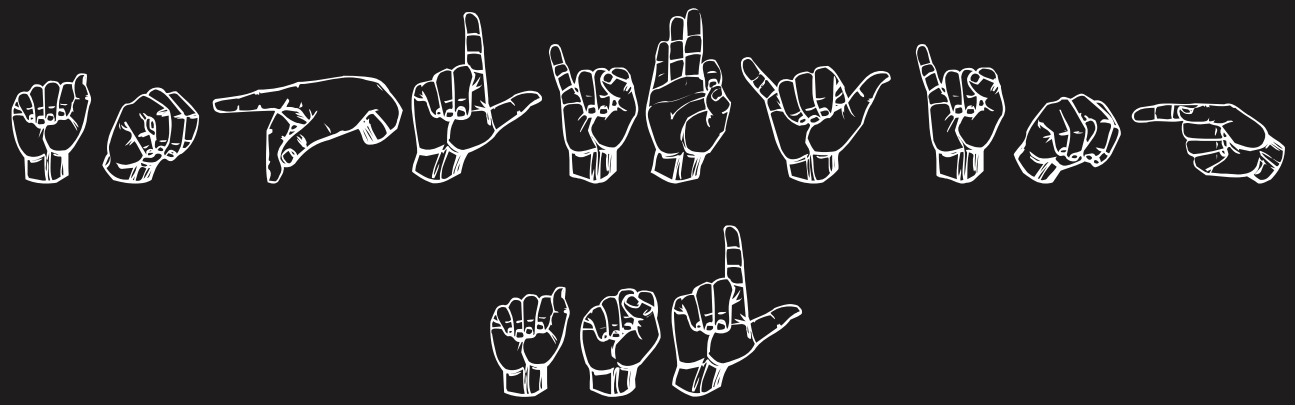

IRB ID: STUDY2018_00000096
IRB ID: STUDY2017_00000478

These studies were approved by the
Institutional Review Board at Carnegie Mellon University

Amplifying ASL:

Designing with Futuring and Inclusion

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A thesis submitted to the School of Design, Carnegie Mellon University,
for the degree of Master of Design in Design for Interactions

ACKNOWLEDGMENTS

Dan Lockton, thank you for the support and encouragement to challenge norms, research through making, and for always believing and trusting in the craziness.

A deep and heartfelt thank you to the friends who have supported me and the colleagues who have made this journey with me.

Most importantly, to my parents. I would not be where I am today without their love, support, and encouragement.

This work is dedicated to my grandparents, Russell and Nancy Simmons.

ABSTRACT

This Master's thesis project studies the intersection of design and technology in its relation to those who are d/Deaf in a way that is both evaluative and critical. This was done in order to better understand the gaps that currently exist, both within projects and products as well as design processes. Design research, futuring, and technical explorations were used to better investigate this intersection. Through reviewing literature and existing precedents, there appear to be two major roles of products, correction or connection. A series of interviews with both deaf and non-deaf were conducted to understand the perspectives of both parties in order to better situate the approach taken throughout this project. A futuring workshop was used for creating and imagining new futures from the perspective of those within and closest to the Deaf community.
A handful of technical explorations were conducted using current technologies as to better comprehend their capabilities. Ultimately, these explorations were used to reframe current trends in technology and create artifacts from the participants' futures.

This project aims to raise more questions than necessarily propose solutions. It aims to provide a sort of case study and framework that can be used to question, or incorporate into, a designers process. This study has researched and implemented several design processes including participatory design, futuring, speculative design, and inclusive design. As a result, this project proposes that the evolving and growing design practice of inclusive design begin to embrace futuring as a valuable aspect of the process.

CONTENTS

PART ONE

INTRODUCTION

Our daily interactions with people and products are so intuitive that there is often little thought as to what makes them possible. However, for the more than 360 million people worldwide who are deaf, social and environmental factors can create barriers to interactions.[1]

Throughout my life, I've watched as my grandparents adapted their interactions to fit with the world around them. Connecting their doorbell and phone to the lamps in their house, taking index cards with pre-written instruction to the deli counter, or carrying a pen and notepad in their pocket to order food at a restaurant. My grandparents are deaf, they spent most of their lives in a world that defined disability as a physical or mental impairment of an individual—any limitations they faced were a result of their impairments.[2] However, since then, there have been several crucial shifts in paradigms surrounding people with disabilities. Most important is a shift from a medical modal to a social modal. In recent years, the World Health Organization(WHO) has redefined disability, reinforcing that shift. The World Health Organization states that "disabilit[y] is an umbrella term, covering impairments, activity limitations, and participation restrictions…[it] is not just a health problem. It is a complex phenomenon, reflecting the interaction between features of a person's body and features of the society in which he or she lives. Overcoming the difficulties faced by people with disabilities requires interventions to remove environmental and social barriers."[3]

This shift from medical model to social model brought with it an increased awareness of inclusion and accessibility. Inclusive design, universal design, and an adoption for greater accessibility, notably by several large corporation, are generating a broader awareness on the issues of inclusion and accessibility for many. Concurrently, our world is being transformed by technology. Recent trends in technology—augmented and virtual reality (AR/VR), motion tracking, machine learning, artificial intelligence, to name a few—are creating a more connected, innovative, and intelligent world. This is also driving research at the intersection of technology and disability forward. Utilizing emerging technologies, many of these advances aim at removing the barriers that lead to exclusion. However, it's crucial to evaluate these trends critically. Looking at ***who they are made for***, ***who they benefit***, and ultimately ***what sort of role do they take on***—functional, expressive, connective, etc. One recent trend at this intersection has been to "translate" American Sign Language (ASL) in order to help bridge the gap between deaf and non-deaf. However, many of these projects have taken on a more audist approach to the space — ultimately creating products that benefit the hearing population more than the deaf population, disregarding important cultural and linguistic factors.

This thesis project offers a critical approach to the design process and the role of technology in relation to the Deaf community. Through the context of technology and the Deaf community, this work investigates the process of inclusive design in order to offer considerations for designers who may be hesitant or weary about working inclusively. This is done by investigating the beauty and intricacies of ASL through technology, in a series of interviews, exploratory probes, technical explorations, futuring, and proof of concept artifacts. Ultimately, the intention of this project's critical approach is to continue the conversation around designing with d/Deaf users and the unique, innovative, and sometimes similar perspectives they have to offer. This is done in order to shift the way we, as designers, use design and technology so that it may better align with the needs and desires of diverse users.

LITERATURE & PRECEDENT

A variety of literature and projects were reviewed to understand the scope and landscape of both technological and social dimensions of d/Deafness and related areas, including many directions which I have not pursued directly in this thesis. The following sections summarize the findings which are directly applicable to my work here. Focusing on American Deaf culture, design processes, and technology. A more extensive reading list and discussion, which I have updated over the course of my studies, are available online.

Literature & Precedent:
https://tinyurl.com/ThesisReading

General Inclusion & Accessibility:
https://tinyurl.com/ThesisInclusion

TERMINOLOGY

This section outlines terminology used throughout this paper. Key definitions included a variety of design processes as well as a variety of terms relating to those who are d/Deaf. Through research and in talking with participants, I use "d/D" where applicable, this paper aims to be as inclusive as possible and does not assume that someone who is deaf is also culturally Deaf. In addition, this paper focuses on those who are d/Deaf and the Deaf community, as such 'non-deaf' is primarily used to refer to anyone who is hearing. While I have tried my best to use proper nomenclature, I acknowledge that I am still a non-deaf adult doing their best to write about work for and with the Deaf community.

Universal Design:

A 1996 CHI paper introducing the idea of "Universal Design," it stated that "design considerations for users with vision, hearing, or movement impairments overlap with those for the general population across a variety of tasks and contexts."[4] This paper inferred that there is something to be learned from the way people with disabilities adapt to their environments.

"Universal Design is the design and composition of an environment so that it can be accessed, understood and used to the greatest extent possible by all people regardless of their age, size, ability or disability." [5]

"Universal Design is the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design."[6] The intent of universal design is to simplify life for everyone by making products, communications, and the built environment more usable by as many people as possible at little or no extra cost. Universal design benefits people of all ages and abilities.

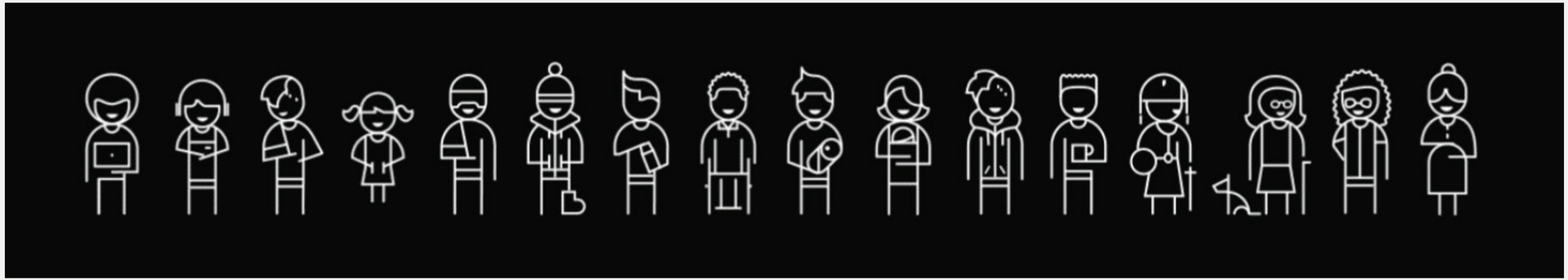


Figure 1 *Screenshot from Inclusive Design at Microsoft*

Inclusive Design:

"The design of mainstream products and/or services that are accessible to, and usable by, as many people as reasonably possible…without need for special adaptation or specialized design." "Every design decision has the potential to include or exclude customers. Inclusive design emphasizes the contribution that understanding user diversity makes to informing these decisions, and thus to including as many people as possible."[7]

"We have defined Inclusive Design as: design that considers the full range of human diversity with respect to ability, language, culture, gender, age and other forms of human difference."[8] The Inclusive Design Research Center at Ontario College of Art and Design has scoped their definition of Inclusive Design even further, outlining three dimension — 1: Recognize diversity and uniqueness, 2: Inclusive process and tools, 3: Broader beneficial impact. It is there definition that is most similar to the work that Microsoft is doing in the space.

Microsoft Design Inclusive:

Within the past two years, Microsoft has been making strides to establish Inclusive Design as a design methodology that enables and draws on the full range of human diversity. They released Inclusive: A Microsoft design toolkit to help designers and teams begin to integrate inclusion into their work. This means including and learning from people with a range of perspectives. Designing inclusively doesn't mean you're making one thing for all people. You're designing a diversity of ways for everyone to participate in an experience with a sense of belonging. Many people are unable to participate in aspects of society, both physical and digital. Understanding why and how people are excluded gives us actionable steps to take towards inclusive design. [9]

Social Innovation:

"A novel solution to a social problem that is more effective, efficient, sustainable, or just than existing solutions and for which the value created accrues primarily to society as a whole rather than private individuals."[10]

Participatory Design:

"Participatory design exercises engage stakeholders and end users in the process of solving a design problem. Participants bring their own perception of the problem and may offer unique ideas and design solutions based on user needs and preferences that were not evident to the researcher."[11]

"Participatory design (PD) is an approach where all stakeholders are involved in the design process." Participate in Design, a firm based in Singapore, goes on to outline three components of PD—Principles, Methods & Design, Process.[12]

Speculative Design:

"Speculative design is a discursive practice, based on critical thinking and dialogue, which questions the practice of design (and its modernist definition). However, the speculative design approach takes the critical practice one step further, towards imagination and visions of possible scenarios. Speculative design is also one of the most representative examples of the new interaction between various disciplines."[13]

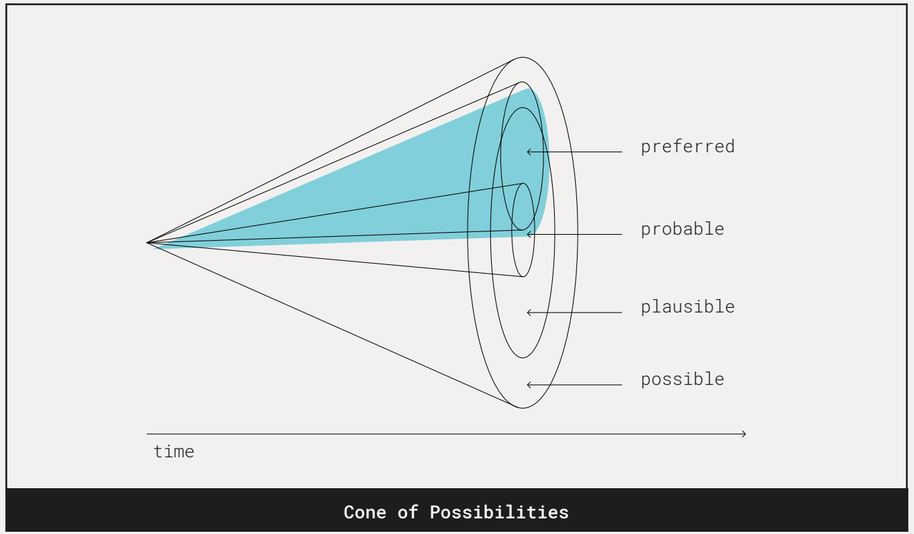


Figure 2 *Cone of Possibilities based on Joseph Voros's original graphic.*

Futures:

"Futures studies does not--or should not--pretend to predict "the future." It studies ideas about the future--what I usually call "images of the future"--which each individual (and group) has (often holding several conflicting images at one time). These images often serve as the basis for actions in the present. Individual and group images of the futures are often highly volatile, changing according to changing events or perceptions. They often change over one's life. Different groups often have very differing images of the future. Men's images may differ from women's. Western images may differ from non-western images, and so on."[14]

Figure 3 *Graphic showing Deaf Adult, SODA, CODA*

American Sign Language(ASL):

ASL is a linguistically complete and complex visual language used by many in North America. A more complete explanation is outlined in the following section.

Deaf & deaf:

"We use the lowercase deaf when referring to the audiological condition of not hearing, and the uppercase Deaf when referring to a particular group of deaf people who share a language – American Sign Language (ASL) – and a culture."[15]

CODA & SODA:

Child of Deaf Adult. Sibling/Spouse of Deaf Adult.[16]

Audism:

n. 1. The notion that one is superior based on one's ability to hear or behave in the manner of one who hears. 2. A system of advantage based on hearing ability. 3. A metaphysical orientation that links human identity with speech.[17]

Ableism:

n. discrimination or prejudice against individuals with disabilities.[18]

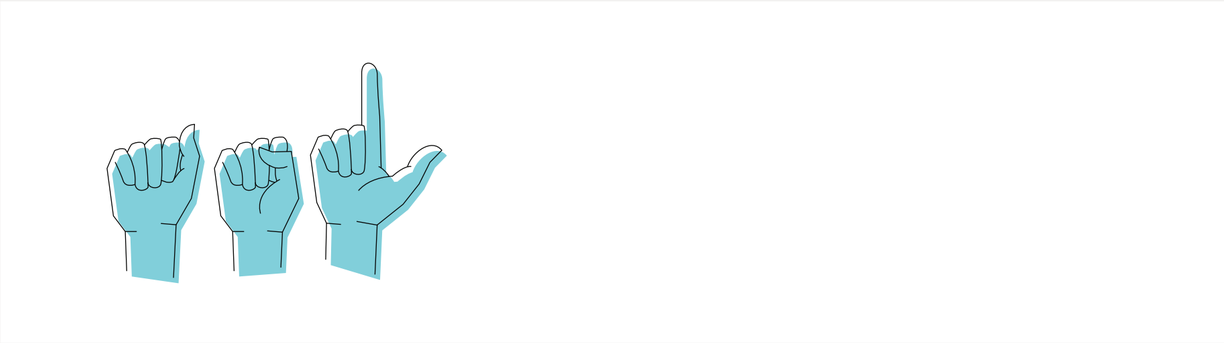


Figure 4 *ASL in sign*

AMERICAN SIGN LANGUAGE

"American Sign Language (ASL) is a visual language. With signing, the brain processes linguistic information through the eyes. The shape, placement, and movement of the hands, as well as facial expressions and body movements, all play important parts in conveying information."[19] ASL is a linguistically complete and complex language used by many in North America. It is not a universal language as many countries have their own signed language, Japanese Sign Language, British Sign Language, Korean Sign Language, and French Sign Language, to name a few. ASL actually has its roots in French Sign Language. Despite this, there is still little awareness for those outside of the Deaf community.

