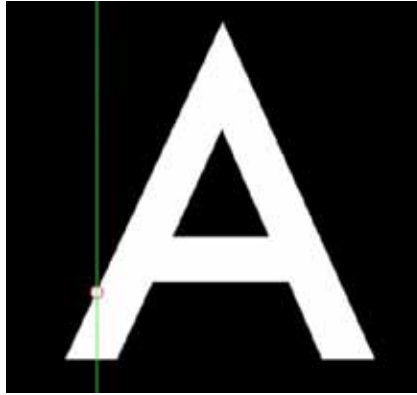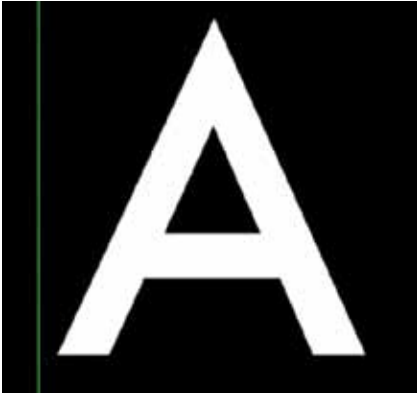
Processing sketch "playing" the Futura A

Regarding vulnerability and interactive experiences, I was interested in observing interactions with something familiar, letterforms, to do something new, create sound compositions. Every participant is familiar with letterforms, but using them to create sound compositions is something different. How does the interactive experience change when participants interact with something familiar in unfamiliar ways? Is there a conflict between what we are familiar with the letterforms and how the system is using the letterforms? Does the familiarity with letterforms encourage participant interaction?

PROCESS

As there are many ways to map visual information to sound, I wanted to use a simple letterform as a starting point. I chose to start with the geometric typeface, Futura, and the letter "A". I imagined how the Futura "A" would sound as it was "played" from left to right. What would the rise of the letterform sound like to the sharp apex of the letterform? What would the decline of the letterform sound like? What would the crossbar sound line? I thought it would sound similar to sequentially playing the notes from a C major scale, first going up the scale to a sharp, crisp pitch and then back down the scale. In parallel, the crossbar would maintain the same note as it was read.

To explore this, I wrote a program in Processing that would read an image of a letterform and scan the letterform from left to right. As the letter was being scanned, or "played", my algorithm analyzed the vertical pixels to detect the shift between the black pixels and the white pixels to detect the edges of the letterform. Then, I mapped the height to the appropriate musical note on the scale.

After I heard this one letterform, I wanted to hear what other letterforms sounded like and combinations of letterforms, or words, sounded like. I created a simple black console where I could type in whatever letters I wanted to be played from left to right. In this console, I could also select a typeface from a drop down box to change the font. At this point, I realized that I needed a way to represent the thickness of the stroke. For example, Didot's drastic change in thicks and thins would have to sound different than the constant thickness of Futura. I knew this would sound different, so I mapped the thickness of the stroke to the volume of the pitch.

As I was experimenting with words, I discovered how sound compositions could be made from the letterform combinations. First, I started exploring what words sounded like. Then, I moved on from listening to "words" and began to choose specific forms to make the sounds I wanted to start and end the compositions.

HAMBUR

Processing program, "playing"
letters from left to right

Then, I was interested in seeing how I could manipulate and transform the letterforms themselves to create sound compositions. So I printed out letterforms from my computer, cut them, repositioned them on the floor and used a web camera to process the letterforms as before and hear them. I was able to make more interesting shapes based off of, but not limited to, the alphabet. I began transforming this base set of letters by cutting the shapes into the forms I wanted to create a sound experience that I wanted.

I also explored hand drawn letters and letters found in the environment, such as on a sweater I was wearing. It was interesting to see how the letters sounded when they were shaped and deformed on my sweatshirt.

PROTOTYPING: FRESH MEDIA

At this stage, I wanted to get this system in front of participants to see how their experiences compared to my own. I wanted to develop a system where participants could move physical letterforms in space to create sound compositions. First, I laser cut a full alphabet from the Futura, Clarendon, and Didot typefaces. It was surprising to me feeling and holding the letterforms in my hand. I could feel the sharp tip of some of the Futura letterforms. I also felt the fragility of the Didot letterforms with the extremely thin strokes. Holding physical letterforms in my hand gave me an expected way to experience the letterforms. I hoped that the tactile letterforms would provide a method for participants to manipulate the letterforms (e.g., rotations) or keep them upright as usual.

For the physical setup of the system, I struggled to find a way to mount a camera to "read" the letterforms. Luckily, one of my classmates, Shan Gao, had designed a wooden setup to hold a web camera above a table so that the camera could look down on a table to read an image. This was the same issue I was trying to solve! Shan graciously shared her design with me, and I laser cut a similar stand to hold a web camera. I placed a horizontal strip of paper below the camera to indicate where letters should be placed to be scanned in and read by this system.

In setting up this project at Fresh Media, one issue I ran into was unanticipated noise distraction from other nearby sound pieces. When testing out the system myself, I couldn't hear the sound output. To deal with this issue, I connected a pair of headphones I had with me. Unfortunately, the cord was short which required people to stand at an uncomfortable angle to interact with the system. The headphones also made this a one person experience. In observing people interact with my own and other projects observations at Fresh Media, I noticed that many participants liked to interact with projects with another person. In the future, I would be interested in exploring other sound options, like speakers, to support multiple participants at one time.

Many people at Fresh Media were hesitant to try this system. Because the interface was non-traditional, it was not clear what participants were supposed to do or expect based on their action. I needed to provide clear instructions and guidance for approaching the system. One issue I discovered through user testing was the lack of visual feedback. My system was continuously looping and would play any letters it came across. However, it was not possible to tell which letter was being "played" at the moment. This was a major issue as a participant could add, remove, or change a letter, but not hear the resulting sound

this update until the software looped backed to scanning that letter, sometimes a significant amount of time, making it hard to understand. At the end of the show, I brought my laptop out from under the table and showed a girl the screen which showed the letters and what was currently being scanned. There was a huge "aha" moment for the participant. I realize this was the missing piece in this puzzle. This subtle shift in the feedback quality improved the overall two-way exchange of information. I also observed a common entry point for using the system. Most participants started with spelling their name to "hear" what it sounded like. This common entry point made jumping into the system easier as there was a direction to start with instead of facing too many possibilities.

Based on all these observations, I wanted to think about how I could design for the challenges these participants faced interacting with such an unfamiliar system in the future. What process do participants go through? How can this process shape how I think about designing for this initial interaction with participants?

INTERACTIVE PROCESS

Based on my observations, I developed a process to investigate interactive experiences. The interactive process is composed of the following stages: *awareness*, *exploration*, *interaction*, and *knowing*.

AWARENESS

The first stage in this process is awareness. Before any type of interaction with a new interface can occur, the participant must be aware of the system. While this may seem trivial on the surface, I think this can be a complex challenge to designers. How do we facilitate awareness of our systems? Do we try to seduce participants into interacting with our systems? Do we try to broadcast the presence of the system? Or does this make the system overwhelming and intimidating? How do we facilitate awareness when there are so many constant distractions and competitions for attention around us? And how do you design the space/context around the installation to facilitate awareness? As an example, in the *Light Pipes* project I use darkness as a way to remove extraneous distractions from the space and light as a focal point to call attention to the interface.

EXPLORATION

The second stage in this process is exploration. After the participant is aware of the system, they will explore the system to understand how to interact with it. In this stage, the participant is looking for affordances and key focal points. In the *Tic Tac Toe* project, I used the tic tac toe game as a metaphor for interacting with the sound layer of the system. As an

example, the *Sound of Type* had less clear affordances making it difficult to understand how to interact with it. Future iterations could include instructions and other considerations to the form of the system.

INTERACTION

Interaction is the next phase in this process. In the interaction phase, participants perform some action to the system and wait for a reaction . The time delay between the participant's action and the system's reaction is a critical component of this stage and a design opportunity. If the time delay is small, participants can more readily link the reaction of the system to their initial action, meaning it is easier for the participant to deduce that the system is responding to their action. If the time delay between the systems reaction to the participant's initial action is large, it is harder for the participant to understand the link between their action and the system's reaction. This was one challenge I observed participants face in the *Sound of Type* project at Fresh Media. Participants would move a piece around to be played, and it was unclear when it was actually played.

KNOWING

Knowing is the last phase of this process. Once a participant knows and understands the system, it is no longer an unfamiliar system. I don't believe that each participant has to know and understand every system they interact with. I think there are many opportunities to have positive experiences without fully knowing the system. Maybe not knowing the full implementation of the system provides a sense of wonder and magic.

I also think there are different "levels" of knowing. For example, a participant can know how to interact with the system, a part of the system, or no part of the system. I also believe that "knowing" a system can change how participants interact with the system. In *Tic Tac Toe*, once participants learned the rules of the sound with respect to the game grid, participants began "playing" the system as a sound composition tool instead of a tic tac toe game. Do they try to push the system to its edges and find the limitations? Do participants find new ways to interact with the system?

