Salutogenic Design:

Bringing the 'Person' Into Personalization in Healthcare
By Designing for Disabilities of the Hand

Stephanie Rossi

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Stephanie Rossi
Supervisor: Tim Antoniuk

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This research is dedicated to my parents, Monika and Dale Rossi,
and to **all whom I love.**

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Abstract

Disability affects around 8 million people in Canada and around 1.3 billion people globally. Those who are disabled experience higher rates of obesity, physical and mental health conditions, and higher rates of poverty than those who are not. This thesis explores disabilities of the hand through illnesses and diseases, congenital conditions, and amputations. Many people experience disabilities affecting the hands, yet may find that devices to facilitate activities and hobbies do not exist or are inaccessible due to the pathogenically oriented healthcare system focusing only on physical health to the extent of being "cured" or free from illness. Those with upper limb differences and conditions affecting the hands can be covered for commercially available prostheses; however, the available devices do not facilitate activities outside of basic functions like grabbing and holding objects. This thesis explores physical, mental, and social well-being and how pathogenic care and commercially available devices do not promote health for all three realms. However, the introduction of sociologist Aaron Antonovsky's 'salutogenesis' provides a framework that helps with all three areas of health and well-being through concepts such as stressors and tension, generalized and specific resistance resources, ease/*dis*-ease continuum, and the sense of coherence. Through the salutogenic model, with the help of design methodology like user-centred design, the research considers how disability could impact someone mentally, physically, and socially. Through a salutogenic orientation, the complex person inside the body with values, emotions, and interests is seen as important rather than just their physical body. The thesis aims to explore how salutogenesis and design can create personalized functional and aesthetic devices for those with hand disabilities so that full health and well-being can be achieved where people can thrive rather than just survive.

Four case studies explore concepts from the salutogenic model and design methodology. Two studies focus on hand prostheses and two on disability devices for the hands. They explore concepts of physical, mental, and social well-being, aesthetics and function, and concepts from the salutogenic model like stressors, tension, general and specific resistance resources, and the sense of coherence. Each case study identified areas of opportunity for design intervention, which led to the ideation of physical prototypes using 3D printing technology for its customization capabilities and low-cost material. The outcome was four different disability device and prosthesis prototypes, two relating to aesthetics and two relating to function. Following the case studies, a participant study is conducted with one participant with a congenital limb difference of the hand. The interview discussed the participant's experience with prostheses, as well as perspectives on aesthetics and function. Ideation phases followed the two rounds of interviews. Analyzing the key points from each interview demonstrated areas of opportunity in aesthetics and functionality that were specific to the participant's interests, aesthetics, and hobbies. The outcomes of the four case studies and the participant study showed areas of improvement for prostheses and disability devices in both function and aesthetics. A salutogenic orientation could shift the focus from the physical body's condition to the person inside the body who requires prostheses and devices that cater to interests, hobbies, values, and needs to live a meaningful life. This thesis explores the potential of the salutogenic model within design. It proposes 'salutogenic design,' where concepts of the salutogenic model can work within a design framework to explore an individual's complex personality and personhood.

Keywords:
Salutogenesis
User-Centred Design
Disability
Prostheses
Disability Devices
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Salutogenic Design

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Chapter 1. Introduction

It is a Saturday morning. You crawl out of bed and put on your favourite sports clothes and runners. You could go to tennis practice or the gym to start your day. It is a challenging exercise, but you feel great that you can move and participate in this activity. After all, you have been at it for a few years and have got good at it. It is part of your routine and keeps you physically healthy. When you come home, you cook your favourite thing for lunch and then participate in your hobbies or housework. Maybe it's playing the piano or perhaps finishing painting the cabinets. In the evening, you plan out your clothes for a social gathering. Your favourite shirt, pants, and shoes. Perhaps some accessories like sunglasses and a watch. These clothes and accessories reflect who you are and how you want to present yourself to your friends on your night out. Your choices throughout the day reflected your interests, lifestyle, and what is important to you.