"American Deaf culture centers on the use of ASL and identification and unity with other people who are Deaf."[20] While Deaf culture centers on the use of language, there is an issue with language deprivation, particularly among deaf children of hearing parents.[21] While my research focused on the components that make up the language and the use of the language, it's important to note that there can be a lack of access to the language. And while I don't address this directly, it is my hope that by using ASL as the basis for this investigation, it shows its potential for more general use and excites people to learn the language, including hearing parents of deaf children.

ASL is comprised of five key parameters—handshape, orientation, location, movement, and non manual signals. A combination of any or all of these make up the visual language of ASL. It is important to note that ASL has its own unique sentence structure and no direct written equivalent. One participant stated that, as some people write in ASL structure, it can sometimes lead to a misunderstanding of intelligence.

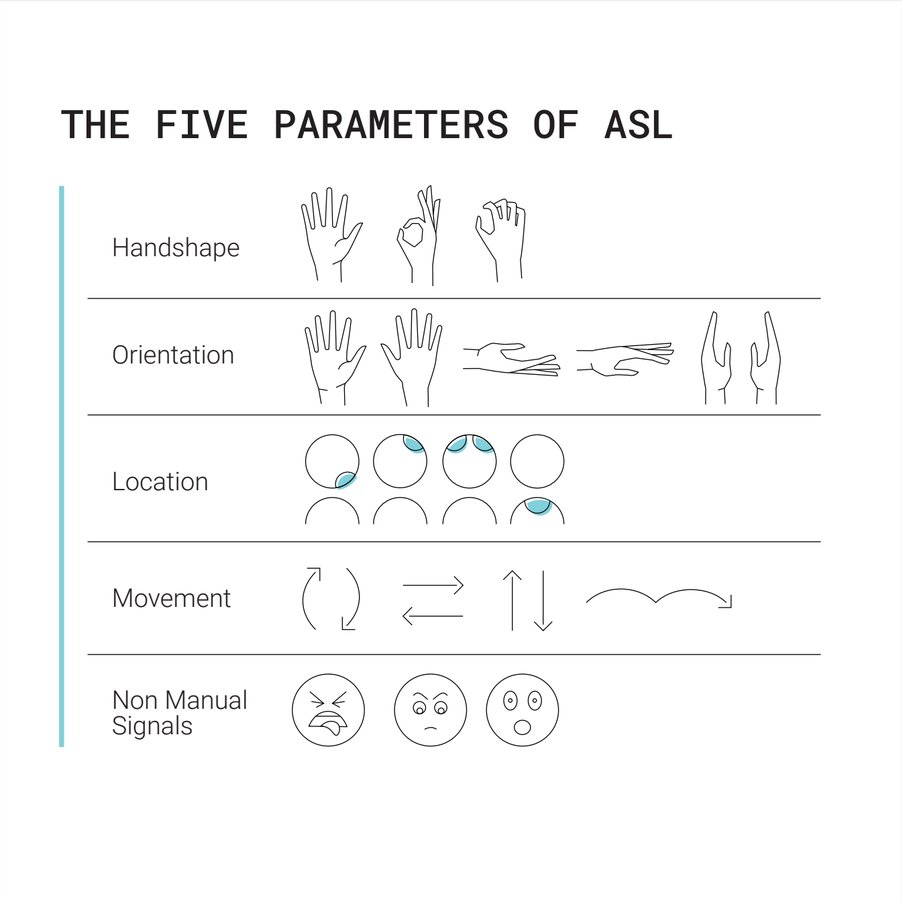


Figure 5 *Diagram of the five parameters of ASL*

Homesigns:

Homesigns are gestures developed by deaf children who are lack exposure to traditional sign languages. "The deaf children produce gestures to communicate with the hearing individuals in their homes."[22]

Name Signs:

Name signs are an important part of ASL and Deaf culture. Name signs are often gifted to a person, the can be mutually agreed upon between the person and their Deaf peers, and even be changed later in life. It is important to note that "You cannot look up a name sign for "JOHN", "MARY" or any personal name."[23]

Dialects & Regional Accents:

Like other languages, ASL contains regional accents and dialects. Rhythm of sign, form, pronunciation, ethnicity and age are all factors that result in fluctuations of the language.[24]

TECHNICAL LANDSCAPE

We are constantly flooded with news of a new application of machine learning, artificial intelligence, IoT or connected devices, and more. Technology is moving fast and companies are moving faster to capitalize, releasing new features and products constantly. Much of the world watches and benefits from these commercial products. However, I sought to understand who is truly benefiting and how is this current landscape working for those who are d/Deaf.

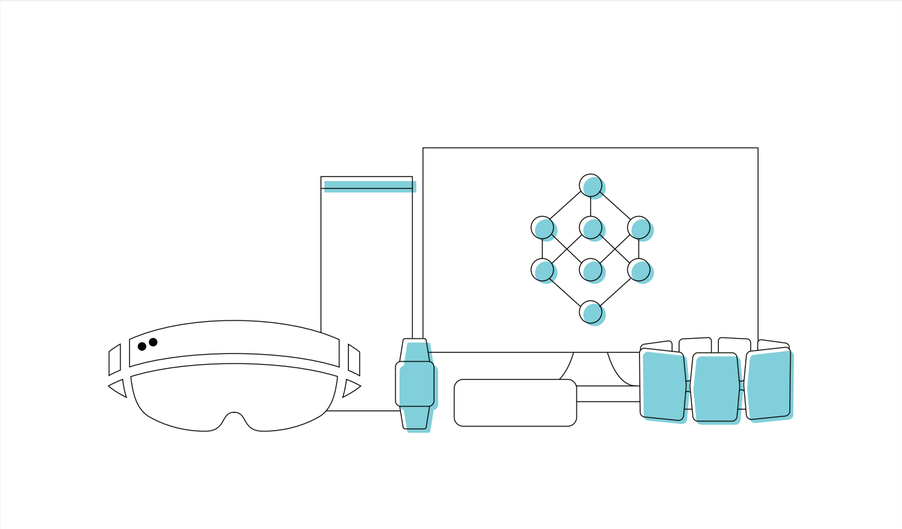


Figure 6 *Tech Trends*

Current Trends:

Currently there are major trends in machine learning, artificial intelligence, augmented reality, mixed reality, virtual reality, the Internet of Things and connected devices, tangible interactions, using data–personal, biometric, and social, integrated systems, facial recognition (commercialized, work, government), hand and body tracking, and computer vision. Just to name a few. These general trends are permeating throughout society and finding a number of applications across in a variety of roles. From commercial to personal to business to government.

Deaf tech:

However, technology and deafness is a bit different. During my literature and precedent review, I investigated video relay systems(VRS), video chatting/messaging services, ASL apps for learning the language, cochlear implants, hearing aids, ASL gloves, and translation software and tools. While these use many of the aforementioned technologies, my research of existing precedents led me to realize that technology marketed directly for the d/Deaf and Hard of Hearing(HoH) communities generally fell into one of two roles, connection or correction. Some that had the role of connection also had the possibility to benefit non-deaf rather those who are d/Deaf [fig. 6]. However, it is vital to note that there are many products that are designed for and by the Deaf community and allies that benefit the community. Speak2Sign and Cardzilla are two example produced by the company Ink&Salt.[25]

Recognizing the gap:

While investigating this current technological landscape, I found that taking a critical approach was imperative. Both in technologies marketed and applied to the general population as well as d/Deaf and HoH, I found that in being critical and asking who it's for, who it benefits, and what is its role (functional, expressive, business, connection, etc.) revealed a gap. The gap is in how these technologies are being utilized for both populations and the role they take on—connection, correction, business, self expression. It is important that we look beyond the "condition" of deafness to understanding the culture, so that we may position ourselves better in designing with and for this population.

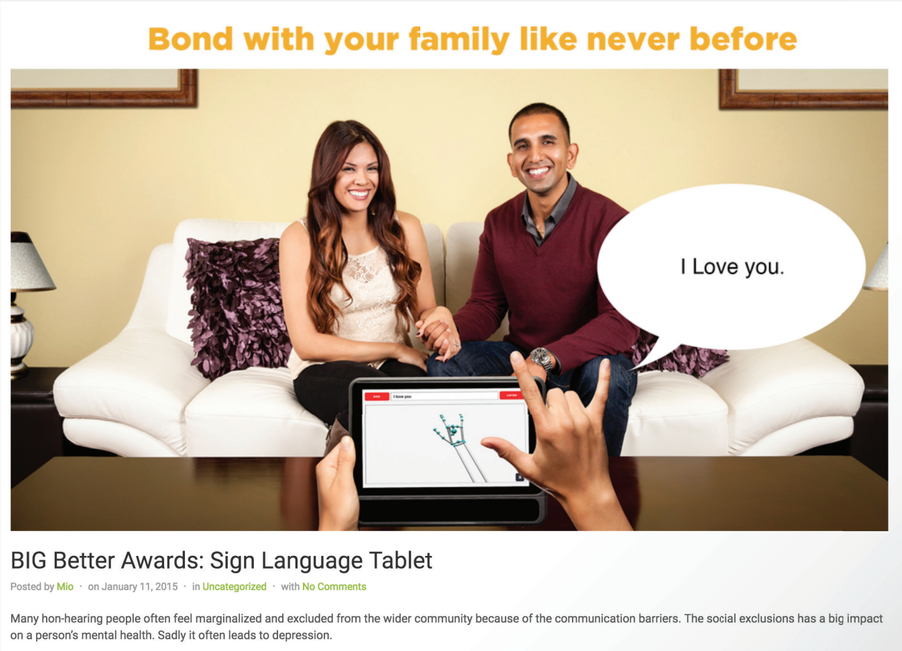


Figure 6 *Screen shot is from The Better Awards showing MotionSavvy. Text reads "Bond with your family like never before" and caption starts with "non-hearing" rather than d/Deaf.*

Figure 7 *Logos from ASL App, Glide, and Speak2Sign. ASL App and Speak2Sign are built by Ink&Salt, a Deaf run production company. Glide is a video messaging application.*

DESIGN APPROACH

Personal Approach:

Be critical, mindful, and curious.

Be critical of trends in tech, design, and innovation in a way that questions the values and inclusive or exclusive natures of them. Be mindful and self-reflective of your own practices and bias. Stay curious, question things, and always be learning.

Ability does not define creativity or innovation and is not limited by a "condition".

There is no 'problem' to be solved. Working to combat the stigmas and misconceptions surrounding deafness and being d/Deaf. Taking the time to understanding the many facets of this community can be more valuable than 'empathy' building exercises.

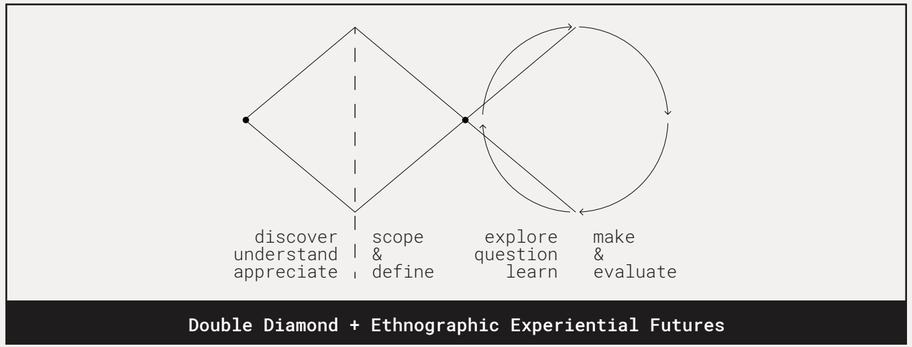


Figure 8 *Illustration of Double Diamond & Experiential Future process*

Inclusive Design

I worked within the principles of inclusive design, particularly those that align more with OCAD and Microsoft. [see terminology section]

OCAD 1: Recognize diversity and uniqueness, 2: Inclusive process and tools, 3: Broader beneficial impact.

Microsoft 1: Recognize Exclusion, 2: Learn from Diversity, 3: Solve for one, extend to many

My Process:

My process somewhat resembles the Double Diamond, however it redefines some of the stages and opens up at the end. Taking inspiration from the futuring cone as well as the Ethnographic Experiential Futures cycle.[26] [fig.8]

My project had four major stages, Understanding & Explorations, Appreciation, Experimentation, and Reflection & Recommendation.

Figure 9 *Illustration of process*

Stage One: Understanding & Exploration

This stage focuses on understand. Understanding the technological landscape, inclusive design, accessibility, Deaf history and current culture. This was done through literature reviews, precedent reviews, and immersion through social media. While the latter may not be an "accepted" research tool, I had been following artists and influencers for years, their accounts and perspectives provide a richer insight into the current culture than any paper had truly capture.

Stage Two: Appreciation

The Appreciation stage built upon the understanding work. I spoke with d/Deaf and non-deaf, signers and non-signers, designers and non-designers. I did so to better understand the perspectives of all stakeholders so that I may better position this project in away that address the desires of those within and closest to the Deaf community as well as misconceptions that non-deaf may have.

Stage Three: Experimentation

This stage focused on technology and futuring. A personal focus on technological exploration allowed me to experiment with the technologies of today in order to better inform the artifacts of tomorrow. While I worked within the scope of technology as it relates to those who are d/Deaf, no specific "problem" was investigate. This allowed me to embrace futuring as an approach to this space. I worked to adapt Stuart Candy and Jeff Watson's Thing from the Future card activity into a remote workshop for those in the Deaf community. Based on futures I received back, I was able to generate a set of scenarios and extract artifacts to bring to life the ideas shared. Based on the technical explorations, I was able to actualize components of these futures into working prototypes.

Stage Four: Reflection/Recommendation

Stage four includes reflection on the process, reflection on how we learn and understand diverse user groups, and reflection on the final artifacts and futures. This led to several recommendations in working with the Deaf community as well as incorporating inclusive design into one's own work.

PART TWO

Interviews
Exploratory Probes
Technical Explorations
Futuring

INTERVIEWS

I interviewed people who are both d/Deaf as well as non-deaf to gain a better sense of perceptions. Perception of those who are deaf, perception of the Deaf Community (from within and outside), and perception of American Sign Language(ASL) (from those who know sign, and those who do not)—if any. d/Deaf included a young professional turned ASL instructor and PhD student and an older participant. Non-deaf included both ASL signers as well as non-signers. Those interviewed who knew sign included an experienced interpreter/ASL instructor/Sibling of a Deaf Adult (SODA) in their 50s, an novice interpreter in their 20s, and two Children of Deaf Adults(CODA) in their 50s. Non-signer interviewees were comprised of designers from multiple cultural backgrounds. While this project focuses on the American Deaf population, it also aims to understand how designers from different cultural backgrounds perceived deafness and language and if those perceptions might play a role in the inclusive design process or hesitation towards adoption of the process.

Questions varied based on who was interviewed. The d/Deaf interviewees were asked about their upbringing, their opinions on the language, and what they wish non-deaf knew about the language or the culture. While non-deaf signers were asked about why and when they

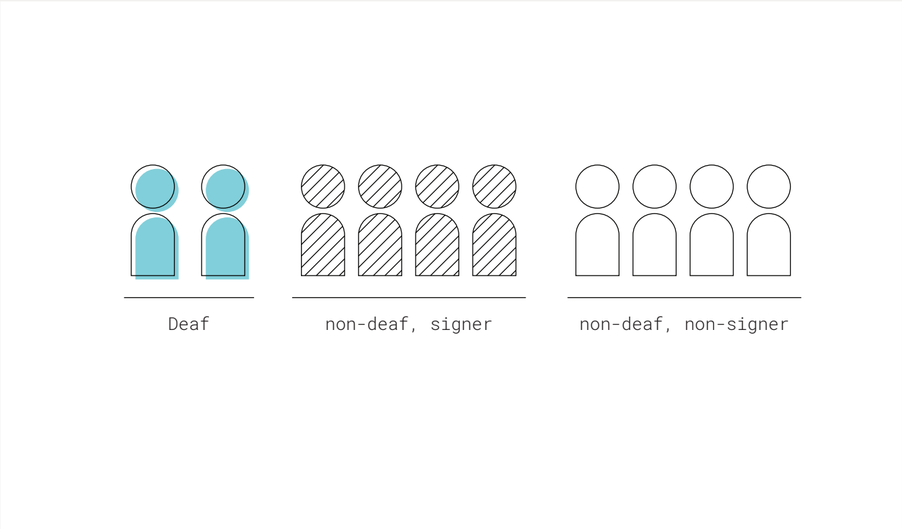


Figure 10 *Interviews with d/Deaf, non-deaf, signers, and non-signers.*

learned the language, what they appreciate about the culture, and what they wished non-deaf knew about the language and culture as well. Some also included personal and shared anecdotes relating to Deaf culture. Non-deaf, non-signers, were asked about their exposure to those who are deaf, prior knowledge or willingness to learn sign language, and finally understanding their cultures perception of those with disability as well as deafness. While I didn't fully immerse myself into this line of questioning, I believe it's important to recognize and call attention to.