INVITATIONS & THRESHOLDS

It can be a challenge to get participants to move from the awareness stage to the exploration stage. There is an implicit threshold that participants cross before they move to explore the system.

"I think it's better to not know certain things. It gives the world an extra bit of mystery, which is important to us human beings."

BJ NOVAK

One approach that helps participants cross this threshold is the use of invitation. In the second iteration of *Sound of Type,* I investigated this process and saw the power of verbal invitations to participants to encourage interaction with the system.

An invitation can take many forms, such as the curation of the space, a welcome mat at the entrance to an apartment, a smile from or a verbal invitation. In person person-to person interactions, a gaze in a person's direction acts as an acknowledgement of the other person's presence and an invitation for interaction. Designer Ying Gao, has created a dress, called the *(no)where(now)here* dress which calls attention to this moment of invitation by gaze. The designed dress responds to another's gaze by lighting up as someone gazes at the dress wearer. Karolina Sobecka also uses gaze in her window installation, *it's you.* In the installation, the projected people gaze back to pedestrians on the street to invite them to explore the installation.

As designers, we must consider thresholds that participants cross to interact with our systems. Thresholds can be a physical entry as well as a metaphorical decision point when the participant decides to interact with the system. When designing an installation in physical space, how do we help support this transition into this space?

Random International's *Rain Room* had a long hallway that would slowly become darker as participants neared the work. As participants approached the *Rain Room*, they would begin to hear the sounds of rain falling down from the ceiling to prepare them for the work. This slow transition helped prepare participants to cross the threshold of interacting with the work as they literally had several minutes to slowly enter the dark space and began experiencing the sound of the work before seeing the work itself it.

INTERACTION PROCESS & MYTH

"Lying on our backs, we look up at the night sky. This is where stories began, under the aegis of the multitude of stars which at night filch certitudes and sometimes return them as faith. Those who first invented and then named the constellations were storytellers. Tracing an imaginary line between a cluster of stars gave them an image and an identity. The stars threaded on that line were like events threaded on a narrative. Imagining the constellations did not of course change the stars, nor did it change the black emptiness that surrounds them. What it changed was the way people read the night sky."

JOHN BERGER

We learn through myth, and more broadly stories. We learn about self, others, and the world. We relay events and knowledge to friends through story. We learn about our family, our culture, and our history through story.

Myths in particular can be seen as sacred stories. These narratives provide knowledge on the human struggle as well as large questions about how the world was created. According to Karen Armstrong in *A Short History of Myth*, myths act as guides that enable us to live more richly. Armstrong describes how myths were " invented stories that enabled us to place our lives in a larger setting, that reveled an underlying pattern, and gave us a sense that, against all the depressing and chaotic evidence to the contrary, life had meaning and value." Many of the most powerful and impactful myths are about when we are vulnerable. These myths highlight challenges and struggles in which we perform a new task in an unknown place, similar to interacting with a new system.

One observation I had when defining this process was how similar the initial user experience process is to the mono myth narrative structure, or Hero's Journey, as defined by Joseph Campbell. In both cases, a person is asked to cross a threshold into the unknown, surmount challenges, and bring back some sense of knowing. Because of this, I believe that the mythic structure is a good framework for considering the challenging of this process in our design practice. This narrative structure provides a language and contextual framework to better design for interactive experiences as it highlights the challenges that the participants faces.

The struggle of the hero in the hero's journey mirrors the struggle of the participant interacting with unfamiliar interfaces. In this structure, participants take on the role of the hero. Participants respond to a call to adventure (an invitation). Participants cross a threshold and descend into the unknown to explore. Then, they navigate perils through their actions, similar to the interaction phase. This ultimately results in some transformation or revelation, similar to knowing or understanding.

THE SOUND OF TYPE V2

I wanted to test out this interaction process on another iteration of the *Sound of Type* project. I also wanted to test this project with typography students as I hoped that they would have an interest in the project, hopefully lowering the barrier to entry. To simplify the interface, I returned to the console-based interface which allowed participants to type in letters to be read from left to right. This interface was more familiar than the Fresh Media setup as it was computer-based and typefaces could also be switched through a drop down menu.
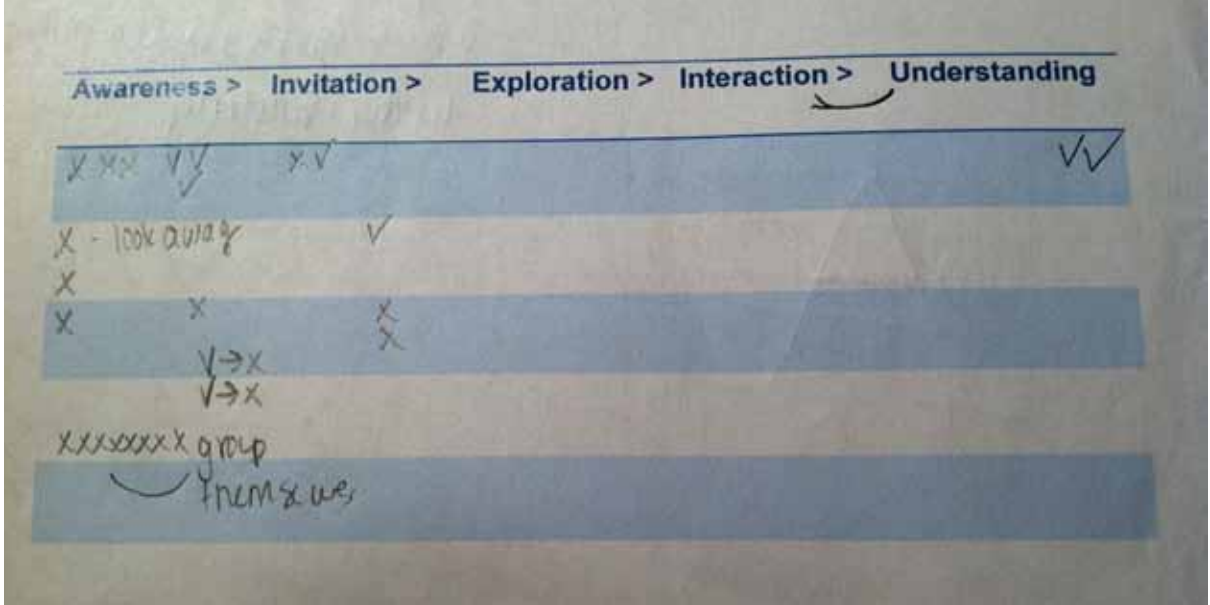
Results from testing

I brought my computer to MassArt's campus. I found and set-up a table and posted some small signs advertising the title of the project. I stood by my project and eagerly waited for the typography students to walk by on the way to their class.

RESULTS

The first thing I noticed in testing this project was how far students went to avoid contact with me. For example, some students would stare at a wall to their left as they walked straight forward. Other students would immediately pull out their iPhone when they saw me set up. I started observing similar avoidance patterns in other situations as well. For example, as I was walking down a hallway at my work one day, another person at the end of the hallway walking toward me would find another place to gaze until the last moment when a greeting was initiated. I also observed my own habit for doing the same thing. I consciously worked towards not continuing this habit.

Something had to change or there wouldn't be any user testing. "Hi, I'm Stephanie, a graduate student at DMI, can I get your help with my typography project?" This question was a clear invitation to ask others for their help. As a designer of the system, I became vulnerable waiting for the participant to interact or not interact with my system. As the students were all taking a typography class, I had hoped that highlighting it was a typography project would encourage students to participate as they were familiar with the topic. With this invitation, I had more success getting people across that initial threshold and interacting with the system.

I also noticed it was much easier to interact with and engage individual students than groups of students. It got significantly more challenging as students began clumping together in groups as they got off the elevator. In groups, students could use each other for a distraction when walking down the hall. Also, when I was extending an invitation, I had to pick which student to interact with. This made it unclear to students who I was initially reaching out and inviting in the group.

During this morning, I had several participants that accepted my invitation and were willing to try the system. After the first student, I realized that I needed a quick way to give them an overview of the system. I needed to metaphorically act as a "guide" to show them the rules and the language of the system before I let them explore on their own. To do this, I demoed the sounds of the Futura "A" and explained the system.

After this demonstration, one student was ready to independently to try out the system on their own. I was surprised at the letters they chose. Curiously, the student chose "P", "Q", and "W". I asked the student about this. He wanted to see how the system responded to the special characteristics of these letters. After trying these letters he had a better understanding of the system and immediately jumped into trying out to make words to lead to sound compositions. However, these "words" were purely based on the visual elements of the letterforms. Another participant did not want to explore and try out the system after the short Futura demonstration. Instead, she wanted a detailed walk through with a close guide helping them think about what to do next and which letters to try. She wasn't able to see what her next steps were with the system and the freedom was too broad for her to explore on her own. In this small user testing session, I was able to observe different strategies participants used to face unfamiliar systems.