Now, hypothetically, let us say that on Sunday, you are unable to play tennis, go to the gym, or play the piano. Maybe you are unable to hold a paintbrush with your right hand, or you now have trouble holding utensils. As morbid as this sounds, it can be a reality for many of us and for countless reasons. New Data on Disability states that 27% of Canadians have had at least one disability (Rabinowitz and Wallace), indicating that 8 million people have or are subject to short-term, long-term, or permanent disability, and further, an estimated 1.3 billion people globally experience a significant disability ("Disability"). The World Health Organization outlines three characteristics of disability: 1) Impairment in a person's body structure or function, or mental functioning; examples of impairments include loss of a limb, loss of vision or memory loss. 2) Activity limitations, such as difficulty seeing, hearing, walking, or problem solving. 3) Participation restrictions in normal daily activities, such as working, engaging in social and recreational activities, and obtaining health care and preventive services. ("Disability and health overview"). These characteristics outline many different types of disabilities but make sense when we consider the definition of disability: "a physical, mental, cognitive, or developmental condition that impairs, interferes with, or limits a person's ability to engage in certain tasks or actions or participate in typical daily activities and interactions" (Merriam-Webster Dictionary, "Disability"). Consider how this would impact you mentally, physically, and even socially. Would your sense of self be diminished or impacted in some way? Would you be able to live the full life you were before?

1.1 Rationale and Objectives

This is what this thesis aims to explore: how would a disability affect you physically and mentally? What would it do to one's sense of self and identity? Would you be able to cope with the changes? Would you be able to manage and find meaning in life afterwards?

Diving into the research of all disabilities, mental, physical, and cognitive –though important topics –would be nearly impossible to cover in the span of a thesis project due to time constraints. Looking interdisciplinary, disability is examined through discussion of physical health, mental health, design, technology, and sociology, but narrowed down through the lens of a certain disability: disability of the hands. This could be through amputation, congenital birth defects, or a sickness or situation that prevents one from using their hands to their full functionality. There are many instances that can lead to limited hand functionality, such as hand fractures, carpal tunnel syndrome, and arthritis ("Hand Conditions | University of Michigan Health") and even degenerative diseases like multiple sclerosis (MS), muscular dystrophy, and Parkinson's disease ("Chronic or degenerative conditions"). Congenital limb differences and amputations resulting in the loss of a limb are more common than one may think. There are estimated to be almost 230,000 Canadians with a limb difference (congenital and amputation) ("Amputations"), and 2 million in the United States, with 185,000 amputations occurring every year ("Limb Loss Statistics - Amputee Coalition").

One may ask why the research was narrowed down to hand disabilities. This research focuses on the design and prototyping of hand prostheses and disability devices for the hand due to the nature of the disability: it is visible, functional, and is a requirement for daily activities and specific functional requirements based on an individual's interests and lifestyle. The aspect of visibility and functionality of hand disabilities were important factors in the discussion and the importance of the role of design. I will explore how design can help functionality and aesthetics for the design of disability devices of the hand through design thinking and concepts and the utilization of technology: 3D modelling and 3D printing technology. Disabilities that are undetectable to the eye, such as cognitive disabilities or disabilities relating to reconstruction (bone implants, nose, ear, eye, reconstruction), will not be discussed in this thesis due to necessary precision and lack of aesthetic liberties that can be taken. This is not to say that other disabilities are not important or that design cannot help other areas of disability, but rather, that the role of design as an industrial designer can help with physical functions and aesthetics starting right from the fingertips.

1.2 Chapter Overview

Chapter 1: The introduction proposes questions, objectives, and statistics on disability relating to stigma, poverty, and health.

Chapter 2: Research on health and well-being, such as physical, mental, and social health. Introduction to pathogenesis and discussion of the pathogenic focus within the healthcare system.

Chapter 3: Introduction to salutogenesis and concepts of the salutogenic model, such as the ease/*dis*-ease continuum, stressors and tension, Generalized Resistance Resources (GRRs) and Specialized Resistance Resources (SRRs). and the Sense of Coherence (SOC).

Chapter 4: Proposes design intervention, the role of a designer within healthcare, and design methodologies such as user-centred design and (experience-based) co-design, and design within healthcare settings.

Chapter 5: Provides further rationale for the focus within the thesis, discusses the importance of function and aesthetics for disability devices, and analysis of existing companies and products.

Chapter 6: Introduces a 5-stage design process and utilizes the process to create artifactual-material SRRs for four different case studies for disabilities of the hands.

Chapter 7: Interview with a participant that includes discussion and ideation of prostheses, validation, and reflection.

Chapter 8: Discussion of concepts, ideas, and findings from previous chapters, limitations observed, and proposal for future research.