Moving forward with the research, it was important to understand perceptions from several sides as to better position my work in a way that includes and understands, while, through my approach to the project, trying to address some of the misconceptions uncovered.

Perception

Perceptions can be based on several factors, society, media, and language barrier. Across many of my interviews with non-deaf, I found that exposure to the Deaf community was mainly through the media, with very few personal interactions. This led many to have almost no opinion, they felt that the deaf community was invisible or isolated. This idea of invisibility made me wonder if the deaf community is there, and the lack of visibility is due to people not using their natural language. Are they truly invisible or isolated or are they more integrated than people think? Or, if they are isolate, how might design and advancing technology combat that and integrate these two populations?

In speaking with signers, both deaf and non-deaf, several key insights were shared with me, many focusing on changing the perception the hearing has towards d/Deaf. I asked each person to leave me with one (sometimes two) thing they wish the hearing community knew. Most focused on "open-mindedness" knowing that d/Deaf people have the ability of anyone else, language does not define their intelligence, they can do anything hearing can–they just do it differently, and that equal and open access is important. This was especially echoed in the interpreters I spoke with. How might a more critical approach to the intersection of disability and design/technology help in shifting perception?

Ability

d/Deaf people are able to do anything that hearing can. I heard this throughout my interviews as well as mirrored throughout my research, particularly in the TED talks and video documentation I watched. Christine Sun Kim gives a beautify talk on music and the way she signs and creates art. Amber Galloway, one of several interpreters aiming to remove the barriers of interpreting at musical events. Using their language in a way that is both expressive and innovative. Their abilities as well as their "work-arounds" are a breeding ground for innovation. How can we learn from this as designers and include d/Deaf people into new approaches to technology?

Access

Perception can influence access as well. A long time interpreted shared several stories of how medical professionals refused interpreter services due to the cost, ADA laws are in place, but many disregard them. "Dollar signs can rule access." From the perspective of interpreters, more access to interpreting services is crucial. Particularly in the case of medical and even entertainment. In addition, "Hearing people are afraid of sign language"... this can lead to mishaps in interpreting—fake interpreting occasionally occur.

The Language

Many non-signers recalled a time in their life where they wanted to learn, but the inclination faded, or the language was too hard. Many perceive it as "cool", especially when they see it in the media, whether that's News, TV, movies, social media. Media and social media bring attention to the language and its creative practices. These things had generated interest, but that interest eventually faded.

Signers, native and learned, know not only the beauty of this language, but the way in which you begin to think differently. When you sign, you feel differently than when you speak...you are able to see and embody what you are thinking. It's a very powerful feeling.

EXPLORATORY PROBES WITH ASL

Based on the secondary research as well as my interviews, it became evident how deeply rooted in identity the language of ASL was within the Deaf community. "American Deaf culture centers on the use of ASL and identification and unity with other people who are Deaf."[27] However, through my precedent reviews and reviews of the technological landscape, I noticed that technology focusing on translation doesn't truly translate, but rather converts.[28] Technology that aims to translate typically only captures hand shape, location, motion and palm orientation, however, it misses the non-manual signals. These signals are crucial in capturing the language as they can denote connotation and tone, as well as give two different meanings to one sign. Sign databases are limited as well, often including the alphabet and numbers and a selection of words.[29] [30] We are in the early stages of sign recognition, much like the early stages of natural language recognition, the libraries developed and grew overtime, but the need/want was more widespread and occurred at an accelerated rate. I also noticed that there are a number of the technologies being used, from computer vision and hand tracking to wearable gloves, that benefit the non-deaf person, not the d/Deaf person. As such, my approach to these explorations was that of a re-frame.

Figures 11 & 12 *Light gloves made to use with long exposure photography in order to capture the participant signing.*

Based on this gap, I chose to explore the five characteristics of ASL through design and technology in the form of exploratory probes. Pairing each characteristic with a technology that has the ability to capture it in a way that highlights that characteristic. For example, using the hand tracking software of the Leap Motion to capture hand shape and palm orientations, long exposure photography to capture the motion and location of both one sign as well as an entire sentence, and in future work using facial feature recognition to capture the non-manual signals.

The goal of these explorations was two fold, it was to better understand the technological capabilities as well as its limitations and to explore how to technology might be used in a way that can translate directly as well as representationally. My hope in these was reframe the way technology is used to translate ASL in order to open the possibilities in conceptualization and actualization. Furthermore, I want these explorations to be an expression of the language, in which d/Deaf people can use their natural language, paired with technology and design to amplify their voices. How to use these facets of ASL to create a platform for expression of self, whatever form that may embody.

Light/Motion :: Motion & Location

This line of investigation was inspired by Deaf artist, Jolanta Lapiak's work, Photowriting, as well as Frank B. Gilbreth's Motion Study Photographs.[31] [32] Each use light to capture human movement, however while Gilbreth studies were to "improve work methods," Lapiak captures the notion of calligraphy in sign. Using long exposure photography and hand made light gloves[fig. 11 & 12], I captured several sentences in ASL. I asked participants to sign two phrases, a control phrase "Nice Meet You," which I would compare across participants, and then a sentence of their choice. The second image was a sentence of their choosing, I did this so that each participant could have a personal artifact that had meaning. This exploration and the evaluation helped in visualizing much of what was presented in the research, sign can vary from person to person, it's like an accent or handwriting, it's very individualistic.

WHAT WAS LEARNED:

Combining the approaches of Lapiak and Gilbreth, this study captured both the quality of participants' movement as well as the beauty, highlighting the handwriting-esque nuances of each person. I was able to capture the spatial visual language in one image, showing the lines that connect each sign. Points where there are more light meant that the sign was held there longer or perhaps that the signer was a bit hesitant. By capturing each image from the front and the side, I was able to see the differences more clearly across the participants. This insight allowed me to address the differences in sign moving forward. While I captured experienced signers, mainly from Western Pennsylvania, it could prove significant to conduct a larger study of participants ranging in sign ability, geographic location, and age.