FUTURE WORK

Throughout this project, I've shown one way to experience typography through sound. I've shown one approach of mapping visual information to sound. There are lots of opportunities for exploration, such as exploring rhythm patterns through the way the letters are "read", fine tuning, other instruments and note variations. Beyond this project, I think there are lots of implications for how we can create sound experiences based off of visual information. For example, what could a painting sound like? What could a photograph or drawing sound like? What could a mark I make sound like? I think there are implications to explore sonification of anything visual in the dynamic medium. For example, would a capital "E" hold it's note longer than the other notes?

SXSW

During the spring of 2014, I presented the *Sound of Type* approach to a group of educators at sxsw. Afterwards, I talked with many educators across the country. Some of the feedback I got was that this approach would be helpful for special needs students. They were also excited at the opportunity I created to make expressive tools out of the curriculum to learn. For me, this talk was inspiring as I think we should continue to push this overall approach. Another idea I have for a project resulting out of this work is to see how I can use sound to help children learn multiplication tables. What if each number had a pitch and students could associate the pitch and pitch combinations to help them remember these rote mathematical facts?

Thinking beyond sonficiation of visual forms, I am interested in how we can more broadly use sound to augment traditional teaching methods. How can we use sound to help students learn dance moves or physical routines? I think this is a large research area that's still open for exploration when thinking about future educational tools.

CONCLUSIONS

Sound of Type allowed me to define and test an overall process for interactive experiences. The process is a valuable tool for understanding the different vulnerability points in interactive systems. Even though I used a familiar form, letterforms, as the foundational element for the Fresh Media *Sound of Type* project, it was still a challenge to get participants to interact with the system.

Based on these observations, I discovered the importance of invitation. Both literal invitations, such as my verbal invitation to the students, or implicit invitations, such as a clear reaction to a person's presence, can encourage participants to explore and engage with an interaction. Through invitations, the interactive system reaches out to the participant and the system is left open and vulnerable, waiting for the participant to respond. By shifting the point of vulnerability initially to the system, I think this lowers the threshold for interacting with unfamiliar systems.
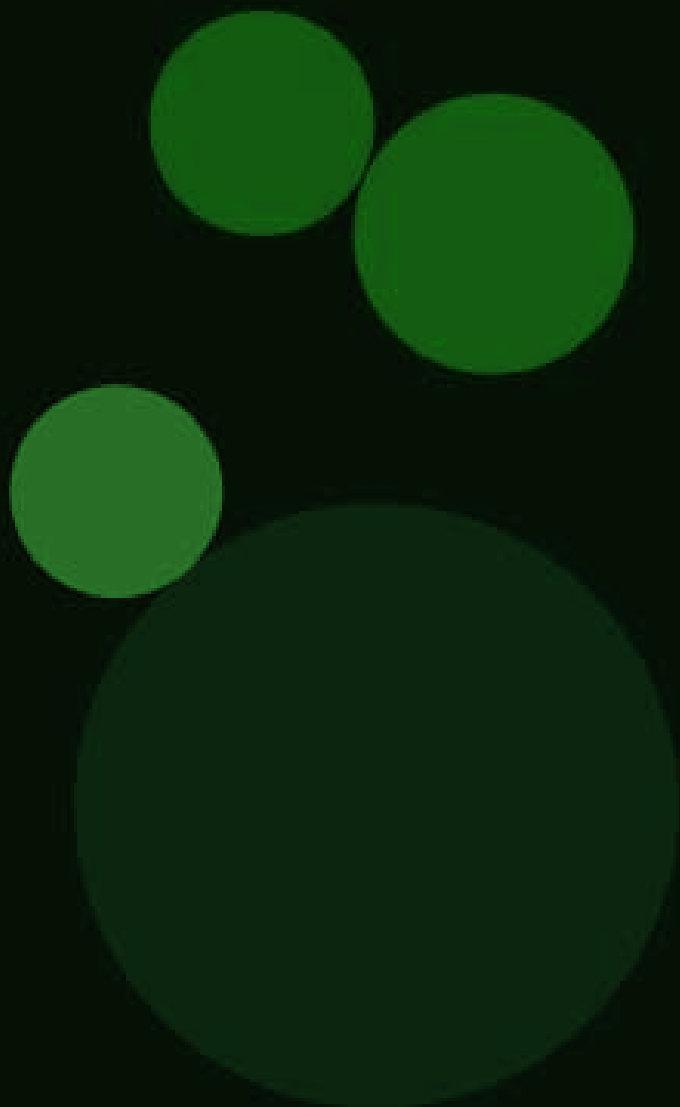
CASE STUDY

SOUNDS OF DISCOVERY

A key part of interactive experiences is the language of communication between the system and the participant. If the language is clear and intuitive, participants will feel less vulnerable and exposed. However, if the language is complex, participants may feel exposed as they try to decipher the language.

In the *Sounds of Discovery*, I investigated how I could develop a clear visual and sound language based on open source data available from NASA's Kepler spacecraft. This spacecraft is home to the Kepler telescope which searches the skies and looks for possible earth earth-like planets.

APPROACH

In the *Sounds of Discovery*, I was designing the sound and visual language to provide an experience of the process of discovery. I chose the Kepler data content choice for this project to explore our overall relationship in the context of the universe. NASA's goal for this project is to explore the universe in search of other Earth-like planets. In doing this, scientists are trying to determine whether we are a "rare earth" or something that is common across the universe.

Astronomers are currently in the process of discovery through this search. In this search, astronomers use telescopes to look at the night sky and observe light passing through atmosphere of celestial objects. Based on how the light appears to astronomers, the celestial object is determined whether or not it is a planet.

RELATED INSPIRATIONAL WORK

In designing an experience around data, it's important to put it into a context that is meaningful to participants. This turns "data" into meaningful "information". Charles and Ray Eames' *Powers of Ten* movie shows the magnitude of the universe and the micro scale of atoms and cells in our body. One of the reasons why this film is impactful to viewers is that the scales are relative to something we know, ourselves. The movie begins zooming out in magnitudes of ten using a person laying in a park as a reference point. Then, when the edge of the known universe is reached, the movie zooms back to the person laying down and zooms into the body to investigate the micro scale of cells, molecules, and atoms through the same magnitudes of ten.

Across all the lunar missions that NASA has ventured on there have been a vast multitude of photographs taken of the context in which we live. It's when we see something familiar, such as an astronaut playing golf on the moon, when we realize that there is something fundamentally different about this place. Through something familiar, we see difference.

Earthrise, is one impactful photograph taken in 1968. In this photo, we see our home from a different perspective. This picture is frequently cited as the "most influential environmental photograph ever taken" as it shows the fragility of our planet. Some credit this photograph to be the beginning of the environmental movement that swept our world.

Another powerful photograph is the "Pale Blue Dot" photograph taken by the Voyager 1 spacecraft. This picture was taken as Voyager reached the edge of our solar system. Before the spacecraft was directed to turn off its camera, NASA requested that the Voyager turn the cameras around to look back at the solar system and take a last photograph.

Earthrise, courtesy of NASA

 Surprisingly, Earth was captured ,in this large scale photograph,. Because of the scale of the distances, Earth occupies only a single blue pixel on the photograph of the vast expanses of space and our solar system.

In P*ale Blue Dot: A Vision of the Human Future in Space,* astronomer Carl Sagan describes his experience of this this photograph.

> "From this distant vantage point, the Earth might not seem of any particular interest. But for us, it's different. Consider again that dot. That's here. That's home. That's us. On it everyone you love, everyone you know, everyone you ever heard of, every human being who ever was, lived out their lives. The aggregate of our joy and suffering, thousands of confident religions, ideologies, and economic doctrines, every hunter and forager, every hero and coward, every creator and destroyer of civilization, every king and peasant, every young couple in love, every mother and father, hopeful child, inventor and explorer, every teacher of morals, every corrupt politician, every "superstar," every "supreme leader," every saint and sinner in the history of our species lived there – on a mote of dust suspended in a sunbeam.

My favorite planet is Saturn, as it is for so many others. The rings are a result of a beautiful balance between Saturn's moons pushing and pulling dust particles and other space debris. This metaphor also reminds me of the balance of great two-way interactions between participants and interactive system.

On Saturn, each ring of debris rotates at its own velocity. Some rings are still being created while others are slowly dissipating. However, the most astounding experience I had was observing a recent picture of Saturn from the Cassini spacecraft and seeing our home within the context of the planet. The small white dot at the top left edge of one of the outer rings is our planet. Seeing this picture within context of something I was intimately familiar with, our home planet, gave me a new appreciation and understanding of this data.