1.3 Background on Disability

1.3.1 Physical and mental health

The most common types of disability are pain-related (15%), flexibility (10%), mobility (10%), and mental health (7%) (Rabinowitz and Wallace). However, it is difficult to pinpoint what causes these disabilities or how a disability could affect different areas. For example, someone can experience arthritis as pain-related, mobility-related, and even flexibility-related, or all three simultaneously. Those with disabilities have higher rates of health complications than those who do not have a disability. For example, the CDC states that 46% of adults who have a disability are obese, as opposed to 29.6% of adults who do not have a disability ("Disability impacts all of us infographic"). There are also higher rates of heart disease, diabetes, and even smoking for those who have a disability than those who do not. Mental health rates of those with disabilities are also much higher than those of the non-disabled population, with mental distress reported five times more often for the disabled population ("The Mental Health of People with Disabilities"). These adverse physical and mental health outcomes may be due to genetic factors or lack of access to mental health counselling, disability aids, and barriers to physical activity.

1.3.2 Accessibility and poverty

Adverse physical health outcomes may be due to a lack of access or options for disability aids or devices, in which people cannot access things like software, ramps, walkers, etc. (Rabinowitz and Wallace). This could be due to the built environment, where people cannot locate ramps or find spaces completely inaccessible. Another factor could be the cost of devices or assistive software. People with disabilities, both mental and physical, face lower employment rates and are experiencing higher poverty rates (Rabinowitz and Wallace). This means that some individuals cannot afford the software and devices they need or may settle on something cheaper that does not fully fulfill their needs. 1.5 million people with disabilities surveyed in 2017 said they had an unmet need for a device, support, or aids, with cost being the number one reason for the lack thereof (Rabinowitz and Wallace).

Negative physical health outcomes may also be a result of the barriers to physical activity, where those with disabilities cannot take part in an activity or exercise due to personal physical limitations or lack or difficulty of access to spaces and facilities that will accommodate them and their needs. It is also shown that people with physical conditions are more susceptible to mental health issues than those without physical problems (Rai et al.). Disability, physical, and mental health do not exist in a vacuum. These things are closely tied and can strongly influence one another. The Canadian Mental Health Association states that "people with serious mental health conditions are at high risks of experiencing chronic physical conditions" and that "people with chronic physical conditions are at risk of developing poor mental health" (“Connection between Mental and Physical Health”). Simply put, poor physical health can cause poor mental health, and poor mental health can cause poor physical health. They are strongly interconnected and feed into each other in a vicious cycle.

To paint a picture of how this manifests for someone with a physical disability: For example, someone with a physical disability, such as the loss of a limb, may have poor mental and physical health. Perhaps this person suffers from trauma, stress, depression or anxiety related to the disability. Their physical health may suffer due to the barriers of achieving physical health, whether it be limited body function, inability to get the assistive device needed to perform physical exercise, or lack of access to spaces to accommodate their exercise needs. They then are at higher risk for developing other physical illnesses such as obesity, diabetes, heart disease etc., which can then lead to further mental and physical disabilities. It may also contribute to their ability to be employed, which furthers them into poverty, and they are unable to pay for the devices and aids that they need. Thus, the vicious cycle continues.

1.3.3 Stigma: The social perceptions of disability

Not only are there physical and mental health-related issues that can arise from having a physical disability. There are also lots of social stigmas surrounding disability. Social stigma is defined as a "negative association between a person or group of people who share certain characteristics and a specific disease. In an outbreak, this may mean people are labelled, stereotyped, discriminated against, treated separately, and/or experience loss of status because of a perceived link with a disease." (“A Guide to Preventing and Addressing Social Stigma Associated with COVID-19.”). The scope of this research is focusing on disabilities of the hand, meaning that most likely, the disabilities that fall into this category are of high visibility, in which it is hard to conceal with clothing, as hand function is vital to our social interactions (grabbing, holding, gestures, pointing, shaking hands and waving). People with visible disabilities may encounter negative interactions, such as receiving unwanted glances or stares, comments, or even treatment that would typically not be the same as someone without a disability. Studies have shown that people with disabilities (mental and physical) face stigmas and negative social interactions, which others perceive as "devalued," "other," "less than human," and other negative reactions (Reber et al., 7; Block; Silván-Ferrero et al.; Park et al., 66). Especially with highly-visible physical disabilities (loss of a limb or mobility impairment), it is in human nature that it elicits stronger anti-social responses than those which cannot be easily detected or non-visible, such as mental disabilities (Park et al., 68). This is due to the evolution of humans protecting themselves against a "threat" of diseases, as diseases are accompanied by visible signs and behavioural cues of sickness; therefore, it is better for survival to stay away and present anti-social behaviors towards those who are "diseased" (Park et al., 68). This is called the "disease-avoidance mechanism" or "disease-avoidance behavior" (Curtis et al.) and is a precursor for the emotion of *disgust*. It has helped us stay away from things that will make us sick, hurt, or kill us as early humans, but unfortunately, the social implications are still in our modern world today. For instance, one may know for certain that a loss of a limb or disfigurement of someone may have been from a mountain biking accident. However, the disease-avoidance mechanism may still internally stigmatize and create anti-social behaviours and thoughts towards that individual who has been disfigured or visibly affected (Park et al. 68). Social stigmas leak into personal interactions, and potentially professional interactions, as mentioned previously, people as those with disabilities face higher poverty rates and lower employment rates. The avoidance mechanisms that have translated into today's world could be tied to the fact that people with disabilities face dehumanizing stigmas in interviews and job recruitment (“People with disabilities”; “Accessibility and attitudes about disability in Canada: Rick Hansen Foundation”; Leah Miltchin Carson).