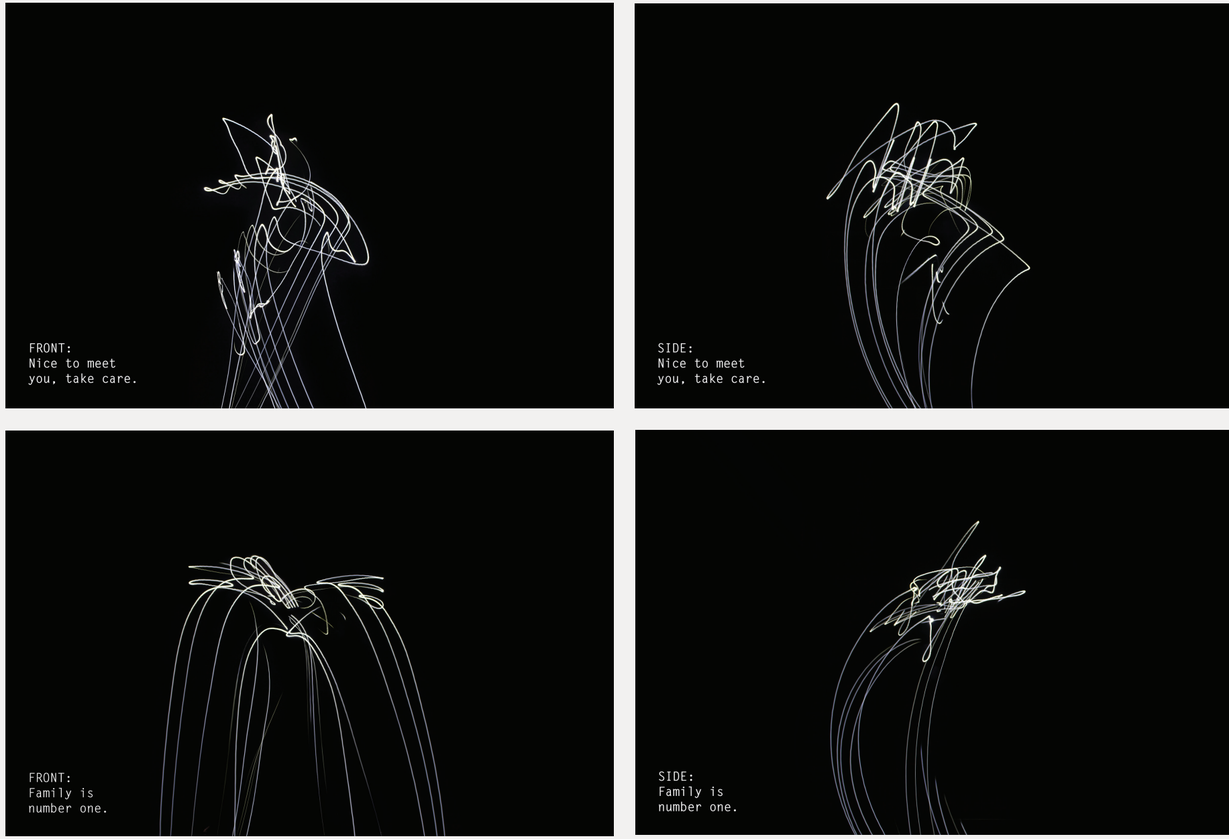


Figure 13 *Participant 04 Long Exposure*

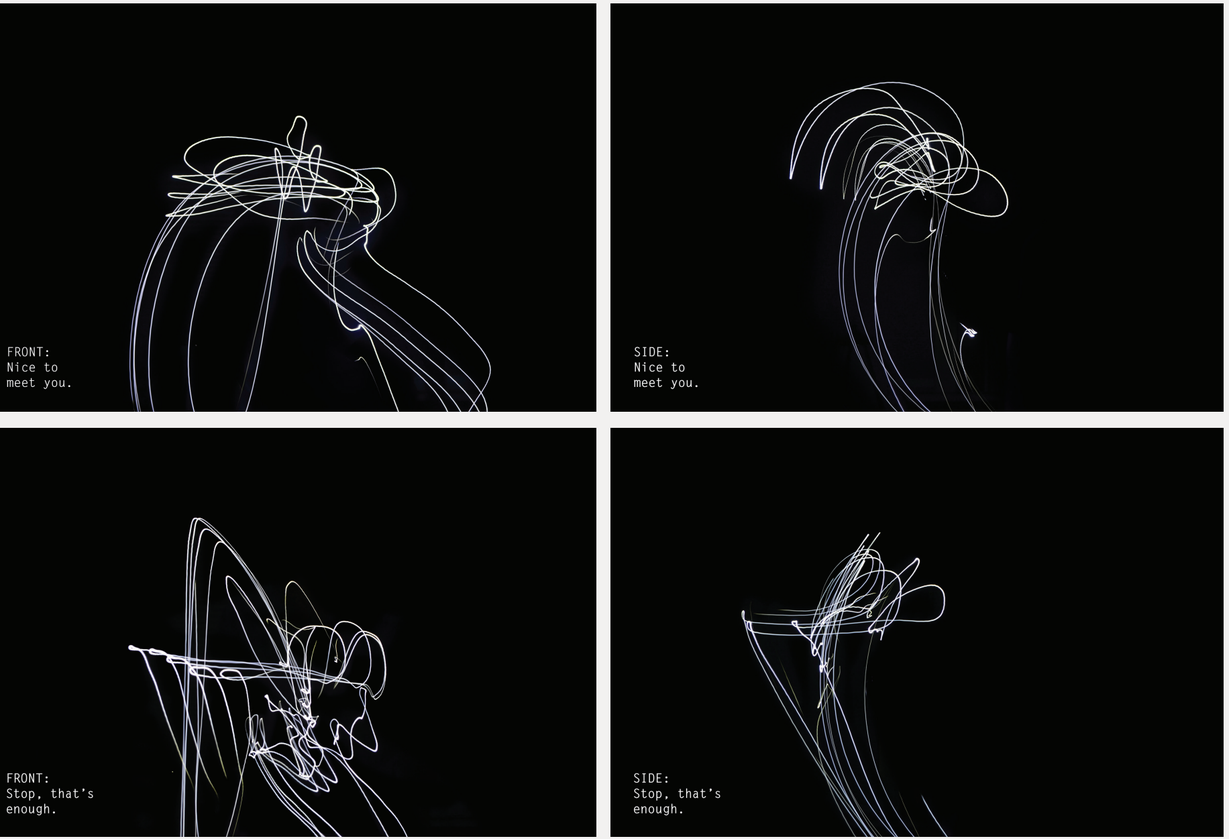


Figure 14 *Participant 08 Long Exposure*

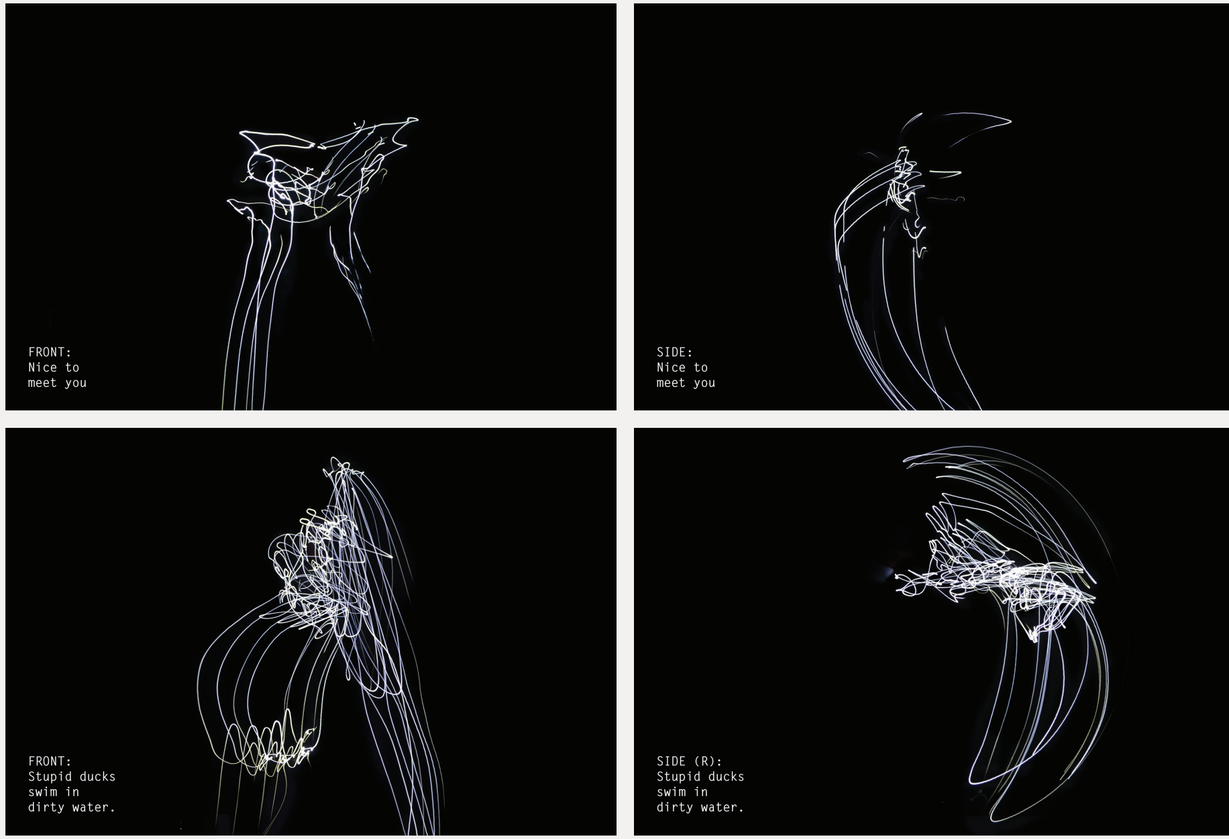


Figure 15 *Participant 09 Long Exposure*

Leap Motion + Processing :: Hand Shape & Palm Orientation

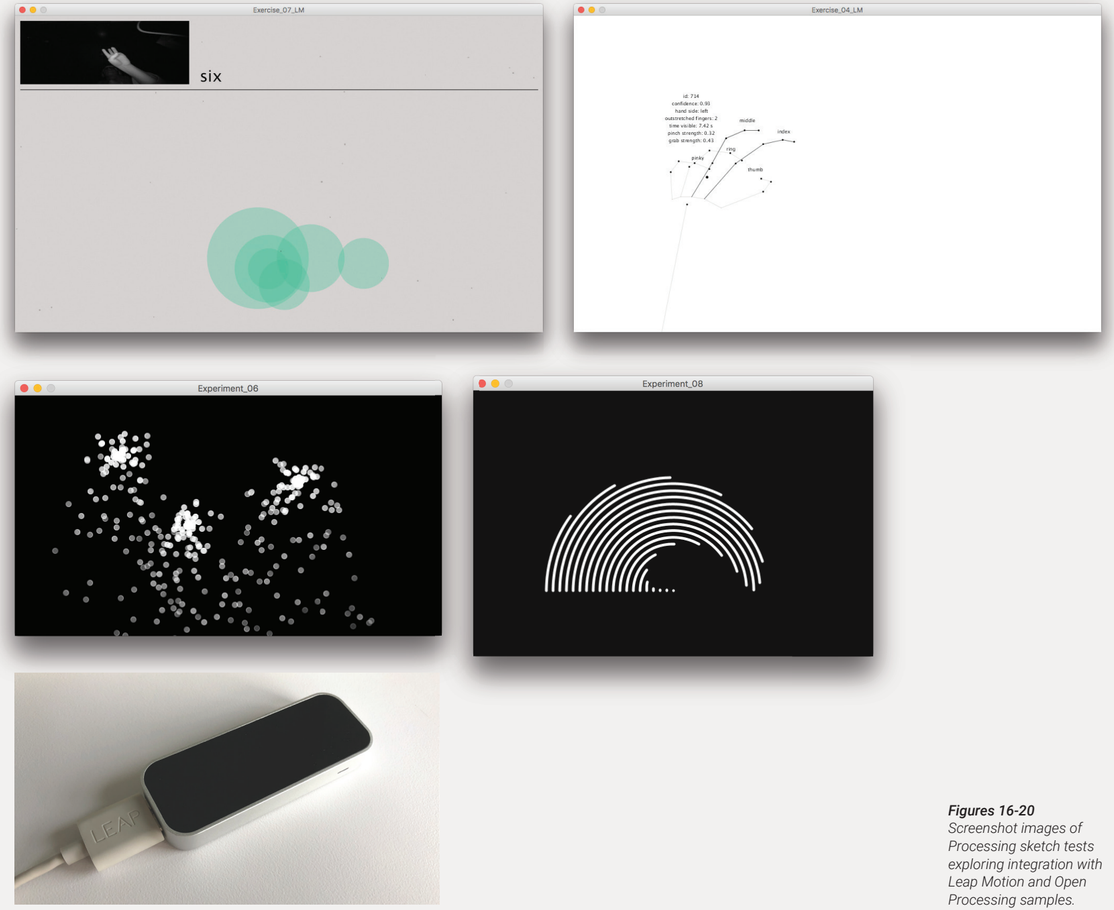
Hand tracking with computer vision and sensors is one of the technologies behind some ASL translation techniques out there. Leap Motion and Microsoft Kinect have been used in variety of ways to capture and translate sign. I want to explore how Leap Motion can utilize processing and translate simple ASL signs into visual representations. I began by attempting to hard code the ASL numbers and representing them through size and color and number of circles. I then moved on to incorporate Machine Learning(ML). I realized through the first exploration that no two signers are the same, signing things differently. Using ML, I was able to train the Leap Motion to recognize these slight variations and respond accordingly.

WHAT WAS LEARNED:

This explorations gave me a greater understanding of the technology, its limitations as well as my own limitations. It showed me the potential of representing ASL through another visual medium, one that is, I dare say, more universal. This simple exploration allowed me to quickly explore the technology of hand tracking and machine learning which I then apply to my final work.

Future Explorations:

I recognize that wearable gloves are also a large contributor to the ASL translation market. Moving forward I would like to use these gloves in a way that benefits the wearer, not the viewer/listener. [see part three] In addition, I would like to explore computer vision and its role in translating non-manual signals. SnapChat, Facebook, and more use facial feature recognition to overlay augmented material, they are rather precises and use only your phone's camera. How might this technology be used to explore non-manual signals for d/Deaf users?



Figures 16-20
Screenshot images of Processing sketch tests exploring integration with Leap Motion and Open Processing samples.

TECHNICAL EXPLORATIONS—RESEARCH THROUGH MAKING

Based on my review of the technological landscape, interviews with participants, and exploratory probes with ASL, I began to explore the technologies more intimately. Focusing on technologies that had the potential to pair well with the ASL language as well as those that could offer up more than just translation. The approach of research through making allowed me to better understand the technologies I was investigating and helped in making more informed design choices later in the process. This process also allowed me to experience first hand the potential of this technology as well as its challenges.

In order to decide what technologies to explore further, I delved into the precedents that relate directly to the Deaf community, in particularly ASL recognition. In addition, I also looked at products for the general public that use current technological trends. In looking at both populations, I was able to identify technologies that would help in addressing the five

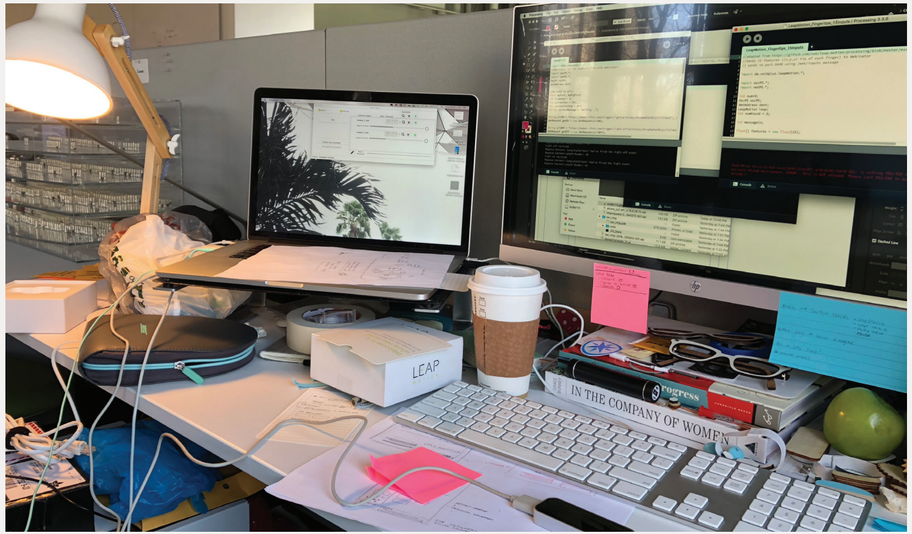


Figure 21 *Desk image of prototyping, includes Leap Motion, Processing, Wekinator, and Philips Hue.*

components of ASL as well as provide starting points for new outputs to ASL translation. Looking at what is currently being used, in terms of technologies and principles, I was able to find accessible technologies that I, myself would be able to utilize. The technologies that had the most potential for exploration were computer vision and hand tracking, machine learning, artificial intelligence, sensors of both body and environment, augmented reality, text to speech, and visualization software.

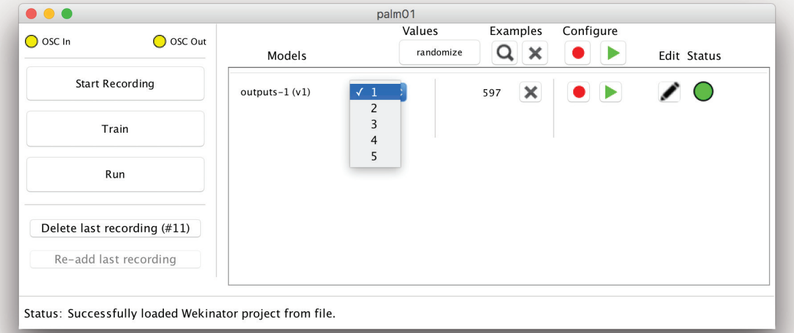
As previously mentioned, it was imperative that I use software and hardware that was accessible, in terms of the ability to learn or use myself. The following is a list of the technologies I used, why I used them, and what I learned from the exploration of each.

Machine Learning :: Wekinator

During my first exploratory probes, I hard coded finger positions using the data from the Leap Motion and its corresponding Processing library. While this worked, it was tedious and didn't allow for many mistakes in terms of the signer or the Leap Motion's hand tracking. One of the technical experts I spoke with suggested Wekinator, a machine learning platform for artists and musicians. "Machine learning is a subfield of artificial intelligence. Its goal is to enable computers to learn on their own. A machine's learning algorithm enables it to identify patterns in observed data, build models that explain the world, and predict things without having explicit pre-programmed rules and models."[33] Machine learning provided flexibility and allowed me to use more intricate hand shapes as well as allowed me to integrate movement and location. I took an online course from Kadenze, Machine Learning for Musicians and Artists, which gave me a basic introduction to machine learning principles as well as the Wekinator platform. The instructor, Rebecca Fiebrink, provided a number of resources, including how to connect with Leap Motion and Processing.

WHAT WAS LEARNED:

Wekinator showed me the far reaching potential of machine learning as well as how easy it is to grasp the concepts behind the technology. In relation to ASL and sign language, machine learning was used to train and code signs, however, the ease of use by an individual has the greatest potential when it comes to home signs and sign names. While it was still a bit temperamental when it came to Leap Motion integration, my own coding knowledge, and perhaps my particular system setup [fig. 52], overall using this software as proof of concept work was extremely powerful.



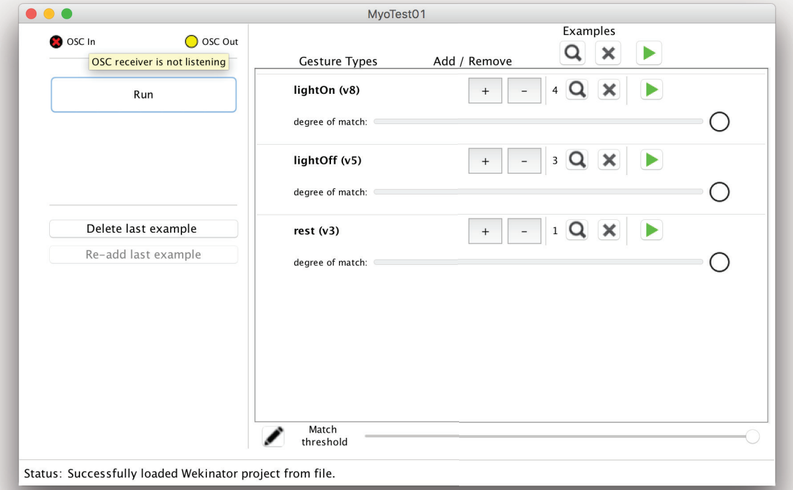


Figure 22 *Wekintor training examples*

Figure 23 *Processing visualizing hand and finger data via Leap Motion*

Hand Tracking :: Leap Motion

I decided continue to use Leap Motion for its hand tracking capabilities and paired the Leap Motion with several other technologies in these explorations. While the tracking worked, it's accuracy and speed were lacking. I believe this was in part due to my novice understanding of the software and how to properly extract the data. I paired the Leap Motion with Processing, Wekinator, Arduino, and IFTTT.

WHAT WAS LEARNED:

I was able to better understand the limitations of this particular hand tracking technology. The Leap Motion needed to be placed on the table or on a head mounted display and had a limited field of view. In order for signs to be recognized, they needed to be slow and always in the field of view. This wasn't ideal, as few signs are positioned above a table and many experience signers are rather quick. However, for the purposes of this project, the ease of use outweighed its limitations and provided a platform for me to recognize simple signs.

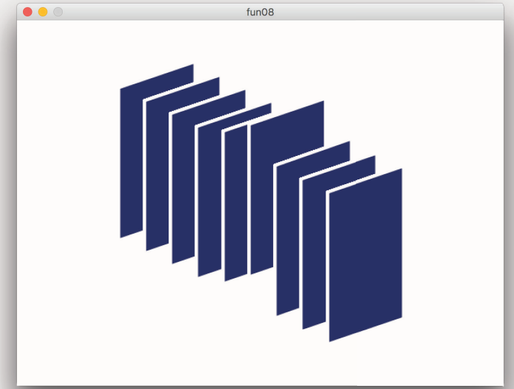
Hand Tracking :: Myo Armband

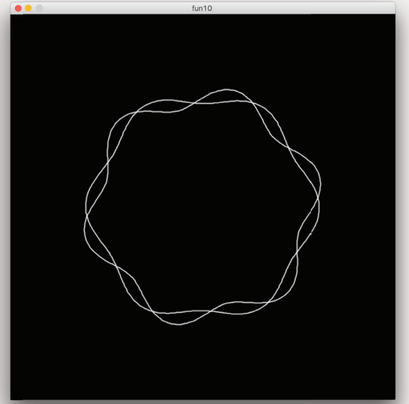
In addition to Leap Motion, I also tested the Myo Armband for use with both hand shape and motion recognition. This band fits snuggly on the arm and contains a number of sensors which "...read the electrical activity of your muscles to control technology with gestures and motion...".[34] The armband proved to be a bit more difficult to work with that I initial thought. It comes preloaded with five hand gestures and the ability to use the arm's Electromyography (EMG), acceleration, and orientation data. This seemed to offer the best potential for gathering arm movement and finger position information. I tested the Myo with Wekinator in an attempt to train a couple of universal signs as well as sign names.

WHAT WAS LEARNED:

I realized, after exploring this avenue for a week, that the EMG data is not sufficient enough. I spoke with Brandon Taylor, a PhD candidate in the Human Computer Interaction Institute at Carnegie Mellon University, whose work centers on creating a complete system that recognizes and properly translates American Sign Language. He said that because of the Myo's placement, closer to the elbow, it does not allow for intricate finger detection. So while they Myo comes preloaded with hand gestures—closed fist, open hand, hand turned right, hand turned left and tapped finger—these are gestures that all require more muscle use and therefore allow for the armband to accurately detect them. The concept of the band is strong and the data works well for arm movement. However, it does not work well enough for training of sign language.

Figure 24 *Myo Armband device*





LeapMotion_Fingertips_15Inputs

```
//====== OSC RECIEVE ======
void oscEvent(OscMessage theOscMessage) {
 if (theOscMessage.checkAddrPattern("/wek/outputs")==true) {
     if(theOscMessage.checkTypetag("fffff")) { // looking for 5 parameters
        float receivedX = theOscMessage.get(0).floatValue();
        float receivedY = theOscMessage.get(1).floatValue();
        float receivedSize = theOscMessage.get(2).floatValue();
        float receivedHue = theOscMessage.get(3).floatValue();
        float receivedRot = theOscMessage.get(4).floatValue();
      } else {
        println("Error: unexpected OSC message received by Processing: ");
        theOscMessage.print();
      }
   }
}

//====== OSC SEND ======
```

Figures 25-27
Processing explorations and serial communications

Visualization of Data :: Processing

"Processing is a flexible software sketchbook and a language for learning how to code within the context of the visual arts."[35] I utilized Processing both because of its ability to visualize data as well as its ability to integrate with several other platforms. I was able to use Leap Motion, Wekinator, IFTTT, Arduino, and Particle Photon through Processing, individually as well as together. This allowed me to prototype working systems quickly as well as visualize the data of sign language hand shapes and palm orientation.

WHAT WAS LEARNED:

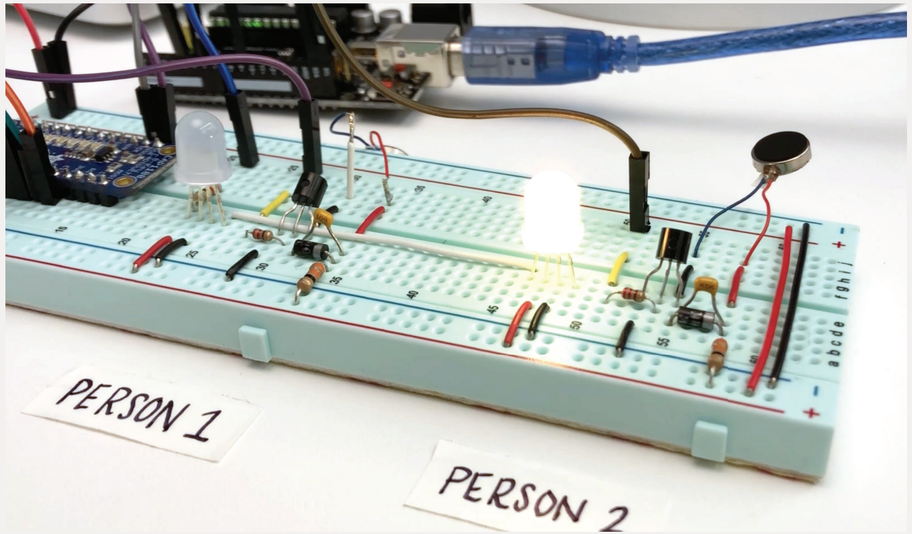
Processing is a versatile platform that can be used for both end product as well as low fidelity connections. Processing can be used to control physical computing, generate stunning visual outputs based on data, used as a connection between to platforms. While it can be challenging to use, it is worth it as it has many libraries that can extend its use and plenty of documentation and resources to help anyone get started.