PROCESS

To create this experience the *Sounds of Discovery,* I worked with open source data available from NASA's Kepler spacecraft. The telescope scans the night sky and does a first search for possible planets. Each object is classified as a possible planet or "candidate planet", an object that was mistakenly selected or a "false positive", or an object that was not able to be determined. To me, this quantitative data was interesting to look at as it expressed this ongoing process of discovery.

Working with this data, I was interested in revealing the experience of discovery of planets across the universe. To do this, I needed to move from pure data to meaningful information. How would the moment of discovery feel like? How would I highlight the anticipation while waiting for results? What about the experience of missteps? And more importantly, what's the sound and visual language?

To create this experience, I wrote a web-based prototype that iterated through each single data element, or celestial object. For each object, I drew a circle on the screen that scaled in size relative to the size of the object's radius and played a note with the pitch relative to the object's radius. For example, if the planet was small the system would play a high pitch note, but if the planet was large a low pitch would be played. Each of these sounds were chosen as they were similar to chimes and gave the experience of single drops in the vast dark space. The name of the planet would also briefly appear on the screen. Over time, the circles would slowly fade making room for new circles to focus the participant's attention on what is coming next. If the object was a candidate planet, it was green and a banner appeared at the top of the screen welcoming the candidate planet to the known universe. If the object was a false positive, meaning it was thought to be a planet but in actuality was not , the circle was blue. If it was still to be determined, it was gray.

As each circle appeared, it appeared in a random location. This also heightened the anticipation of the next data element on the screen. Where would the next circle appear? Would it be a planet?

TESTING

While showing this project to participants, I was surprised at how they implicitly understood the relationship of the size of the circle to the pitch of the sound after only a few circles. There was no formal moment where I explained these mappings.

Because of the design choice to fade the circles over time, some of the circles appeared to

be in front or behind of other circles. This created an incorrect illusion of depth. This was a problem as the project's content and subject matter related to depth, space, and location. I needed to either break this illusion or have this illusion correctly represent the depth. One suggestion to manage this was to map the relative distance of each object to the length of a delay in which the sound is played. For example, the sound for closer objects would play immediately as the circle appears on the screen, but the sound for more distant objects would have a delay. However, I wanted to keep the simplicity of this project as it was accessible to people of all ages. Instead, I made the decision to show only one planet on the screen at one time. This also continually focused the participant on the current planet and heightened anticipation for the next planet.

One piece of feedback was the need to provide some kind of context for this quantitative data on the found space objects. Participants suggested having a scale model of the solar system at the top and other variations similar to this. However, the resulting choice was just to draw a thin white outline of a circle to represent Earth's relative size to each planet as it appears on the screen. This simple cue turned this quantitative data into meaningful information to the viewers.

CONCLUSIONS

I learned that building off of something we are familiar with when designing a visual/sound/other type of language can be helpful. The biggest surprise was how quickly participants picked up the visual and sound language. In past projects, specifically the *Sound of Type* project, I had to have a demonstration to teach the participants how the visual information was mapped to sound. In this project's case, the visual language of size was closely tied to the size of the planets, making it easier to understand. For the sound, I drew upon my own experiences of sound and visual representations where smaller objects have a higher pitch and larger objects have a lower pitch. In this case I was drawing upon an implicit sound language that we've all experienced, so this is what made the sound language intuitive to participants.

However, we also need to be careful to watch out for what we may unknowingly be building on when designing the language of communication. For example, when the circles first appeared on the screen there was an illusion of depth. To be a more effective experience, I needed to either embrace this association that implicitly happened or to break it and make it my own. In later versions I scaled the project to only display one planet at the time. This removed the implicit illusion of depth, but still allowed participants to experience the project.

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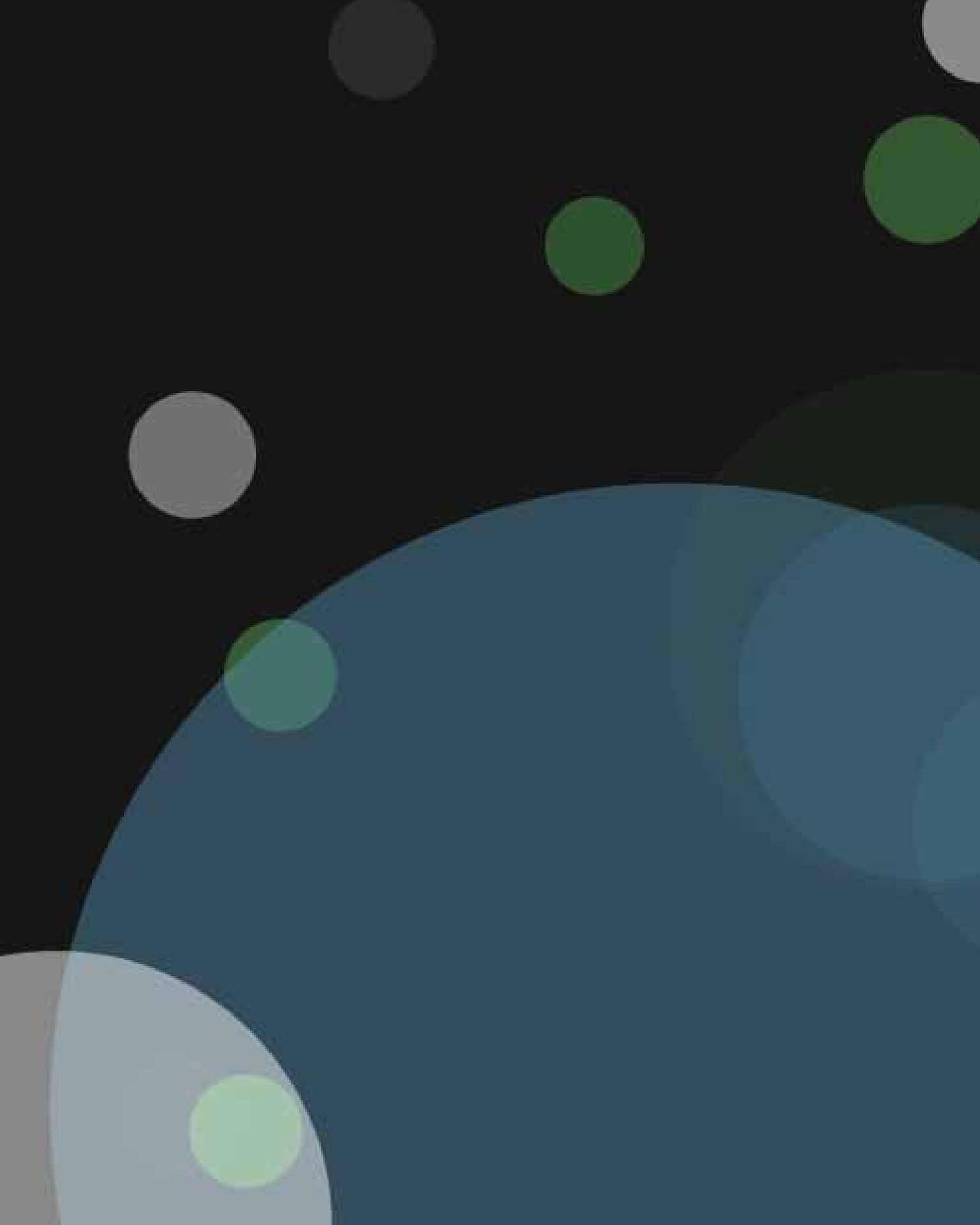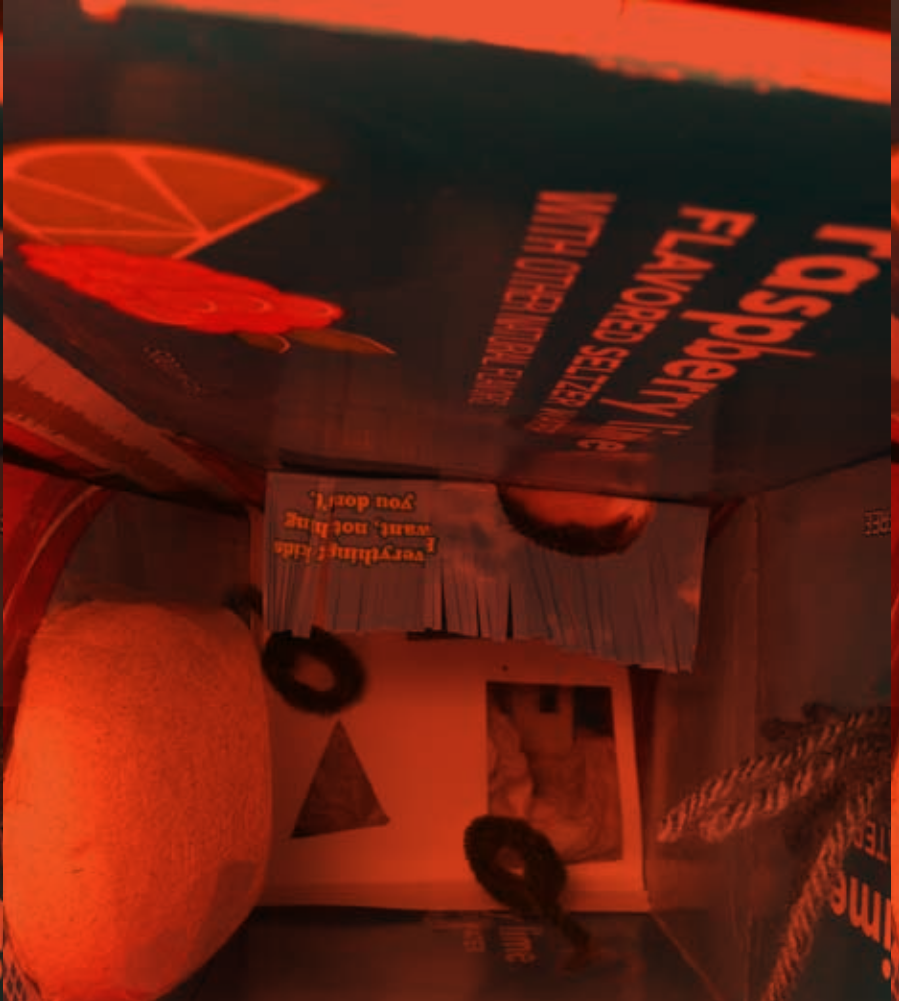
TACTILE DIORAMA