1.3.4 Stigma: The built environment and healthcare settings

Not only social perceptions, but the built environment and social institutions can also stigmatize and affect those with disabilities further. "Structural Stigma" (Reber et al., 2) is a reflection of the societal attitudes towards people with disabilities through the built environment, such as the lack of accessibility and resources for those with disabilities in public spaces, buildings, and transportation (Reber et al., 3, 12). Ramp access at the back of buildings, no ramp access at all, poor navigation, and no elevators or handrails can exhibit messages of "you are not important enough" or "you are an afterthought."

Moreover, not just physical barriers but institutional barriers contribute to stigmatization and further oppress those with disabilities. As discussed previously, people with disabilities face barriers that inhibit the improvement of their physical health, such as accessing assistive devices (this is tied to employment and low-income/high poverty rates) or those in places where there is no public healthcare and cannot access care altogether due to inability to afford it (“Disability impacts all of us infographic”; Leah Miltchin Carson; World Health Organization and World Bank). Nevertheless, it is not just physical care that is lacking; it is the lack of access to mental health care as well. Stigmas, social isolation, lack of physical health, and even potential PTSD or trauma in correlation with the result of disability can all affect the mental health of those with disabilities (“People with disabilities”). People with disabilities are at higher risk for poor mental health conditions yet face multiple barriers to accessing care (World Health Organization and World Bank, 63). When people do address their care, attention will be put on their physical health rather than mental health, as the priority is pain relief or "fixing" the person physically rather than maximizing their whole well-being (Bhattacharya, Sudip, et al., 16; “People with disabilities”; Dunn, 3). This is a problem at an organizational level within healthcare, where the training is focused on curing disease (Dunn, 3). Oftentimes the healthcare system does not have the capacity to look at issues beyond the physiological due to the amount of patients, lack of time, and number of practitioners and workers. Additionally, healthcare workers often experience burnout, which is a result of stress, exhaustion, and high workload (Montgomery, A., et al., 1; De Hert, 171, 174). Even working with external mental healthcare providers outside of the hospital or clinic is complex due to the difficulty in collaborating, communicating, and coordinating care for each patient (“People with disabilities”).

> "For many people living with disabilities, physical care is seen as the first priority — but when a disability impacts a person's quality of life, it can have a direct effect on all aspects of their well-being and daily experiences" (“People with disabilities”).

Mental well-being may be neglected in care, but even concerns with physical health and physical function are limited beyond the hospital stay. How does one learn how to go back to the gym, swim, paint, play badminton, etc. to keep up their physical health and hobbies without the options or access to the proper device? In turn, how does this lack of access to devices and activity and personal lifestyle hobbies affect the physical health and mental health of an individual?

Chapter 2. Full Health and Pathogenesis

2.1 Full Health and Well-being

Both physical, mental, and social consequences can come from having a disability. However, our healthcare system primarily focuses on just the physical body. This can lead to continuous physical and mental problems since physical and mental health are intrinsically linked ("Connection between Mental and Physical Health"). When it comes to the care and accessibility that people living with disabilities receive, there has to be a shift in looking into more mental health approaches rather than just looking at the functioning of their physical bodies for survival. Instead, the healthcare system needs to focus on giving people a full and healthy life where they can thrive. If healthcare focuses primarily on "fixing" physical ailments and illnesses, then how can we integrate care that will focus on things like stigma, mental health, and physical health beyond survival functioning for people with physical disabilities? How can people with physical disabilities live a full and healthy life that will allow them to thrive and achieve full health and well-being?