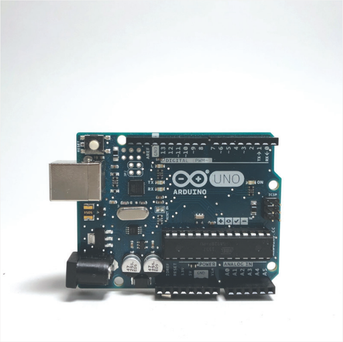
Input/Output :: Physical Computing

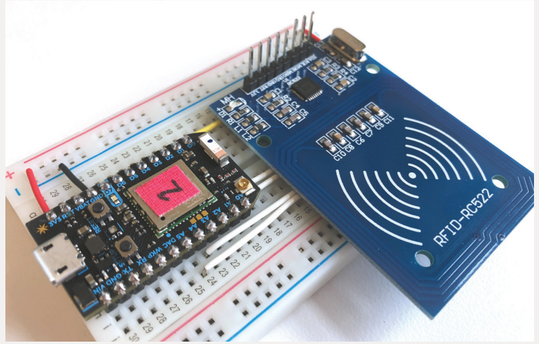
Over the course of this project I explored physical computing in a number of ways. Investigating types of microcontroller boards, input devices/sensors, and output devices. I generated explorations that can sense the environment, respond to websites, and even touch. I also used the integration of Leap Motion and Processing to control physical artifacts. In designing with those who are d/Deaf, it was paramount to work with light and vibration. I worked with a variety of light products as well as vibration devices as well. I also used sensors such as accelerometers and flex sensors to try and capture and movement. With my somewhat limited knowledge, this proved to be one of the most difficult explorations. However, I wanted to try these particular sensors as they are seen in almost every variation of the "ASL Translation" gloves.

WHAT WAS LEARNED:

Through this line of exploration, I became interested in tangible interaction. The ability to control, manipulate, and interact with the physical spaces we occupy was eye opening. Physical computing and understanding how things work proved to be extremely beneficial. It allowed me to conceptualize and speculate on a number of possibilities and integrations with ASL. It also allowed me to prototype and actualize those possibilities. One of the most rewarding moments of this process was being able to use sign language to control the built environment. While there were limitation in my knowledge of mechanical engineering and coding, I was able to work towards screenless interactions. I felt this was important as screens can sometimes be a barrier between two people wanting to communicate naturally.





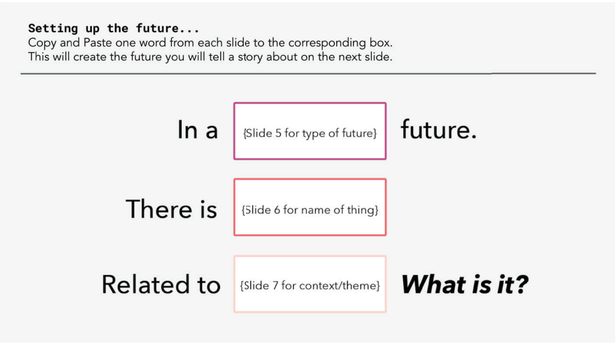


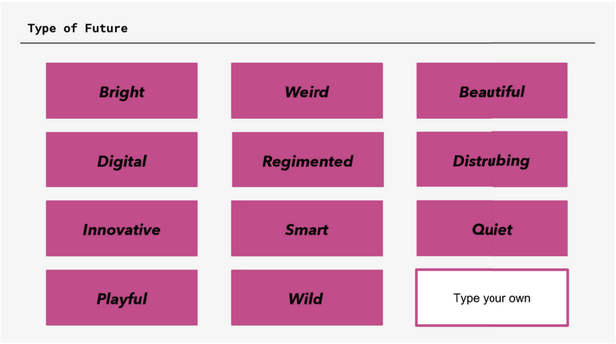
Figures 25-27 *Tests with physical computing, lights, RFID and vibration motors.*

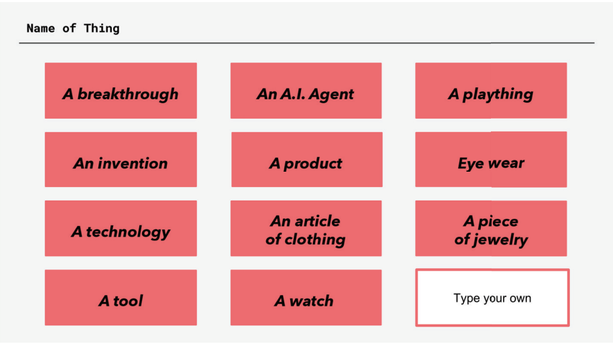
INCLUSIVE THING FROM THE FUTURE

In addition to the aforementioned, I integrated futuring into my processing. Futuring looks at the present day for signals of what might be possible, plausible, preferable, and probable as we move towards the future [fig. 2] . After participating in a number of futuring exercises as well as courses that incorporate futuring and speculative design, I felt that futuring with those who are d/Deaf or closest to the Deaf community would prove to be advantageous. In my experience, futuring and speculative work provides a platform that allows for imagination of tomorrow, criticism of today, and reflection of the past. Stuart Candy and Jeff Watson's The Thing from the Future [fig. 28] was particularly inspiring. A simple card deck activity that allows people to imagine and create artifacts from future scenarios. There are three categories of cards—the future, the thing, the context—each category has about 34 cards each, allowing for "3.7 million possible creative prompts".[36]

Figure 28 *The Thing from the Future card activity.*







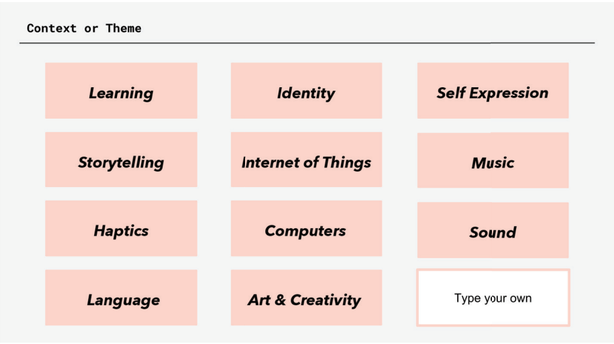
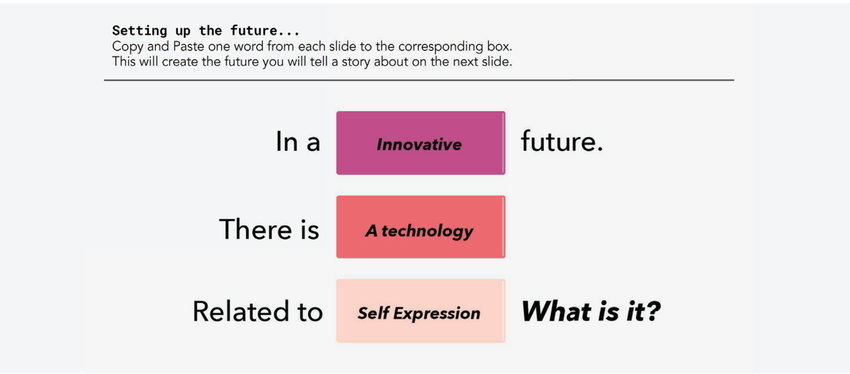
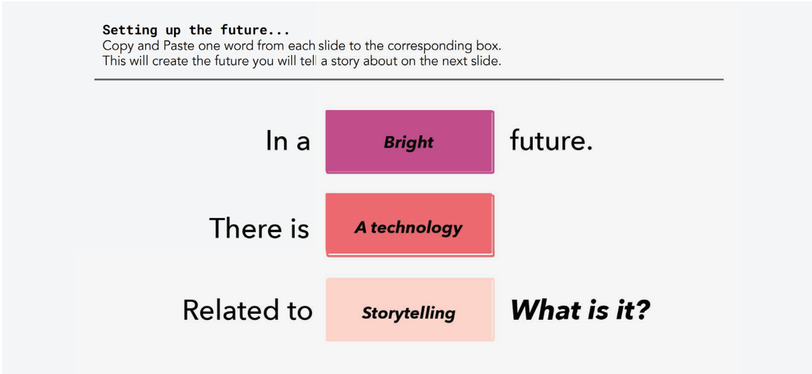


Figure 30 *Screenshots of adapted card activity.*

This card activity showed promise in addressing the role of emerging technology specifically in regards to the Deaf community. The idea of working with those who are d/Deaf to generate futures that involved technology was exciting. Instead of designers, engineers, or social stereotypes deciding how technology is used within the Deaf community, this activity allows for those within and closest to the community to decide for themselves. The aim of this futuring activity was to better understand the desires of the community from the community, rather than listen to what the technical trends where telling me.

However, I realized that the original activity was extremely broad in the possible futures. I ended up needing to adapt Candy & Watson's Thing from the Future to narrow the scope to address specifically the space of technology, Deaf culture, and language. I ended up using eleven words per category, keeping a few of the original prompts as well as adding in ones that would help guide participants to think of futures related to technology, Deaf culture, and language. In addition, the card deck is typically used in group workshop settings, yet logistics prevented me from conducting an in person workshop with a group. And so, I needed to adapt the activity's form to closer align with my research goals and target audience. I used the platform of Google Slides which allowed me to quickly replicate the activity to send to multiple participants as well as reach people in different states and timezones. These screenshots depict the final adaptation that was sent to participants. [fig. 30]





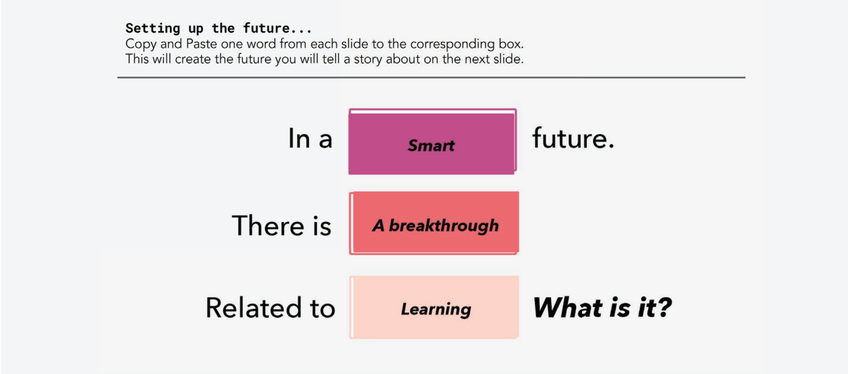


Figure 31 *Screenshots of participant futures.*

The remote activity was sent to those within, and closest, to the Deaf community. This included those who are d/Deaf, Children of Deaf Adult (CODA), and Sibling of Deaf Adult (SODA). I received three responses back, one from each category of participants. Almost every response used three different cards to formulate their future scenarios. [fig. 31] The stories generated by participants will be discussed in greater detail in Part Three. In a bright future. There is a technology related to storytelling. In a smart future. There is a breakthrough related to learning. In an innovative future. There is a technology related to self Expression.

What I learned & What I would do differently:

I consulted with Stuart Candy on adapting both the card's medium and content.

He cautioned me to keep the content as broad as possible so that no matter the combination of cards, the scenario made sense together. In addition, he suggested making hard copies to send via mail, however due to timing and remoteness, I was concerned that sending physical copies had the potential to be lost and forgotten. Access, in terms of communication with me, was also a concern. Having a digital version allowed me to answer questions within the document itself and the participant would receive notifications. While, overall, the results of the remote activity were successful, there were several lessons I learned in terms of participatory design and copywriting. It's crucial to build strong relationships with participants, especially those in more diverse communities. I feel had I built more relationships and fostered them over the last two years, I would have been able to send this activity to more people. I also feel that they way in which I presented the instructions, since it was remote and not able to be done in person, could have benefited from more clarity. In the future, I believe adding and example use case could take care of the ambiguous instructions.

Participant Stories
Conceptual Scenarios
Ubiquitous Inclusion
Proof of Concept

PART THREE

IN AN INNOVATIVE FUTURE. THERE IS A TECHNOLOGY RELATED TO SELF EXPRESSION.

"With this technology Deaf people can have access to everything and during real-time in their language and English."

One participant, a deaf adult, described a future that looked at the past for inspiration. They spoke of Martha's Vineyard, where nearly 200 years ago, everyone spoke sign language. In the mid to late 1800s through to the early 1900s, Martha's Vineyard was home to one of the largest hereditarily deaf populations. It was in the towns of Chilmark and West Tilsbury that everyone spoke sign, it was ubiquitous and knowing sign was something to be envied. Deafness was not seen as a difference.[37] They envisioned a future where sign was ubiquitous once again and there were technologies that support that vision. In their future, every home would have a bilingual "mainframe," which would know and respond to both signed languages and English(textually).

What the participant addresses:

In Mark Weiser's, The Computer for the 21st Century, he states "The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it."[38] This participant addresses the use of ubiquitous computing in relation inclusion, entwine technology that recognizes sign language into everyday life. They discussed a "technologically and environmentally advance city" where they are notified of everything from food expiration date to signed information from city officials.

Components to extract:

- A system that recognizes sign language
- A notification system, that can alert for a range of events (ex. small: food expirations, med: someone at the door, large: emergency city alert)
- Connection through smartphones

IN AN BRIGHT FUTURE. THERE IS A TECHNOLOGY RELATED TO STORY-TELLING.

"It's important for her to tell me the story, I want to watch her tell me the story, The most important is hearing/seeing the words of the story through my mom. It's a bright future, because my mom has never been able to do that before, this technology lets us interact in that way. And now she can do that to my children, and their children."

In another future, from a CODA participant, they described a past event to inform their future. They had always wanted their mother to read them a story. However, their mother didn't know how to read well, because of this she would be able to read a few lines of the story then stop. This participant wanted a technology that would allow the mother to read stories. They described a technology that might be put on the mother's voice box, or something that converts her signs into text or voice.

What the participant addresses:

This participant addresses a more creative and whimsical approach to sign to text and sign to speech application. While there is hardware and software that seek to address this today, this participant's specific scenario might pose a unique use case. In this scenario, it is not just about the translation of sign, but the translation of a story as well. In addition, the participant want to be able to hear or see the words of the story come to life through their mother's voice. Beyond a computerized voice or simple text, how might the output manifest?

Components to extract:

- How is sign translation viewed?
- How can sign enhance storytelling
- How can storytelling enhance sign?

IN AN
SMART
FUTURE.
THERE IS A
BREAKTHROUGH
RELATED
TO LEARNING.

"I envision K-12 schools having ASL classes for everyone! The world would be visually connected in person and through videos...It would bring families together, it would give the world more quiet spaces, and it would totally fit with our video centered world."

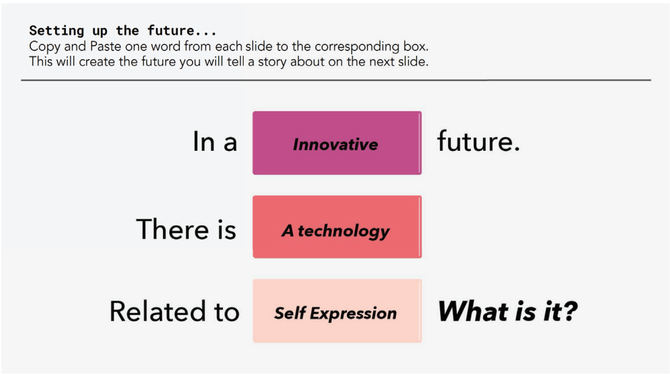
A third participant, who is a SODA, ASL interpreter and instructor, described a future where ASL is integrated into schools and the education of everyone. They saw an opportunity for sign to become a part of everyday life for both d/Deaf and non-deaf alike. This future also included reference to our current 'video-centered world'. Content is available instantly, we can share images, video, animated emojis that mimic our face. What is stopping us from using those same technologies to connect people through a visual language?

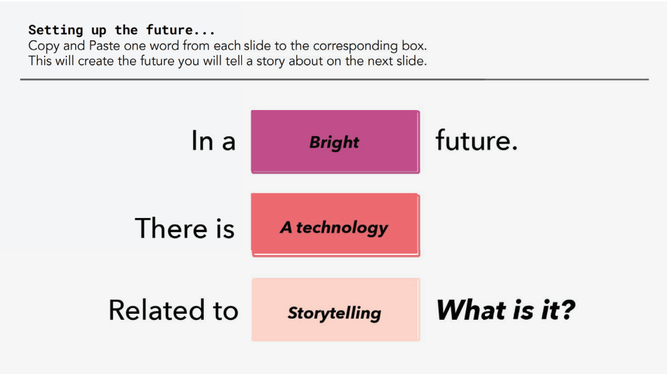
What the participant addresses:

This participant links one of our current trends of sharing and connecting through video to a future that takes a advantage of video connectivity for inclusive communication. In its application to ASL, this is being done across various social media platforms such as YouTube, Facebook, and Instagram. There is also a current app, Glide, that is used for video messaging. So the question is how might an integrated, inclusive, education be supported by our current technology and the way teens/youth are using it now?