The idea for this project came from my interest in creating a purely tactile experience. This project was inspired by the dioramas I saw in elementary school. In dioramas, a scene was created within a box. You could look through a small hole to view the scene. For this project, I envisioned something similar but exploring a space completely by touch. While I didn't immediately realize it, asking a participant to experience this box purely by touch was a challenge for participants. This project became the perfect platform to observe strategies participants used to cope with vulnerability in interactive experiences. In testing of this project, I observed different strategies and approaches used by participants to cope with this challenge.

This project was inspired by the dioramas I saw in elementary school. In these dioramas, a scene was created within a box. You could look through a small hole in the mysterious box to view the scene. I envisioned something similar but a purely tactile scene. Participants would explore the box by touch. While I didn't immediately realize it, asking a participant to experience this box purely by touch was a significant challenge as I was asking them to stick their hand in a dark box without any understanding of what was inside. This created a vulnerable encounter . The tactical diorama became the perfect platform to see how participants responded and coped with vulnerability.

PROCESS

I created a box from found materials and used different textures and shapes to make the tactile landscape. The box itself was a long rectangle. Some textures were soft, like puffy yarn, and also rough, like cut cardboard. There were some strings suspended from the air and some plastic wrap placed on top of cardboard mounds that many participants thought was water. The materials I chose were soft materials. Many of the materials were common-place and familiar, which I believed would encourage further exploration of the box. I was trying to create a soft, non-threatening tactile landscape for the participants to explore.

I didn't want participants to see into box, so I used felt to create a small red curtain at the opening of the box. Towards the end of the box, I created a wall with shape cutouts that participants could stick their hand through to access a hidden space at the back where a pine cone was hidden under tissue paper. Because of the size and shape of the box, participants had to stick most of their arm in to get to the hidden space at the back. I created that space to see how far people navigated in the box itself by asking them what the furthest thing was that they felt.

TESTING

The most interesting part of this project was watching how people responded to the invitation to explore the box. When I first presented this box and asked for volunteers, I got complete silence. No one wanted to stick their hand in this weird box. I didn't give any of my classmates any context for the materials in the box. They had no idea what the experience would be like. Would the box contain gooey elements? They didn't know if it would be a pleasurable experience or something uncomfortable. All they knew was that I was inviting them to blindly stick their hand in the box.

One of my bravest classmates, Jeff Bartell, broke the silence and boldly volunteered to go first. He physically dove right in to the box and felt around. After seeing him survive the process, other classmates became interested in trying the box. Some of my classmates were

asking him questions to try to get a better understanding of what was in the box. Later, some of these same questioning classmates asked me each time they felt something new what the object was. They had to know what was in the box.

RESULTS

I noticed several categories of participants based on how they interacted with my box. Some people were ready to dive in and explore the box independently, like Jeff. Others dove into the box after they observed Jeff successfully trying the box out. Finally, I noticed other participants that slowly moved their hand inch by inch into the box. As soon as these participants touched something, they pulled their hand out and passed it along to someone else as if they had filled a quota for minimum amount of interaction. Some participants explored the entire space of the box, but very few participants got to the end of the box. Only a few of my classmates actually found the pinecone at the end. Metaphorically, some participants slowly dip their toes in to "test the water", while others dive right in. Others will test the water or dive right, but only after observing others first. Some people had to know what it was that they touched, while others didn't care. These were similar strategies I had observed across other projects but this explicit vulnerable encounter highlighted them even more.

Based on my observations of the different types of participant approaches interacting with the *Tactile Diorama* project, I defined several parameters to define the variation in the

approaches used cope with vulnerability. These parameters include: *approach for initial interaction,* the *style and speed of interaction,* and a *need to understand the system.* In approaching initial interactions, does the person interact with the system or must they watch others first? For the style of interactions, how does the person interact with the system - slowly and cautiously or do they dive right in? Finally, regarding understanding the system, does the person need to fully understand and know the rules of the system? Or is it enough for the person to interact with the system without understanding the underlying rules?

Below, each of these strategies are methods that participants use to cope with vulnerable situations. When we design interactive systems, we should consider which of these personas we will target and which we will not.

EXPERT

Experts need to understand how the system works. When facing vulnerable situations, such as interacting with unfamiliar systems, Experts use rules and logic as coping mechanisms. Experts systematically approach the system to determine the underlying rules and logic. For example, in the *Tic Tac Toe* piece, Experts started working through each square individually to see the underlying logic of the system.

PLAYER

Players dive right into interacting with unfamiliar systems. They do not necessarily need to understand how systems work or why, but simply are looking to have fun and enjoy the system. Players face vulnerability head on by developing an internal goal or approach of having fun with the system through play.

EXPLORER

An Explorer jumps in and feels confident to independently explore and try unfamiliar systems on their own. They may or may not need to know how the underlying system works but will frequently come to some partial, if not full understanding, of how they can use the system to produce the output they want. Explorers face vulnerability head on.

OBSERVER

The observer is the participant who may not directly interact with the system initially, but then after observing others will engage and interact with the system. Frequently, observers

slowly interact with the system and gain confidence to try larger interactions over time. Observers let other's test the system first as a way to reduce potential vulnerability with interacting with the unfamiliar system. Many of the classmates in the *Tactile Diorama* fit in this description as they needed to see someone explore and survive the box first.

WATCHER

This is an often overlooked participant. While Watchers do not directly interact with the system, they watch how others interact with the system to gauge what might happen. Frequently, Watchers are the audience members observing the brave participants interacting with dynamic systems. Watchers may feel too exposed and vulnerable to interact with the system, so instead of being vulnerable they choose to only observe others and not interact with the system.

FOLLOWER

Followers need a guide to walk them through the system. They need clear instructions, as well as suggestions for how to interact with the system and what to try next. Guidance is a Follower's way of coping with vulnerable situations. Sometimes followers need to understand how the system works and other times not so. Followers tend to slowly interact with the system and overtime build confidence to interact independently. This is the strategy employed by one of the participants in the *Sound of Type* project who needed directions and guidance on how to interact with the system even after she understood the underlying rules and logic.

COLLABORATOR

Collaborators are participants who are willing to interact and engage unfamiliar systems, but only with friends or another person. These participants need the support of another to solve and investigate the unfamiliar system with. Friendship and support of others is a Collaborator's way to cope with vulnerability.

I believe each of these strategies and approaches is not participant-specific but more related to the level of exposure and vulnerability a person feels with the specific system. For example, the *Tic Tac Toe* project used a familiar game and had a large playful context so many participants felt comfortable exploring the system. However, the *Tactile Diorama* project the experience was completely unknown. Participants felt a high level of vulner-ability, so many of the participants used the Observer strategy to deal with this challenge. As designers, we must consider both the level of vulnerability as well possible strategies participants may use to cope with the challenge.

LIGHT PIPES

Light Pipes is a project that explores how interaction with light can be used to manipulate sounds. In this project, participants had to go into a small, dark room to interact with an abstract-light based interface. Between the enclosed dark space and the abstract interface, how could participants be more vulnerable?

This project builds upon all the elements of past projects to craft a vulnerable experience. The dark, small room is opposite of the light, social context in the *Tic Tac Toe* piece. The abstract interface based around light is a challenge to explore and interact with it.

The inspiration for this project was to see how I could use sound as a reward for getting people to move in space. As the project evolved, I was interested in working with light as a formal medium as well as an interface. Light as a medium, brought forth many challenges, specifically the need for darkness and participant's implicit vulnerability in dark spaces. This project went through several iterations and was shown at Fresh Media 2013.