The World Health Organization (WHO) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (World Health Organization, 1). Let us take a look at those three realms the WHO outlines.

2.1.1 Full health and well-being: Physical health

Of course, being free of disease or illness is not always in the control of the individual, depending on circumstance, but there are ways to achieve good physical health despite this. Physical health goes beyond physical fitness, as it is also determined by the function of organs, bodily systems, and ability to execute daily demands (Marshall-Seslar Body health basics: What is physical health?). Each person's version of physical health is different. Someone can achieve their definition of physical health despite a disease, a disability, or age. The best ways to achieve good physical health, as outlined by the National Institute of Health (NIH), is to engage in physical activity, eat well, maintain a healthy weight, and maintain and build muscle mass ("Physical Wellness Toolkit"). Great emphasis is placed on physical activity. The WHO recommends that adults do 2.5-5 hours of moderate-intensity physical activity or 1.25-2.5 hours of vigorous-intensity activity per week, along with muscle-strengthening exercises and limiting the amount of sedentary time (World Health Organization, “Physical Activity”). The WHO states that this is also the recommendation for people with disabilities. Engaging in regular and adequate physical activity causes a significant decrease in obesity, chronic conditions, and premature mortality (Warburton and Bredin; Posadzki et al., 3-7; World Health Organization, “Physical Activity”). Multiple studies and cross-analyses have shown that physical activity can lower the risk of a plethora of diseases and illnesses, such as obesity, hypertension, cardiovascular diseases, diabetes, COPD, osteoporosis and osteoarthritis, colon and breast cancer, overall mortality risk, and more (Warburton; Carlson et al.; Pedersen and Saltin). Evidence shows that regular physical activity can reduce these risks by at least 20% to 30% (Warburton and Bredin, 495; Warburton, 801). In contrast, it is shown that those who do not participate in physical activity have an increased risk of developing numerous medical conditions (Warburton and Bredin, 499) and can even double the risk of mortality and cardiovascular diseases (Fox, 411). Physical inactivity as a contribution to the development of these diseases and illnesses can account for 3.2 million deaths annually, globally, making it the fourth leading risk factor for mortality (Warburton and Bredin, 495). Physical activity helps overall physical health but is also linked with increased mental health. Regular physical activity is seen to improve stress, anxiety, cognitive function, and other mental conditions (Carlson et al., 1; Warburton, 801; Ohrnberger et al., 43; Fox, 412) and even help those with depression by increasing the volume of the hippocampus, as those with depression have a lower hippocampal volume (Pedersen and Saltin, 3). It has also shown that people who partake in physical activity perceive themselves to have greater life satisfaction (Maher et al., 4) and increased subjective well-being (Fox, 413).

There has been some criticism of the recommended 2.5 hours (150 minutes) of weekly activity, not because of the health benefits but for the accessibility concerns. Warburton and Bredin argue that 150 minutes for the average adult, or an extremely sedentary one, would mean to increase their activity by 100-400% to attain the recommended guideline, which can be highly off-putting and perhaps become a barrier to activity (Warburton and Bredin, 500). 150 minutes may simply not be attainable for some demographics, such as those with disabilities or the aging population. What exactly “high” and “moderate” intensity exercises are is also unclear. Carson et al. give a better illustration of this by defining “vigorous-intensity activities” as “heavy sweating or large increases in breathing or heart rate” and “light- or moderate-intensity activities” as “light sweating or slight to moderate increases in breathing or heart rate” (Carlson et al., 3). Even with these more precise definitions and outlines of what people are recommended to do, it still may not be attainable for some of the population. The recommended guidelines should be adjusted within the context of each individual. Someone who finds themselves in a sedentary (very low physical activity) lifestyle should engage in some sort of physical activity and not be discouraged by the 150-minute (minimum weekly) recommendations. The good news is that any increase in physical activity can show some significant health benefits. For instance, Warburton and Bredin state that any increase in activity, even less than half the recommended guidelines, can be as significant (Warburton and Bredin, 501). Increasing physical activity can perhaps be a 10-15% risk reduction rather than 20-30%, but it could still be comparable to blood pressure medications that lower blood pressure in those with hypertension (Warburton and Bredin, 500). They point out that medications with a 15-30% reduction in risk for heart disease would be “highly regarded clinically,” so increasing physical activity by a small amount could help reduce these diseases and illnesses to the same degree (Warburton and Bredin, 500). It is also important to note (though a cliché) that it is never too late to start. Studies have shown that people over a five-year period who increased activity and went from “unfit” to “fit” had a mortality risk reduction of 44% (Warburton, 802).