Components to extract:

- Messaging systems that support ASL as natural language
- Language education program that seeks to reframe learning ASL to become more pervasive in mainstream society





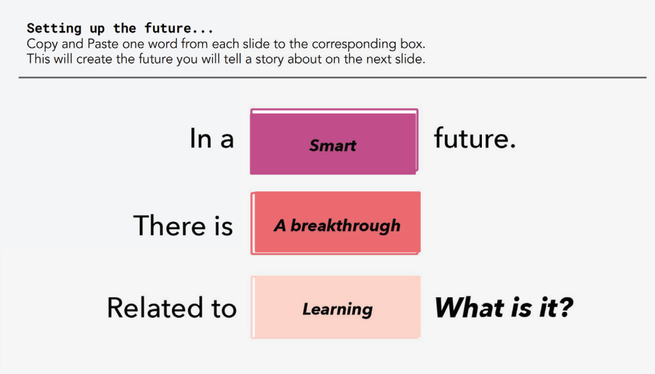


Figure 32 *Screenshots of participant futures.*

What I learned & What I would do differently:

This exercise reveal a great deal about the type of futures that those within and closest to the Deaf community desired. To overlay this with technology and products that are marketed for those who are d/Deaf, one might see a stark difference. Few of these address communication in terms of translation. Instead, they aim to make ASL more universal in order to remove societal barriers. Moving forward, it would be interesting to use the same prompt with some of the non-deaf participants from my interviews to see how the stories might compare.

Despite the challenges, working with those within and closest to the Deaf community–deaf and non-deaf– was invaluable. In breaking down the futures that have been create I was able to identifying that these desired futures are not that far off, technologies are in place to work within this space and take a step forward towards a more inclusive desired future. In the coming sections, I use technologies, products, and current concepts to generate artifacts from the future.

CONCEPTUAL SCENARIOS

The year is not far off, we live in an integrated and inclusive world where the lines of technology, design and the human condition blend.

These following five scenarios were generated based on aspects of participants futures. .

SCENARIO ONE

Doug is moving about his typical Saturday. Cleaning the house, running errands, and planning his next trip. A small buzz on his wrist goes off, followed by a subtle light in the corner of his eyesight. He signs "open" and sees an interpreter appear in AR and sign him the breaking news about his city. After a few minutes he realizes that this isn't pertinent to him and waves away the interpreter. Later in the day, as Doug cleans the kitchen, his glasses have desaturated all of the expired foods so that he can quickly glance to see what foods have expired and which foods are about to expire. Moving around the fridge's contents appropriately.

That evening, Doug's neighbor, Jamie, comes over to talk with him, Jamie signs "hello" but soon is unable to keep up with the conversation. While they grew up next to each other and Jamie learned some sign, she isn't able to pick up as much of the conversation as she use to. However Doug's glasses take over and show the interpretation of what she is saying. On Jamie's end, she is wearing a special hearing aid that converts Doug's sign into speech, feeding it directly into her ears.

Artifacts:

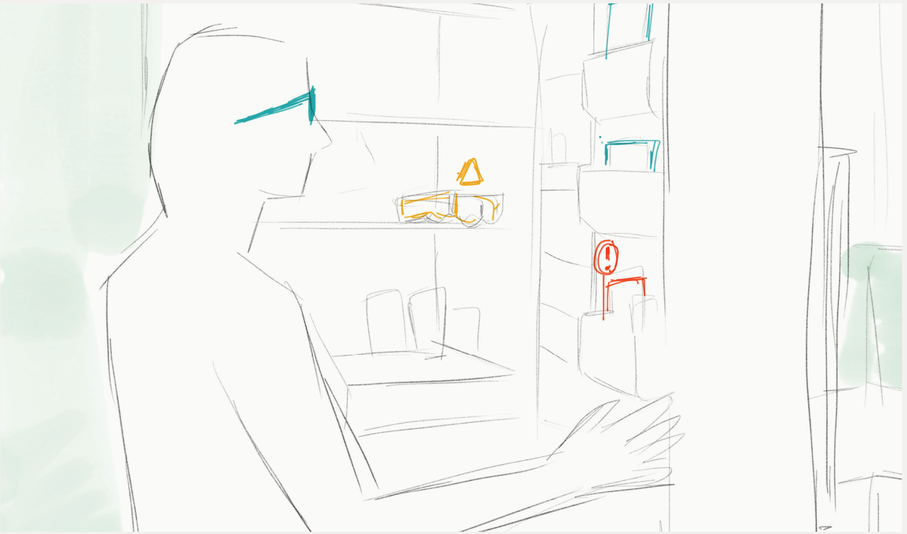
- AR glasses
- Wearable
- Hearing Aid

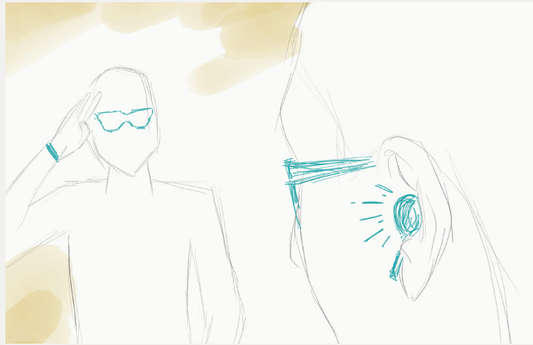
Proposed Tech:

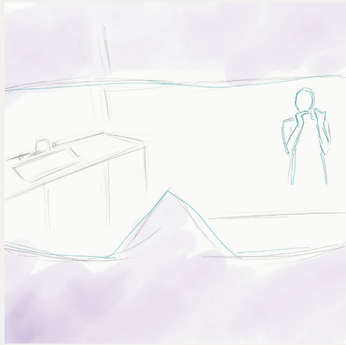
- Sign to speech
- Speech to Sign
- Augmented Reality
- Computer Vision

Tech Signals:

- Sign to speech
- Speech to Sign
- Augmented Reality
- Hololens, Magic Leap, Leap Motion Headset
- Fitbit, Apple watch, Myo Armband
- Google Pixel Buds







Figures 33-35 *Scenario storyboards–AR, Hearing Aid*

SCENARIO TWO

Zavannah is trying out a new contact system for her class reunion later that week. She walks through setting up each of her friends' names, much like inputting her fingerprint, she signs each of their names, adding them to their existing contact. She does a quick test with her friend Joseph, signing his name, she is able to call him on their video relay system (VRS) or FaceTime systems.

At her class reunion and Zavannah wants to get Louise's attention from across the room, she simply signs her name and Louise is notified through a gentle vibration notification. As she looks around towards Zavannah direction, the buzzing gets slightly more intense, it's then that she sees Zavannah waving her over.

Artifacts:

- Phone with ML
- Wearable

Proposed Tech:

- Machine Learning
- Haptic feedback
- EMG sensors
- Positioning Sensor
- Bluetooth

Tech Signals:

- Iphone fingerprint
- Fitbit, Apple watch, Myo Armband
- Google Cloud AutoML
- Teachable Machine

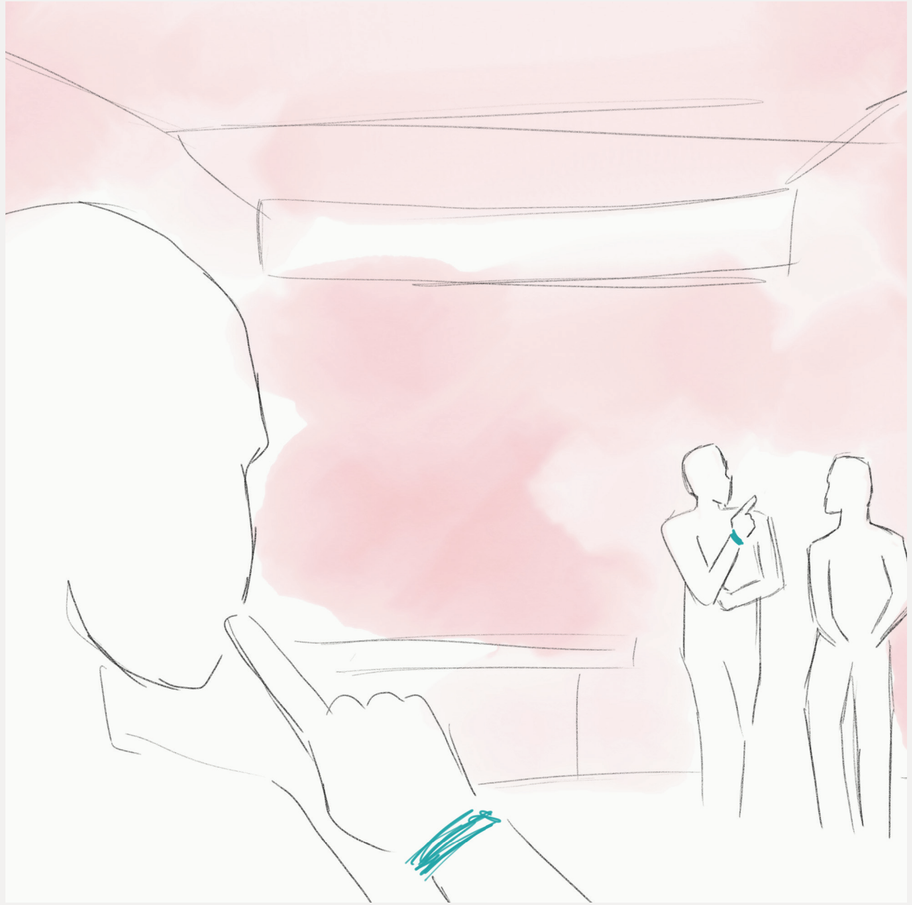


Figure 36 *Scenario storyboard–notify*

SCENARIO THREE

Earlier in the day, Caiti's dog Oscar ran off because of a loud noise. As Caiti was getting ready to go out and look again, her neighbor knocked on the door. The doorbell notification had stopped working and he was trying to get her attention. Away from her phone and any alerts, the knocking alerts Caiti by gentle vibration, she then sees the door indicator gently glowing in AR. She goes to the door, where she is reunited with her dog Oscar.

Artifacts:

- Sensors
- Phone with system
- Wearable
- AR glasses

Proposed Tech:

- Haptic feedback
- EMG sensors
- Vibrations or sound sensor
- Augmented Reality

Tech Signals:

- Augmented Reality
- Hololens, Magic Leap, Leap Motion Headset
- Fitbit, Apple watch, Myo Armband
- Piezo sensor, tilt sensor

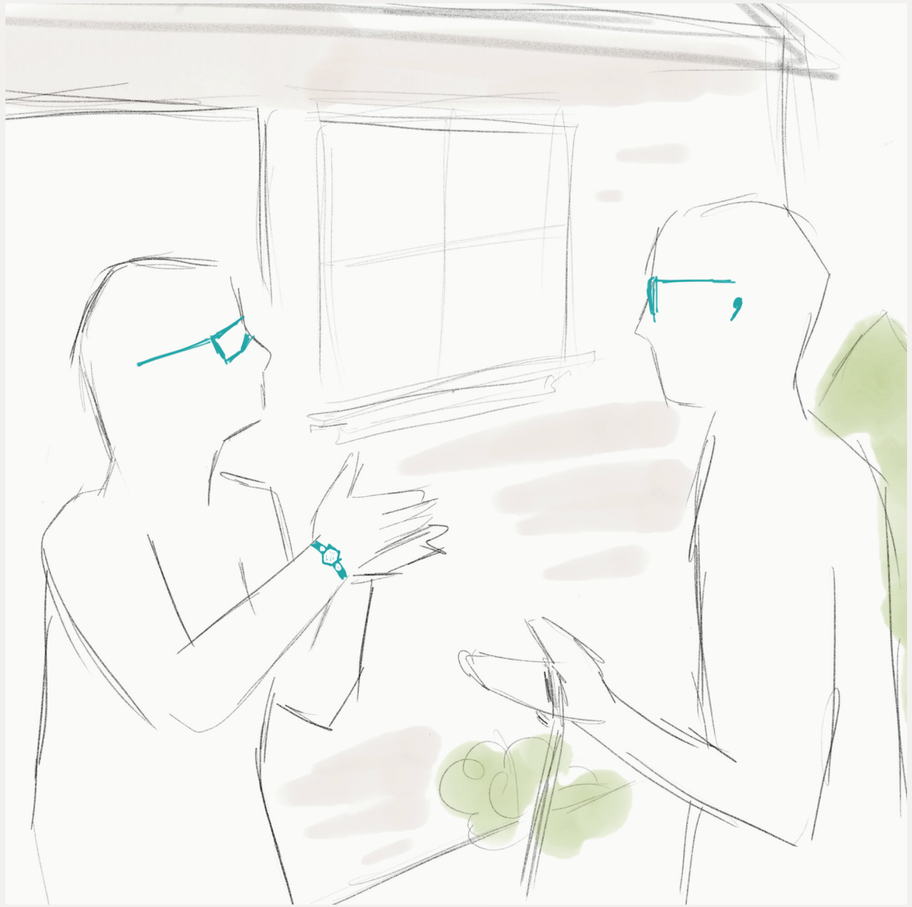


Figure 37 *Scenario storyboard–translate*

SCENARIO FOUR

Stephanie wants her grandpa to read her a bedtime story. Reading from her favorite book, Stephanie's grandpa begins to sign her the story, the room starts to come alive with color. The signs, movement, and tone are reflected in the lighting. Stephanie hears her grandfather's words as she watches him sign, picking up a few sign words here and there, but thanks to the hearing aid, she is able to hear his voice directly to help compensate for what is missed.

Artifacts:

- Hearing Aid
- Integrated Room lighting
- Sign to Speech
- Sign to Text

Proposed Tech:

- Sign to speech
- Speech to Sign
- Smart lamps
- Projection
- Computer Vision

Tech Signals:

- Sign to speech
- Speech to Sign
- Google Pixel Buds
- Philips Hue

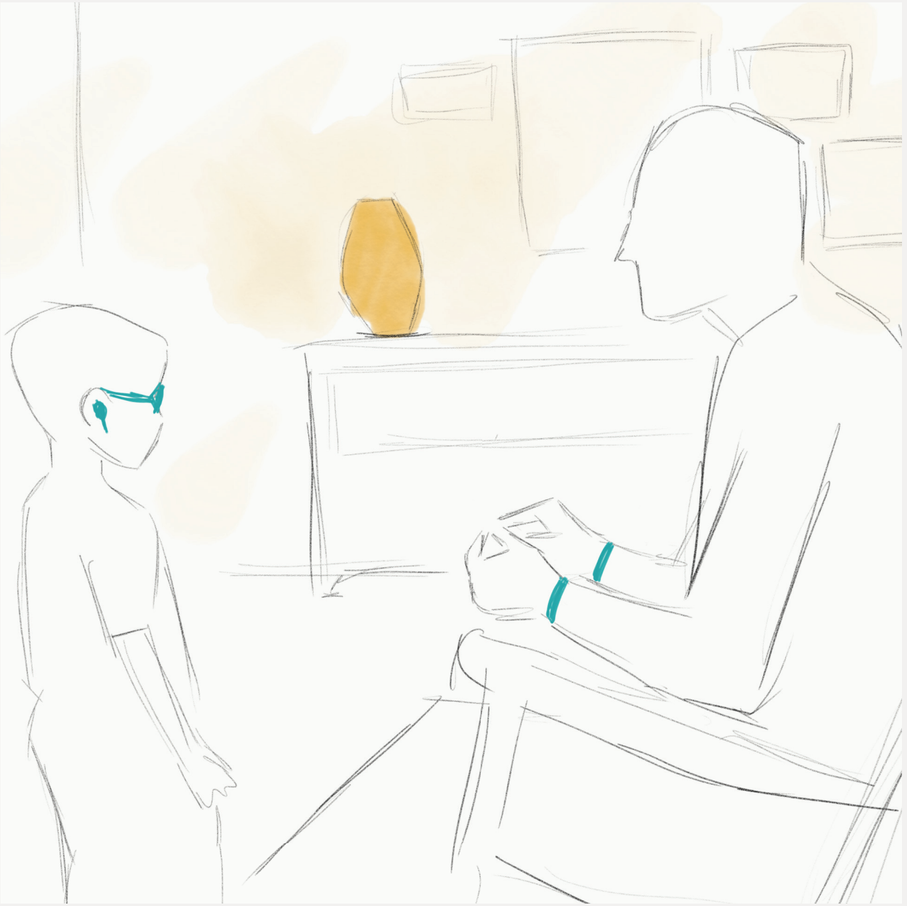


Figure 38 *Scenario storyboard–translate*

SCENARIO FIVE

Nancy was never able to read well. But she can tell beautiful stories of her childhood. Her daughters wanted to capture those stories for future generations in the form of a book to pass on to their children and their children's children. So they record Nancy telling some of her favorite memories, school with her friends, baseball games in the summer, how she met her husband. As the stories are converted they maintain their ASL structure as well as the English translation. To maintain the ASL structure is to highlight the importance of the language. While there is no direct written language, since ASL is visual, this was crucial in capturing one of the difference between ASL and English. Stories from many older generations of Deaf are captured and shared in this way, images can be scanned via the application and AI adds them to the story where appropriate.