INITIAL IDEA

The catalyst for this project was an interest in investigating how I could map body movement in space to sound. I was interested in how to get people interact with some visual form in space to produce sounds. Initially, I didn't have any set material forms or guidelines and was trying to get people to move in space. While the prevalence of gesture and body-motion interfaces are becoming more popular in gaming and in the industry, it's still challenging to ask someone to move around in space. Participants can feel exposed and vulnerable. Because of this, I wanted the sound to act as a reward for the bravery putting forth moving their body in space.

PROCESS

The early vision of this project I imagined the manipulation of a ball along a wire to make sound. By raising and lowering the ball along the wire, the pitch would also rise and fall. A ball would start at the bottom of the wire and could be raised by the participant to raise the pitch of a sound.

I was excited about the different shapes the wire itself could take. For example, the wire could bend across two surfaces and the ball could rise and fall to manipulate the pitch. While this ostensibly is a similar interaction with the interface previously described, this situation made me think about the effect that physical forces, such as gravity or the weight of the ball, could have on the system. I hypothesized that changing the form of the wire would change the interaction people had with this system. For example, in the picture below, would the valleys become "resting points", specific notes that the ball would get trapped on? What would these sound like with respect to the ball and form being played?

PROTOTYPING & TESTING #1

To get started, I explored a wide range of materials. I went to the hardware store to see my range of options. I was interested in exploring body-size forms to encourage large movements in space. However, I didn't find anything that fit what I had envisioned.

Making the technical functionality (tracking the ball's movements, continuously outputting a pitch) on its own was going to be a challenging task. I wanted to get this project out as soon in possible so I could see how participants would use it. This idea was something that I had not experienced before, and I wasn't sure what the experience would be. So, the quickest way to prototype this and get the feedback I needed was to fake it or use the "wizard of oz" prototyping approach.

In this approach, I simulated the sound outputs with my computer as I watched someone move a ball up and down on a pipe cleaner. I used a pipe cleaner as the material would emit no sound and the sound would come purely from the computer. In this prototyping approach, I became the computer and would manually change the pitch as what I envisioned the system would do. As the person raised and lowered the ring, I would raise and lower the pitch on my machine. This was much easier than developing code to do this.

 Surprisingly, even though I was sitting in plain sight next to this crude prototype, this was more than enough to observe the interactions. As my classmates raised and lowered this ball on the pipe cleaners, I raised and lowered the sound by hand on my computer. While this was a very low-tech approach, many of the classmates thought the system actually was built and working on its own until I revealed my prototyping approach.

In this early stage of prototyping, I observed my classmates rapidly and aggressively moving the ball up and down, breaking the forms. This aggressive interaction was the exact opposite of what I was going for. Instead of a slow, thoughtful movement, my classmates were aggressive. I knew I needed to explore a different method. Luckily, I was happy to test the system early on and see how people responded to this interface before investing a lot of time and effort in the initial vision.

PROTOTYPING AND TESTING #2

For the second version, I wanted to explore how I could facilitate more thoughtful, soft, and gentle interactions for the second version of the project. I explored different materials and forms, specifically light.

One technical approach I had for tracking the rise and fall of the ball was tracking a person's hand with a camera using basic computer vision. In much of my testing, I have used a web camera and basic computer vision techniques, as it is much cheaper than physical sensors and circuits. Using the webcam and Processing, I wrote a program to track a hand moving in space. The quickest way to do this wasn't to write an algorithm to track the motion of a hand, but to track the brightest pixel on the screen of a light reflected off the hand. This approximation got me 90% of the way.

To make the tracking better and more precise, I turned the lights off and projected light from the bottom in a vertical line up to the hand. This made it significantly easier and precise to find the hand's location, as it was simply the brightest pixel on the screen. Light needs something to reflect off of, and in this case the hand provided that object so that I could determine the person's presence in space. This also meant that the hand was moving up and down in the light beam.

Moving forward with this technical approach, I decided to ditch the wireforms and the physical ball and instead track hand movements in light beams in space. The first step was to focus and create light to look like an interface. Again, to minimize cost, I opted to find some LEDs left over from a college class versus a fancy projection system. This was significantly cheaper than buying a high high-end flash light or light beam source.

Next, I created a setup in which I could use a webcam to track the brightest light on the surface. I used paper to create a cylindrical shape to focus the light into a soft beam and used books and boxes to create a lab space at the exact height I needed.

Then, I turned off the lights and was able to track motion in space as someone's hands moved up and down in the light beam. In testing this out myself, I quickly realized it was more natural to have two light beams working together for each hand instead of one light beam. By having two light beams, the participant was naturally placed in direction of the camera and also in a forward relationship with the light. This physical relationship was similar to how a conductor would conduct and direct an orchestra.

Revisiting the sound aspect, I needed a way to programmatically and smoothly bend notes up and down to map the smooth hand movements in space. I couldn't do that for two simultaneous hands at a time with the sound libraries available. I found libraries that could play notes and pitches, but only discrete notes and not continuously bend them. While this was not the effect I was going for initially, it was actually an improved sound experience. With perfectly smooth bending notes, it was hard to find combinations that were pleasant. However, with discrete notes, I could curate the set of notes so that the combination of the notes always sounded pleasing.

Light Pipes prototype

In the software, I created an algorithm for mapping hand positions to notes on each draw loop in Processing. I noticed a pulsating sound was played, due to the oh-so-slight delay between each animation frame. While this delay was never detected visually, it was detected sonically by a brief momentary silence or pause between notes. This actually was a surprise feature as it created a dynamic rhythm to be played and relatively complex "songs" could be created.

In testing this project out at home, I saw how all the technical limitations (e.g., the discrete notes caused by the limitations on sound libraries, the break between notes caused by the minuscule time between draw cycles) created a system that allowed for the complex interactions through very simple movements. This was exciting to me. By limiting the movements to medium sized movements in the light beams participants would feel less vulnerable with this system.

As I had this new version of the *Light Pipes* created, I wanted to test out the interactions with participants to see if they were still aggressive. For the light interface, I chose a soft light reflected from a vertical pipe I made with paper. For the sounds, I chose soft notes to encourage more gentle interactions as well as to encourage vulnerable participants to try the system. I was hoping that with this new light-based interface, participants would more carefully and softly move their hand in space than they did with the pipe cleaner interface.

I took this new form to class. I gathered my classmates around the setup and turned off the lights to create a dark enough space for the camera. The camera had to be at the right height, pointed in the correct direction towards the lights. The LEDs were connected to a power source by wires wrapped in aluminum foil and any disturbance caused this connection to be broken and the lights would not turn on. Unknowingly, someone had moved the fragile setup in the classroom. This required my classmates to stand in almost complete darkness as I tried to resolve the issue. While it only took a few moments to figure out the loose connection, the time spent in darkness felt much longer and the room remained silent. I remember the thick awkward and uncomfortable feeling that was pervasive in the darkness as my classmates waited for me to fix the project. As I got the project set up again, the two paper tubes of light turned on, the room had a focus and my classmates relaxed. By adding light into the room, the uncomfortable feelings disappeared.

The interactions I saw my classmates doing with this new form were soft, slow, and gentle movements. I noticed participants were initially timid, but after a few moments went away to try and explore other gestures. I believe this is because of the careful curation of soft material and curated sounds that gave confidence to participants rapidly.

The inevitable question popped up: how did I do this technically? I showed participants my "debugging" interface, basically a black screen with yellow circles on that represented the location of the rise and fall of the hands. As soon as I showed this interface, my classmates became glued to the screen and completely ignored the pipes of light. I was not interested in developing a screen-based interface and this screen greatly detracted from the light pipes. When the screen was not there, people explored the light itself as a substance, considering the boundaries of when they entered and exited the vertical light beam. When viewing the screen, participants eyes were glued to the screen, they stopped paying attention to the light itself. Then, they'd questioned why the system "stopped working". Most often, this was because the participant had moved their hands out of the light beam as they were distracted by the computer and not watching what they were doing. This visual screen, a missing component for other projects, became a distraction from the interface itself and changed the quality and attentiveness people had with the system.

FRESH MEDIA

Later that semester, this project was shown at Fresh Media. One of the biggest challenges for the curators and myself was finding a dark space — the room could not be slightly dim, working with light requires complete darkness. Darkness is my method of subduing all distractions, both from a technical standpoint but also from an experiential standpoint.

By random chance, I ended up getting access to a storage closet at the last minute, due to the magic of Saul Baizman's connections. This was great for the piece, but to get complete darkness you had to shut the door which I knew was a lot to ask of a participant. Who wants to walk into a dark closet and shut the door behind them? Even walking into the well-lit closet with the Fresh Media curators, we were nervous that we were going to get locked in. How would I ever ask a participant to walk into the closet and shut the door behind them when it was dark? I did not want participants to feel that vulnerable.