Artifacts:

- Camera
- Phone

Proposed Tech:

- Artificial Intelligence
- Computer Vision
- Sign to speech
- Sign to text
- Online publishing integrations

Tech Signals:

- Sign to speech
- Sign to text
- Leap Motion, Kinect, Open CV
- Evernote Scannable (scanning images)

Figure 39 *Scenario storyboard–translate & record*

UBIQUITOUS INCLUSION

The 'Ubiquitous Inclusion' ecosystem connects artifacts that were extracted from participant futures and elaborated on through scenarios in the previous section. This goal of this ecosystem and its artifacts are to underline gap in technology and show how apply emerging technology to participants futures can create a more inclusive future world. Working together or independently, these are artifacts of inclusion. Technical signals mentioned in each scenario support the decisions behind each artifact. In addition, IFTTT[39] style platform brings services and devices together, is one of the driving signals for this type of larger ecosystem.

All artifacts were treated with discretion, making sure their form blended more seamlessly into the technological product space. It was also important to create artifacts that did not call attention to their purpose as inclusive devices. Throughout a number of conversations, interviews and presentations relating to this project or other projects working with diverse groups, many noted that they just want 'technology', not something that is labeled as or looks like 'assistive technology'.

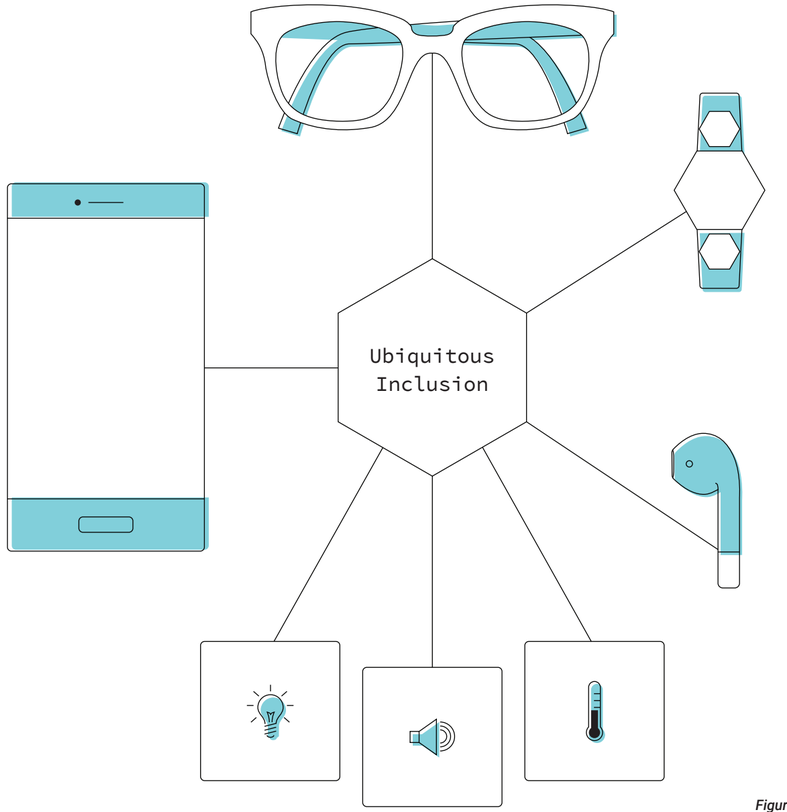


Figure 40 *Ubiquitous Inclusion connected ecosystem*

Figure 41 *Phone artifact*

Phone :

The phone is significant throughout many of the scenarios presented in the previous section. Its platform allows users to connect devices, assign functions such as notifications, and most importantly train home signs and name signs [see ASL section of Part One] via the camera and machine learning software.

Signs can be trained similarly to those trained in the technical explorations. While this project utilizes the Leap Motion for training, machine learning software with facial recognition as well as hand tracking can use the phone's front facing camera. Personal machine learning is already being used and explored, when we train our phones to recognize our fingerprint, Google Cloud AutoML[40] and Teachable Machine[41] help general users understand and use machine learning for personal use in projects. All of these technologies are helping to make machine learning more accessible to everyone.

Proof of Concept & Technical:

UI wireframes were created to show an example of adding a contact and training the system with a new sign name to use with that contact. In addition Leap Motion and Wekinator were used to train two different sign names. This is outlined further in the next section.

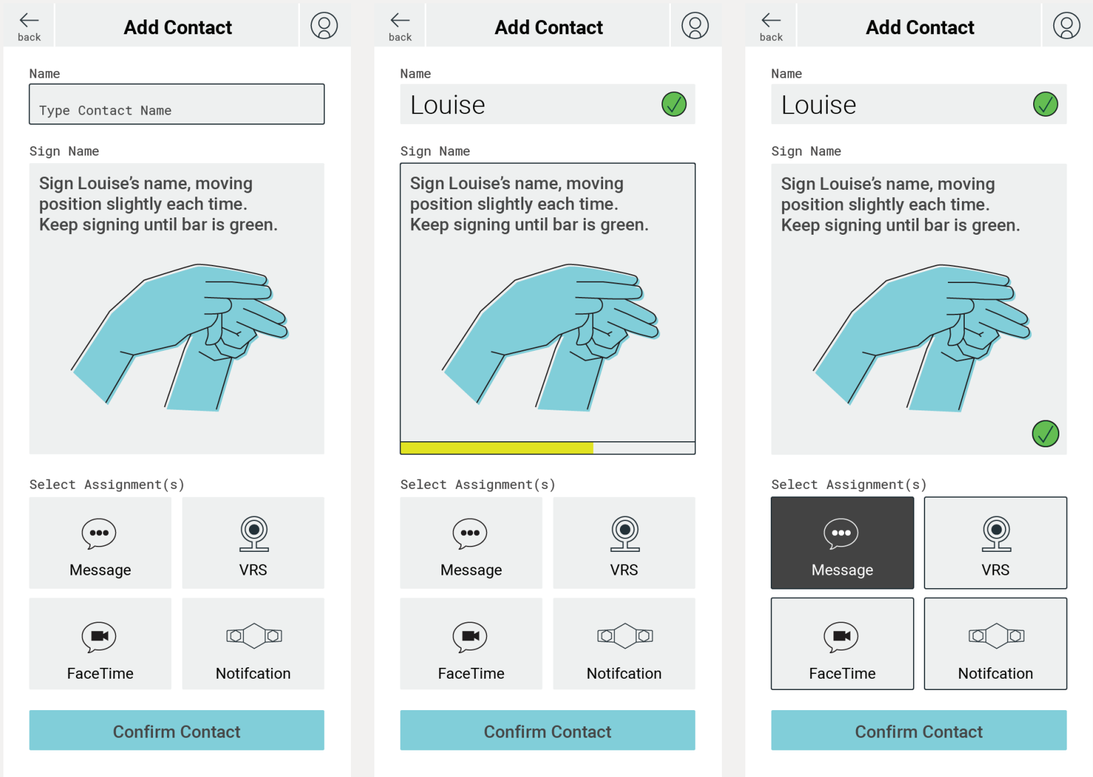


Figure 42 *Example wireframes of training a name sign.*

Figure 43 *AR glasses artifact*

Augmented Reality Glasses:

AR Glasses appear in several scenarios as well. Augmented reality was chosen because of its ability to maintain visibility while also providing an additional layer of information. This is beneficial as it does not remove the sense of sight, but must also be treated with care, as visual attention is crucial in those who are d/Deaf.[42] [43]

Overlaying information in real time for those who are d/Deaf is quickly becoming reality, projects such as HoloHear[44] and SpeechBubbles[45], are using Microsoft Hololens to bring augmented captioning and interpreting to fruition. These glasses created from these futures take those concepts further, to work together within the larger ecosystem, integrating with sensor information and signed information. In addition, ***the glasses and system should be used by both d/Deaf and non-deaf***. For those who are d/Deaf, translation can come in the form of ASL interpretation or textual overlay, for those who are non-deaf, the glasses would use camera information to translate sign to text or sign to speech, feeding into the connected hearing aid.

Figure 44 *Sensors detect and notify through AR*

Figure 45 *wearable artifact, two sensors with a vibration and light notification*

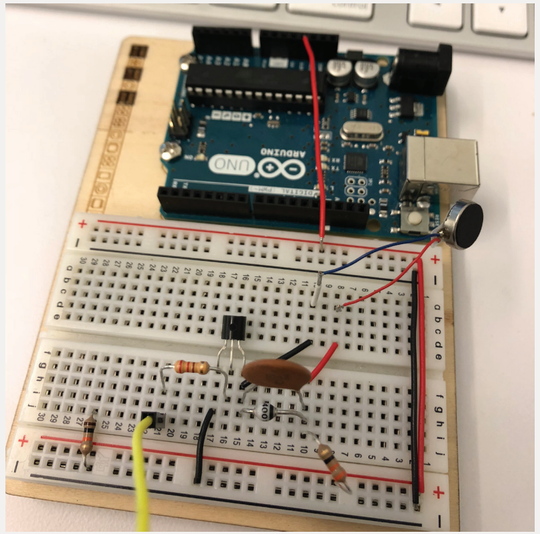
Wearable:

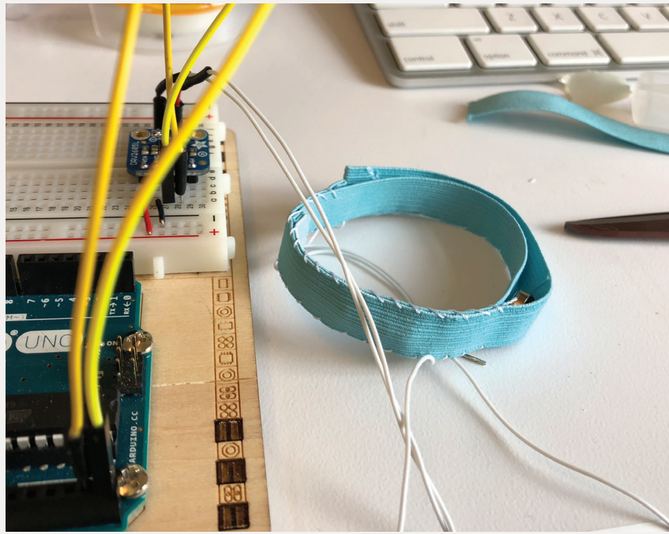
A wrist wearable acts as both notification and sign detection. Sensors read EMG data from the hand, and sit closer to the hand, detecting more subtle muscle movements from the fingers. In addition, the wearable contains orientation sensors and a vibration motor. This gives it that ability to be both input device as well as output.

The wearable technology takes signals from the Myo Armband as well as wrist wearables such as the Fitbit and Apple Watch. Combining aspects of each as well as taking into account a more discreet form factor. A future wearable to should also be multi-modal as to work best for a range of users, even those who are non-deaf. To address a multi-modal concerns, haptics and light are both considered in the design of the wearables' notification system.

Proof of Concept & Technical:

Using Arduino and vibration motors, I was able to test possible interaction and affordances of this wearable device.





Figures 46-48 *Wearable artifact, prototypes and testing*

Figure 49 *Hearing aid artifacts*

Hearing Aid:

Smart earbuds, "hearing aids", that assist the non-deaf in hearing those who are d/Deaf. These earbuds connect with wearables and AR devices to translate sign into speech. These smart earbuds are for use by non-deaf, including those who are hard of hearing. They can not only sync with the Ubiquitous Inclusion system, but also with any other device to stream music and offer translation of spoken languages.

The hearing aid's functionality was informed by two particular smart earbuds, the now defunct Here One by Dobbler Labs[46], and the Google Pixel Buds[47]. Here One started as smart earbuds that connected to your phone and allowed for full control of the soundscape around you. For that reason, they were marketed towards those who are hard of hearing, offering an alternative solution in the hearing aid market. In addition, the Pixel Buds offer real time translation and Google Assist, bringing the support and resources of a large tech company to the smart earbud market. The strength of the Hearing Aid lies more in its integration into the system rather than its hardware or form.

Sensors:

A number of sensors are ready to be integrated into the home and built environment. These can be used to sense a number of things, from light to sound to temperature to your food's expiration date. These sensors can be connected, assigned, and unassigned through the system, ensuring that they have multi-functional capabilities.

Perhaps not everyone home has integrations capabilities, introducing sensors that can help monitor and notify was a way to build the home ecosystem. A set of sensors that are easy to install, connect, and monitor was key. Taking cues from systems such as Philips Hue[48] for its connectivity to the Hue app and even IFTTT, as well as littleBits for its ease of use and ability to connect multiple bits simply. "littleBits makes technology kits that are ***fun, easy-to-use, and infinitely creative***. The kits are composed of electronic building blocks that are color-coded, magnetic, and ***make complex technology simple*** and fun."[49]

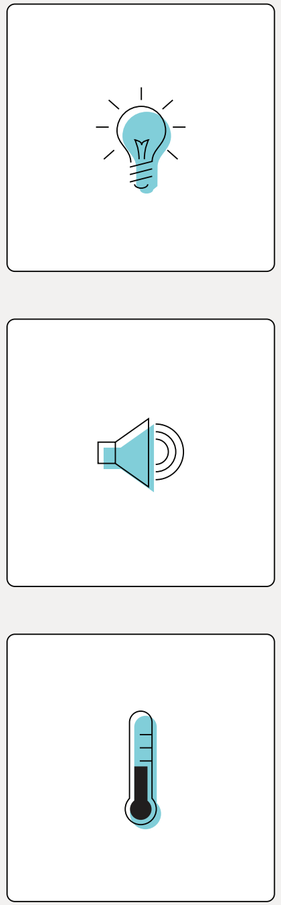


Figure 50 *Types of sensors–light, sound, temperature*

PROOF OF CONCEPT

Two proof of concept technical demos were created to show how current technologies could work together to bring aspects of participants' futures and the artifacts created to life. The proof of concepts are directly influenced by the futures and scenarios generated based on those. The specific aspects showcased are machine learning for sign names, the notification wearable and integrated home sensors. It is important to note that the storytelling and education futures are not addressed in these proof of concept works due to their complexities of sign and my own limitation in terms of working with sign databases.

Figure 51 *Setup of working prototype*

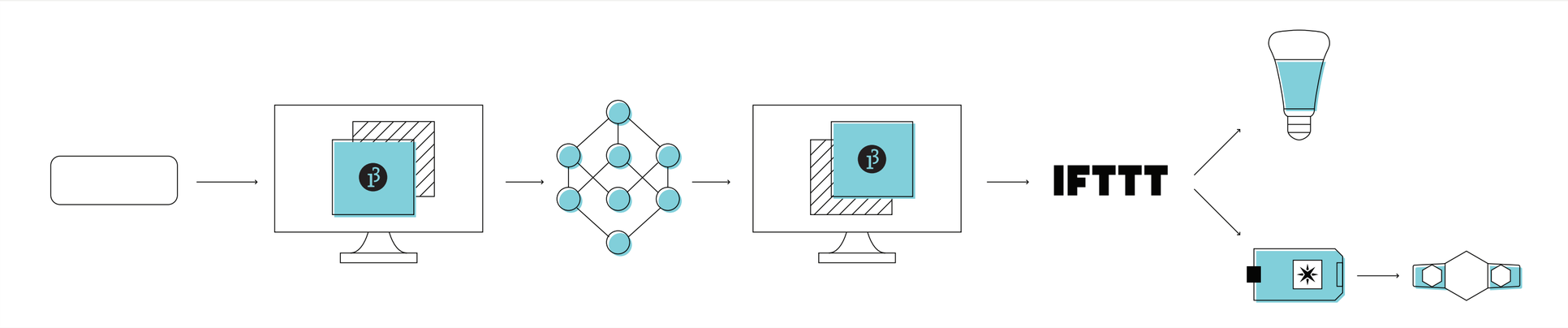
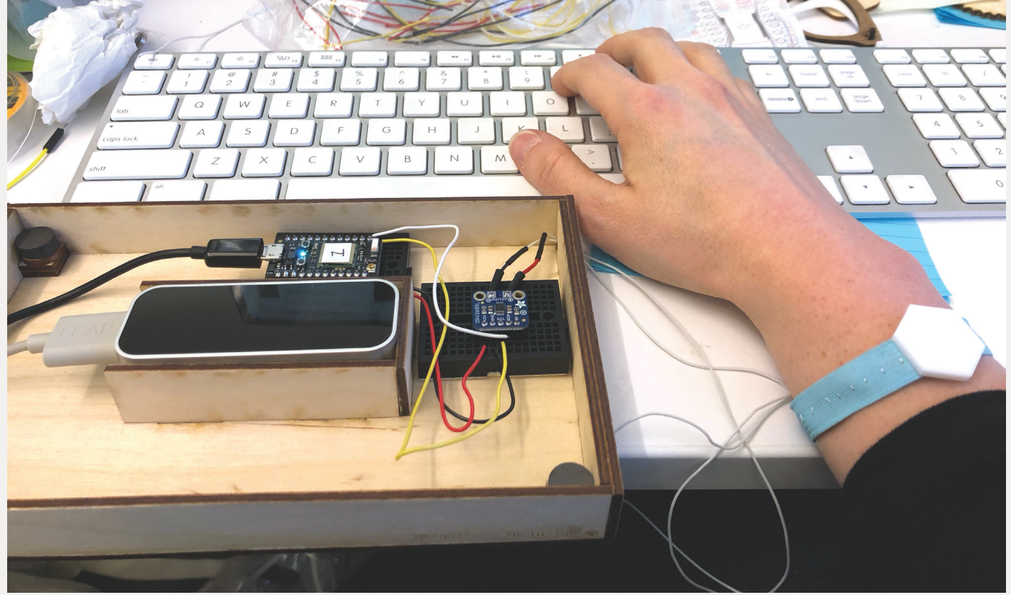


Figure 52 *Leap Motion to processing sketch 1 to wekinator to processing sketch 2 to IFTTT to Philips Hue/Particle Photon to light/wearable*

ML : Hand Tracking : Wearable

The proof of concept demo employ Wekinator for machine learning, Leap Motion for hand tracking, Processing for relay between Leap Motion and Wekinator and IFTTT, Particle Photon to control a vibration driver, and Philips Hue to control lighting. Below is a diagram and explanation of how this particular workflow functions.

Leap Motion detects the hand position and slight movement, as mentioned in Part Two, technical explorations, it is important to reiterate that it has a limited field of view. Working through the Processing software, the Leap Motion hand data is sent to Wekinator. It is there that signs are trained. Signs that were trained for the demo were "light on," "light off," "Louise," and "Nancy." Once the training is complete and properly detecting the signs, Wekinator can run the dataset, sending signals back to Processing. Each sign has a corresponding signal that Processing is looking for. If Processing detects "light on" or "light off" a message is sent to IFTTT to trigger the Philips Hue accordingly. If Processing detects "Louise" or "Nancy," then another message is sent to IFTTT to trigger an event with Particle Photon. The Particle Photon will vibrate the wearable in one of two ways, depending on what name it receives. Ideally, there would be a wearable for each person, however due to technical constraints, one wearable was made to handle two functions.

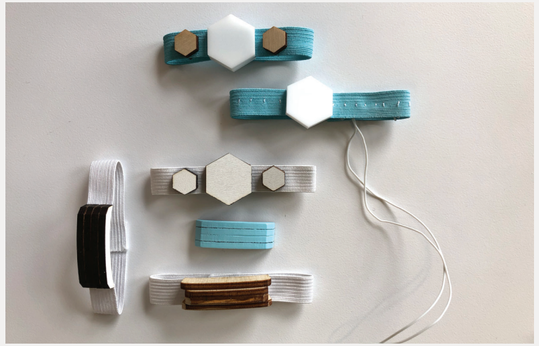


Figures 53-57 *Images depict process of artifact creation and prototyping*

TECHNICAL RESOURCES

Code files and other technical resources are available for use online.

Please visit ***tinyurl.com/ThesisTech***



PART FOUR

Discussion
Reflection
Future Work

DISCUSSION

Through literature and precedent reviews, participant interviews, exploratory probes, technical explorations, this project explored the relationship between technology and the Deaf community. It took on the approach of inclusive design, recognizing exclusion, learning from diversity, and understanding the broader applications. However, this work went one step further, incorporating futuring as part of the design process in order to understand the desires of those within and closest to the Deaf community. A review of the current technological recognized a gap in how technology is currently being applied to the Deaf community. This project addresses that gap through futuring with relevant stakeholders, artifact creation, and proof of concept technology demos. Showing how, by combining futuring with inclusive design, as we progress forward with design and technology we may do so in a way that includes everyone.

Futuring could provide a more engaging form of participatory design around the desires of diverse users.

Introducing futuring into the process allowed participants to imagine the futures they desired for themselves. While the remote futuring activity was framed and organized in a way to narrow the scope to focus on technology, Deaf culture and language, it was left open enough for each participant to have their own interpretation. A similar approach might be introduced into the inclusive design and participatory design processes. Allowing for users to imagine their own futures, void of any preconceived solutions imposed by designers, reinforced that users do not want technology that addresses a 'condition'. Rather, the envisioned futures focused on education and self-expression. Had these futures been void of language(ASL), it might be indistinguishable to what user group conceptualized them.

By understanding the technological landscape, a better sense of the possibilities can be achieved for both designers and users.

Familiarizing oneself with the technological landscape allowed for a better understanding and actualization of desired futures. To study current trends in technology and familiarize oneself with how they work provided an opportunity make and test working proof of concept pieces. Bringing these desired futures one step closer realization. This insight comes from both the secondary technical research as well as the technical explorations, in conducting this research upfront, generating artifacts and proof of concept prototypes were possible. In addition to designers, helping participants better understand technology may allow them to articulate their desired futures better. One participant in this study had a difficult time expressing detailed thoughts on how the technology in their desire future would work. As a result, their story was more general and open to interpretation than the other participant stories.

In addition, through understanding the technological landscape and learning the basics of many of the technologies outlined, proof of concept prototypes were obtainable and functional. From augmented reality to hand tracking to machine learning, each technology allowed for more possibilities of interaction past the screen to be imagined. The conceptualization and creation of the artifacts reinforced this insight.

Taking a critical approach to design can help in recognizing and removing barriers for a more inclusive world.

Taking a critical approach to design, design processes, technology and even inclusive design can help ground your work and remove barriers in a way that aligns more closely with those we are designing for/with. Recognizing barriers and diversity is an integral part of both Microsoft's Inclusive Design process as well as OCAD definition of Inclusive Design.[50] [51] In being more critical, you challenge your biases and those imposed by society or existing precedents. Asking why and who more often. Why is it being done this way? Who is it benefiting?

Understanding and Appreciation over Empathy.

Finally, the most important consideration should refocus on to understanding and appreciation versus empathy. Empathy can sometimes connote sympathy, in addition, sometimes during the design process empathy building can rely on simulation of abilities and might not result in a better understanding of the user. Microsoft Inclusive Design addresses this briefly, "When building empathy for exclusion and disability, it's misleading to rely only on simulating different abilities through blindfolds and earplugs. Learning how people adapt to the world around them means spending time understanding their experience from their perspective."[52] It is important that we understand not only their experience, but understanding the person, including their culture, their ability, in addition to their unique perspective. Appreciating who they are, the challenges they may face, and the possibilities they have to offer.

Technology

The deaf community has contributed to and perpetuated some of the most used technological advancements over the past decade, SMS, Vibration/light notifications, video calling. However, as we continue to propel forward and emerging technologies —AR/VR, motion tracking, computer vision, machine learning— find new applications, a more mindful approach to their integration with Deaf culture should be considered. Motion tracking and computer vision, sensors have been propelling ASL translation, however, these applications only cover some of ASL parameters and often fully overlook the the structure itself in translation. This has led many to critique these as merely conversion tools, converting the word itself, not the meaning or sentence properly. Non-manual signals are crucial in understanding meaning and intent. Even some learning applications made in partnership with Deaf are just beginning to evolve from vocabulary to include sentence structure.[53] A more critical approach to the design of these tools/projects should be taken into account. In the case of the many 'translation' gloves available, it's crucial to ask who do these technologies truly benefit?

Perception

Perceptions can be based on several factors, society, media, and language barrier. Across many of my interviews with non-deaf, I found that exposure to the Deaf community was mainly through the media, with very few personal interactions. This led many to have almost no opinion, they felt that the deaf community was invisible or isolated. This idea of invisibility made me wonder if the deaf community is there, and the lack of visibility is due to people not using their natural language. Are they truly invisible or isolated or are they more integrated than people think?

In speaking with signers, both deaf and non-deaf, several key insights were shared with me, many focusing on changing the perception of the hearing. I asked each person to leave me with one (sometimes two) thing they wish the hearing community knew. Most focused on "open-mindedness" knowing that d/Deaf people have the ability of anyone else, language does not define their intelligence, they can do anything hearing can–they just do it differently, and that equal and open access is important. This was especially echoed in the interpreters I spoke with. How might a more critical approach to the intersection of disability and design/technology help in shifting perception?

Ability

d/Deaf people are able to do anything that hearing can. I heard this throughout my interviews as well as mirrored throughout my research, particularly in the TED talks and video documentation I watched. Christine Sun Kim[54] gives a beautify talk on music and the way she signs and creates art. Amber Galloway, one of several interpreters aiming to remove the barriers of interpreting at musical events. Using their language in a way that is both expressive and innovative. Their abilities as well as their "work-arounds" are a breeding ground for innovation. How can we learn from this as designers and include d/Deaf people into new approaches to technology?

Access

Perception can influence access as well. A long time interpreter shared several stories of how medical professionals refused interpreter services due to the cost, ADA laws are in place, but many disregard them. "Dollar signs can rule access." From the perspective of interpreters, more access to interpreting services is crucial. Particularly in the case of medical and even entertainment. In addition, "Hearing people are afraid of sign language," which can lead to mishaps in interpreting—fake interpreting occasionally occur.

Language

Many non-signers recalled a time in their life where they wanted to learn, but the inclination faded, or the language was too hard. Many perceive it as "cool", especially when they see it in the media, whether that's News, TV, movies, social media. Media and social media bring attention to the language and its creative practices. Which generate interest, but it eventually fades.

Signers, native and learned, know not only the beauty of this language, but the way in which you begin to think differently. In one conversation with an interviewee, they elaborated that when you sign, you feel differently than when you speak...you are able to see and embody what you are thinking. It's a very powerful feeling.

REFLECTION

Participatory design & Relationship building:

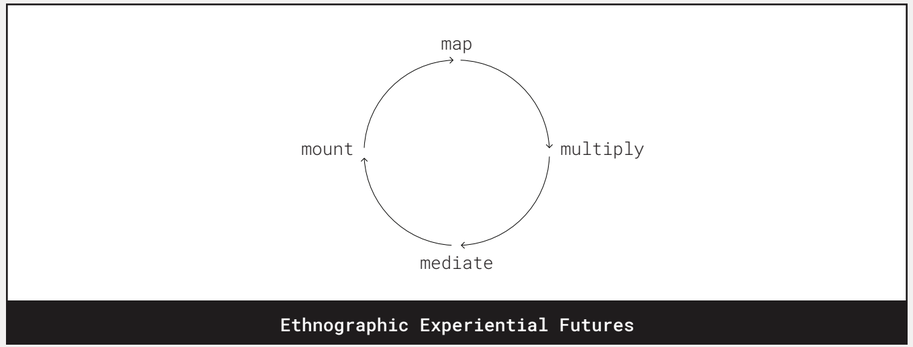
Participatory design can provide stakeholders with a sense of ownership over what is being designed, rather than a feeling of consultation. This project relied heavily on connection with the Deaf community, d/Deaf and non-deaf. It was evident, as this line of research continues, that relationships within the community must be nurtured better in order to maintain a more participatory design approach. Keeping participants actively involved would benefit both those designing and those whom we are designing for/with.

Exploratory probes:

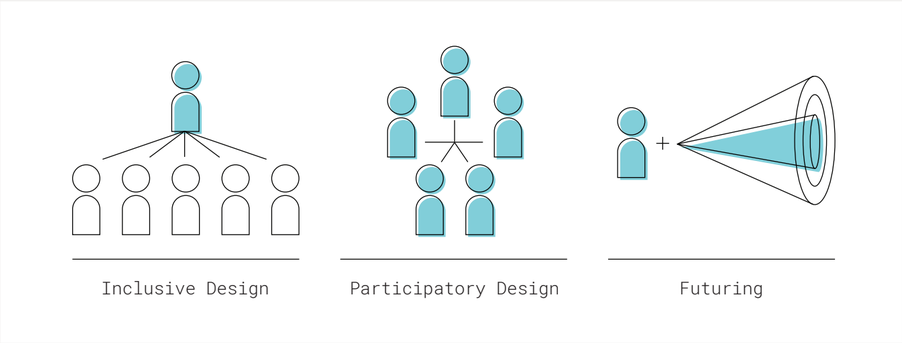
These exploratory probes were valuable in not only visualizing the parameter of ASL, but providing a more universal visual representation in response to a already visual language. Participants who knew sign and interacted with the probes were amazed to see ASL representing in a way they weren't familiar with. Non-deaf, non-signers, were also able to see qualities of the parameters more clearly than just reading an explanation. However, only half of the ASL parameters were explored and it would have been beneficial to generate probes for each of the parameters that both signers as well as non-signers could experience and evaluate. Moving forward, I plan to work with OpenCV and facial recognition software to begin to interpret non-manual signals.

Technical explorations:

The technical explorations were an essential part of this process. The final prototypes would not have been possible had I not taken the time to learn and explore the technologies at hand. Machine learning, hand tracking, and physical computing were just the beginning of a lifelong commitment to better understanding the technology we design for. Moving forward, I plan to further explore augmented reality, speech and sign recognition, IoT integrations, and data visualization.



Figures 58 *Illustration derived from Candy & Kornet's Ethnographic Experiential Futures*



Figures 59 *Illustration depicting Inclusive Design, Participatory Design and Futuring*

Futuring and inclusive design:

Futuring allowed participants to fully explore what they desired in the future. There was no timeline to the future, for them this could have been in five, ten, or even twenty years. As work with integrating Futuring and Inclusive Design continues, Ethnographic Experiential Futures will be crucial in the process. Stuart Candy and Kelly Kornet outlined a cyclical process for using futuring in ethnographic studies. First the process maps peoples' images of the future. Next, it multiplies those images in order to "challenge or extend existing thinking."[55] After that, it mediates, transforming those images into a tangible form factor. Then it mounts, producing experiential interactions. Finally, it brings it full circle by mapping again in order to record reactions. Completing the final step of this process [fig. 58] would be beneficial to further iterations of the artifacts and scenarios.

*Inclusive Design + Participatory Design + Futuring = force to be reckoned with.**

These three design processes can work together to foster strong relationships among diverse communities, open discussion for understanding what users desire for their own futures, and removing barriers that can lead to a more inclusive world for everyone. This thesis explored these three processes in one interwoven process, demonstrating that no one design process needs to work independently.

*Not an actual scientific equation.

FUTURE WORK

Over the course of this project, there have been several articles written [56] [57], tools created[58], announcements made that align with and support this line of work. In particular, Microsoft recently announced it's initiative "AI for Accessibility." They have committed $25 million to projects and research focused on AI for accessibility.[59] "AI can empower people with disabilities with tools that support independence and productivity, as technology rapidly changes the way we live, learn, and work."[60] It is my hope that the public support of companies such as Microsoft, projects like this one and the work presented here continue to drive interest in the space of inclusion, accessibility and technology.

Future work will continue to focus on how emerging technologies intersect with d/Deaf culture but hopes to extend to those with other abilities as well. As mentioned earlier, the work with technologies such as augmented reality, computer vision, artificial intelligence and machine learning will progress forward. Through further technical experimentation and learning, I plan to continue working with ASL parameters such as non-manual signals as well as ASL sentence structure.

In addition to continued work with technology, I plan to extend this project's scope further in terms of the process. As addressed in Part Two, the interviews with multicultural non-deaf, non-signers revealed that many perceived the deaf community to be non-visible. While I didn't fully immerse myself into this line of questioning, I believe it's important to recognize and call attention to. Companies are made up of diverse, multicultural, employees, and with that comes cultural preconceptions regarding people with disabilities. As companies continue to invest and adopt inclusive practices, it will be beneficial to understand and address cultural biases. How might we work at removing these added barriers?

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ADDITIONAL RESOURCES

Literature & Precedent:

tinyurl.com/ThesisReading

General Inclusion & Accessibility:

tinyurl.com/ThesisInclusion

Technical Assets:

tinyurl.com/ThesisTech