I found alternative ways to position the project into a dark corner. With the project slightly off centered facing the corner, the door could remain open and people could partially walk in and experience the work. Now, people interested in the project would "only" have to walk a few feet into a dark closet with the door open.

Even with the door open, walking into this small, dark space was a challenge to most people, especially in a noisy environment like the opening of Fresh Media. However, once someone was partially inside the closet, it was a quiet space where I could actually talk to people. Individuals sometimes went in and frequently walked by. Of the people who did walk into the dark space, most people walked in as a small group or left someone outside the closet to observe them.

Of those that tried the project, I did see that most people spent time gently and cautiously exploring light as a substance and paying more attention to its existence, a core hope in the design of this project. I believe it is due to using light as a material and crafting this quiet, soft space in the dark closet.

NEXT STEPS

Future areas of exploration for this project include extending from two tubes to three, four or six to see if and how multiple people to work together across these sets of light pipes. Would people collaborate more or less? Or would it tend to be a single person interacting with the light pipes? I think by adding additional light pipes participants could observe others and try the system in parallel. I think having multiple people playing with the system in parallel will lower the feeling of a single individual performing and encourage more participants to try the system. Most people walked into this small space in groups. If there was something for everyone in the group to participate in, I think it would lower the amount of exposure an individual participant would experience. I also would be interested in exploring the space between the tubes. For example, what if the tubes were set apart too far for one person? What if you had to rely on another person to reach the other tubes to work together and make harmony with the sounds? I think requiring that multiple people work together would also lower the amount of vulnerability a single participant would experience. When people are trying something new together, sometimes the mood becomes lighter as it's a shared experience versus an individual performance.

I also wonder how the relationship of the person to the system changed if the light was responsive to a person's presence. For example, how would the experience change if the light slowly turned on and faded out as someone approaches the light pipes? How would that change if the light flicked on and flicked off? I think that by having the light respond to the participant's presence, it will implicitly give a signal that it is open and ready to be interacted with. Frequently, it's challenging to know what can be interacted with, especially in abstract interfaces. By adding a simple light-based reaction, I believe this will encourage participants to interact with the system.

Finally, another area I'm interested in exploring is the orientation of the light pipes, what if they were no longer vertical?. What if there were many light pipes on a circular surface? What if the light pipes extended down from the ceiling to the ground? What if they extended out from the wall perpendicular to our bodies? Would we interact with them the same way? I assume not as the relationship of raising and lowering our hands would be unnatural. I think by exploring the form that these light pipes take on will implicitly change the space around the participants. In this iteration, by placing the pipes on a stand on a table in front of them, it's very formal, but natural. However, if I change the scale and form, I could explore how to make an informal and playful context to support interactions.

CONCLUSIONS

I saw two classes of participants in testing this project: people that interacted with the system directly and others than purely observed. Sometimes the observers would then interact with the system, sometimes not. Overall, I had fewer people interacting with light pipes than other projects. However, the conversations I had with people seemed more intimate. I wonder if the intimate nature of the conversations I had were due to the dark quiet space. For example, inside the space someone told me about their aging mother and the difficulty she was having growing older and sicker. Where outside of the project space many of the conversations were more cursory and high level, which I suspect was due to the noise and distractions.

Early testing allowed me to find major issues with how people were interacting with the system. Technical limitations often helped me find new directions. One of my early explorations to try drawing was to create a line that forced a constraint for me to work around. This limitation was crucial in giving me a boundary but also guidance for something to work within.

I would be interested in exploring and/or highlighting the quality of light, possibly through adding glitter or other material into the light beams. I think this would help create a more "magical" experience, possibly creating a more playful context in the dark room. Ignoring the technical feasibility of this, I am curious as to what the experience would be if there was some physical warmth to the light. I imagine this would help participants feel when you exit and enter the light beam. I think this physical warmth, if treated carefully, could create a comfort for the participant in this dark space.

This project was challenging as I didn't have any clear visual feedback beyond the person's hand position in the light beam. Instead, the feedback was primarily through the pitch of
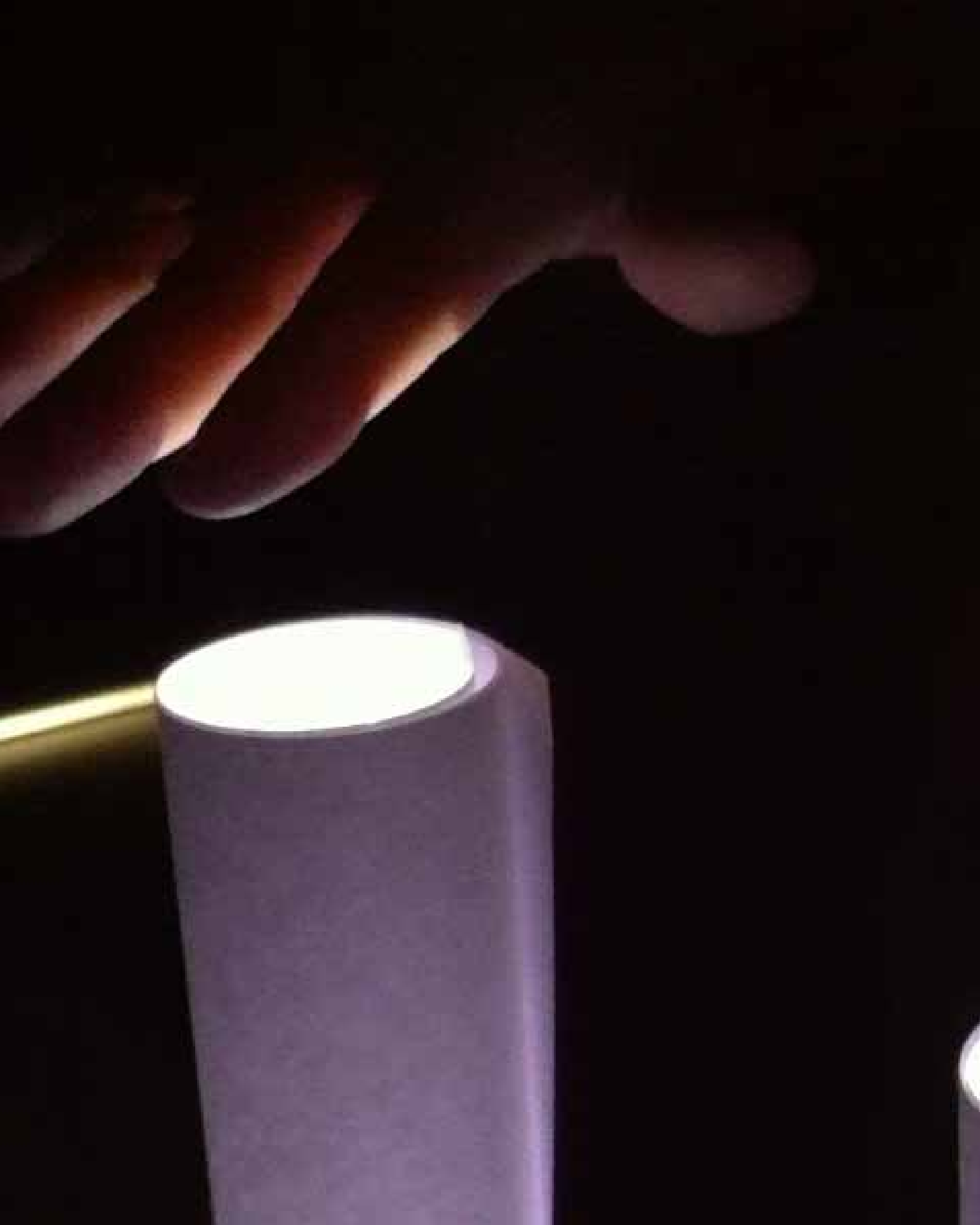
the sounds. It can be difficult to ask participants to rely on sound feedback. It requires focused and attentive listening from the participant, but this focus and awareness was what I was hoping for.

One of my earlier projects, the *Sound of Type,* was missing direct visual feedback on the state of the system. However, there is always a delicate balance between showing visual feedback and hiding it. Sometimes the visual feedback can take away from the experience as my diagnostic display did, especially if you are already working with a visual medium, such as light, in this case.

The small space drastically reduced the overall group size. While groups can offer individuals support to enter in a small dark space to try out an unusual light project, the individuals that entered the space on their own possibly had a more personal experience.

Working with light requires darkness. As a designer, it's challenging to get people to enter into dark spaces, especially quiet, dark spaces. Because of the soft quality of the light I used, I was able to create a soft, not intimidating space to explore even within the challenging, dark environment of the closet.

Small spaces, like the closet, inherently reduce the number of people in the room and limited the small audience to only a few people. The small space made this an intimate experience. If the space was larger, larger groups of people would have fit, and I wonder if there would have been increased performance anxiety for the person trying out the system.

Often, when a person interacts with a system in front of other people they may experience performance anxiety. Curating the sounds so that it is easier to create something that is pleasant will reduce performance anxiety. This also encouraged others in the group to "try it too" as they saw how easy it was to "make it work" well.

I noticed that after an individual worked with this project for a few seconds and "got it", their posture changed. The participant's interaction with the system changed as they explored broader methods and had more confidence working with the system. By making it easy to succeed early on through the careful curation of sounds, participants were able to feel less vulnerable quicker and felt more confident with the interactions.

A FEW LAST THOUGHTS

Interactions are a core part of our experiences. We interact with each other, we interact with the world around us, and we interact with dynamic systems. This thesis is a call to action to remember the difficulty and the challenge of interactions. More importantly, this is a reflection on the moment of vulnerability in interactive experiences. This is a human moment in interactions.

Across my projects, I've investigated the challenge and the opportunity vulnerability presents in interactive experiences. In the *Tic Tac Toe* project, I explored how the physical space and form of game pieces for a familiar game can encourage interactive experiences with dynamic systems. In the *Sound of Type* project, I defined a process for interactive experiences which gives designers an opportunity to consider touch points to design for vulnerability. In the *Tactile Diorama*, I presented different strategies and approaches participants use when feeling vulnerable with unfamiliar systems. In the *Sounds of Discovery* project, I discussed how to better design visual and sound languages to allow more fluid interactions in dynamic experience. Finally, in the *Light Pipes* project, I draw upon all the lessons learned and designed an interactive system that brings out the vulnerability in interactive systems, specifically working with an abstract interface in a small, dark room. *Light Pipes* also explored how to work with light as a medium to craft space to implicitly invite people into the dark space as well as the interface itself. I also developed an intuitive sound and gesture language to allow clear communication between the participant and the interactive system by mapping the pitch of the sounds to the height of the participants gesture.

As a result of this work, I've made several contributions to the field: the definitions of participant strategies in vulnerable situations, an interactive process, and exploration of vulnerability across interactive experiences. While much of my project work in this thesis explicitly references the vulnerability of participants in interactive systems, we must consider the vulnerability of the systems and by proxy the vulnerability we feel as designers when we put our work out into the field.

My time here has been a time of movement. I've moved across the different perspectives to understand interactions and vulnerability. I've observed vulnerability that participants experience with dynamic media systems. I moved to understand that as designers create a system, we are also vulnerable as we are waiting, exposed, hoping for interaction.

I don't believe everything around us should be interactive. Some things just should be as they are. Interactive does not necessarily mean better. Instead, we should carefully consider and design when these interactions should happen. We must question what things are interactive. I've learned most of all, that interactions are hard, challenging, and developed a deep sense of gratitude for the interactions with others and when participants have interacted with my work.

PROTOTYPING

I was fortunate to have the ability to prototype many of my projects. I enjoyed taking my projects from conception to realization. In that process, projects evolved as they were made. Very few times was the end result the initial vision I had. When designing an experience, I'd advise to not think about how to technically make the experience until you are in that phase. Be free and open and let the design of the experience come first. Then, when you move into making the prototype, technological approaches will matter, but stay open minded with the concept and let it evolve.

Another observation I have in making prototypes is how quickly technology finds a way to limit what you are able to make, either through available software or hardware tools or because of financial costs. While these constraints are annoying, frustrating, and disappointing, use them to your advantage! In the *Light Pipes* project, much of the project evolution was in response to some technical limitations I ran into. Use these limitations and constraints in your process.

USER TESTING

As a DMI student with an engineering background, I offer the advice many people gave me. Test early. However, mine is with the caveat to test whatever you can as soon as possible., You don't need to have a fully fleshed out prototype to get the feedback you want. There are lots of different approaches for testing. Use paper. Test only part of the system. Most of all, fake it. You can pretend and stand in place of a "real" system, just as I did with the *Light Pipes* project.

When you have your system in front of a user, you are not asking participants what the system should be and how it should change. Instead, you're looking to see how they use it as is. Are they having the same experience you envisioned? Feedback from participants is extremely valuable, however you must always keep the role of the designer and be responsible for crafting the experience for the user you want, not rely on them to tell you how to make the experience for them. Ask them what they think is happening. Ask them what the experience is they are having. Then adjust and try again. If they say, "this would be better if it lit up when I came near by." Take that as one suggestion, but one of many possible approaches. Instead, look for the underlying problem, which may be a larger issue.

LIGHT & DARKNESS

Light as a material is perfect for the topic of vulnerability and interactions. We see light based on light's interaction with an object or surface. Light needs the object to be reflected off of. We experience light through interaction. Light is also closely integrated into sacred narratives across cultures. Many myths utilize light as a metaphor to reinforce meaning.

I had the opportunity to work with Seth Riskin, a foundational light artist. This was a formative experience for me as a designer , artist, and maker. Our early discussions centered around my experience as a climber. I am continually fascinated by the transient space that is created in a climb through the motion of body in space.   Much of this work was driven by emotion and feeling. This is when I began to make by experience. As a software engineer, I make by algorithm, code, and rely heavily on my analytical thinking. When I moved to work with light in space, I finally had a material to work with: light. This material has properties and qualities that I could experience. I could manipulate light through lenses and experience the sense of space or motion and adapt. This was much different than writing an algorithm to do this and adapting it. No longer was I planning out the experience, coding algorithms and down in the technical weeds for a few days. Now, I could sit in my room with the lights off and *experience* the space I crafted with light and adjust. I was making based on my emotional reaction and my experience.

This type of making led to many studies exploring how light can craft space and provide a sense of time as well. As part of this work I also found the importance of darkness. We need darkness to work with light. These two aspects work hand in hand together. It is because of darkness that we see light. Darkness can mask the unimportant to give way to let light provide a focus. Darkness can also be seen as a canvas that's ready to be painted , shaped, and sculpted with light. Darkness is an opportunity that is to be valued and can be shaped by light.

In our age of artificial light, it's challenging to find true, deep darkness, but I'm not sure if many are looking for it or notice it's gone. In *The End of Night*, Paul Bogard describes the intensity of the artificial light pollution that we are living in through current satellite images depicting an earth on fire. We are in the process of losing true darkness. What else do we lose when darkness disappears? As one example, Bogard calls out now eight out of ten Americans will no longer live in a location to see the Milky Galaxy in their lifetime due to the light pollution. What does it mean to no longer have the stars to look up in the sky? These are the same stars that inspired great myths and stories that layer the foundation and culture for the human race. By seeing our space, our context that we live in, I believe we get a sense of scale, magnitude, and wonder.

"To go in the dark with a light is to know the light.
To know the dark, go dark. Go without sight,
And find that the dark, too, blooms and sings,
And is traveled by dark feet and dark wings."

WENDELL BERRY

LIG

HT

I have just begun exploring our human relationship with light. Light has so many metaphors frequently attributed to it. Things are "brought to light" when something comes into view. We can be "enlightened". Light can mean good, but it also can mean life. Through studying light we see planets across the universe and can look back into time to find out about the origins of the universe. Light is energy, and light is life. This study could be an entire thesis by itself. There are many artists currently exploring this area. James Turrell explores how we see light through his work on perception. Otto Piene, a foundational light artist, creates kinetic mechanical light sculptures that project seemingly alive organic shapes moving across a surface. Piene also uses light to paint the sky in his "sky art". Seth Riskin, a contemporary light artist, uses motion of light in space and time with his body to craft experiences to experience space. In *Blue Light for György Kepes*, Riskin creates a space with blue light and uses his body relative to light to help bring the community to terms with the passing of Kepes. In *Light Dance,* light extends from Riskin's body to extend his body and craft space.

Between the materiality, the connection to crafting space and context, as well as our human relationship with light, I believe there's room and opportunity for this medium in explorations of vulnerability. Light provides an invitation into a dark room. Just as night lights can soothe a child, light can also provide comfort when we are feeling vulnerable. Going forward, I'd like to explore this relationship further and continue making by experience with this material. I'd like to continue these explorations of light as a material beyond projection and led-based displays. Through independent projects, I'd like to continue to explore the quality of light, crafting of space with light, and ability of light to help participants face vulnerable situations.

Seth Riskin, Blue Light for György Kepes

These challenge of vulnerability are not solved and not going anywhere despite all the technology in the world. Interactions will continue to change as our technology evolves as well as how we evolve. However, vulnerability will always remain a core component of interactive experiences. The challenge of interacting with others and the world around us is not new and not purely part of dynamic media. We feel vulnerable interacting with technology, and we feel vulnerable interacting with each other. This challenge is apparent in classrooms looking at vulnerability in teacher-student interactions, relationships, short hallway greetings, and asking for help in a foreign country. Looking forward, I hope that these small encounters that I've created and learned from can give someone hope, courage, and bravery to try interacting with someone or something and to explore vulnerability.

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