Physical health is essential in overall well-being, and physical exercise and activity help overall physical health by offsetting diseases, illnesses, and premature mortality. Physical fitness helps with mental well-being as it can help improve the effects of depression, anxiety and stress. A surprising factor is that it may indirectly help with social well-being due to its links with self-esteem, body image (Fox, 415), and sense of capability and identity (Maher et al., 4), which may impact our social interactions, which also in turn affects mental health (Ohrnberger et al., 43). It is clear to see the importance of physical health and how it impacts mental and even social well-being. As we discuss further, we will begin to see that physical, mental, and social well-being are interconnected and equally as important.

2.1.2 Full health and well-being: Social well-being

Social well-being is also referred to as “social wellness” and “social health” and has many definitions. The University of New Hampshire defines social wellness as “building and engaging in trusting, respectful, and authentic relationships” (“Social Wellness”). The Government of British Columbia defines it as “the ability to communicate with others and build meaningful relationships where you can freely be yourself” (Government British Columbia). Social relationships can take the form of family, friends, acquaintances, and community (such as religion). It also says that healthy social relationships can improve physical well-being by impacting blood pressure, heart rate, and stress hormones, and reduce health conditions later in life (Government British Columbia). Numerous studies show that social well-being, or social health, is directly connected to physical and mental health. (Cacioppo and Cacioppo; Holt-Lunstad and Smith; Umberson et al.; Umberson and Karas Montez). Studies have shown that high-quality relationships can present in physiological ways, such as reducing blood pressure, heart rate, and stress hormones (Umberson et al., 5,10), improving overall physical health (Umberson and Karas Montez, 4), and ultimately, reducing disease susceptibility and mortality risk by 50% than those with low quality or weaker relationships (Holt-Lunstad and Smith, 42). High-quality social relationships also strengthen mental health by reducing the impact of stress, increasing perceived emotional support, and “fostering a sense of meaning and purpose in life” (Umberson and Karas Montez, 3, 4).

Alternatively, people who have weak or low-quality relationships face a greater risk of high blood pressure, metabolic syndrome, poor sleep, and poor immunity (Cacioppo and Cacioppo, 6, 9), ultimately leading to greater mortality risk than those with more substantial, high-quality social relationships (Holt-Lunstad and Smith, 44; Cacioppo and Cacioppo, 12; Umberson and Karas Montez, 2). Poor social relationships and loneliness can contribute to adverse mental health as well. Loneliness can contribute to depression, impaired cognitive function, lead to cognitive decline, Alzheimer's disease, and heightened cortisol levels (stress) (Cacioppo and Cacioppo, 1, 9). Humans are meant to have social relationships and do not fare well in isolation, as it directly affects mental and physical health. The National Institute of Health suggests increasing social wellness by connecting with others, shaping health habits, building healthy relationships, and bonding with family. However, interestingly, it also suggests that “taking care of yourself” and “getting active” are ways to increase social well-being (“Social Wellness Toolkit”), suggesting that mental health and physical health strongly correlate to social well-being.

2.1.3 Full health and well-being: Mental health

Good mental health does not mean just being free from mental illness. The WHO defines mental well-being as “a state of mental well-being that enables people to cope with the stresses of life, realize their abilities, learn well and work well, and contribute to their community” (“Mental Health,” World Health Organization). There are many ways to ensure mental health and well-being: caring for the physical body and the conceptual person. The WHO also says that “Mental health is more than the absence of mental disorders. It exists on a complex continuum, which is experienced differently from one person to the next, with varying degrees of difficulty and distress and potentially very different social and clinical outcomes” (“Mental Health,” World Health Organization).

Taking care of the physical body by exercising, eating healthy, getting enough sleep, and limiting alcohol consumption can drastically improve mental health (“Improving Mental Health”). It is no coincidence that all these things are explicitly tied to the physical body, yet affect the mind drastically. Exercise, as discussed in 2.1.1, can improve physical health but also improve cognitive health, anxiety and depression, and overall quality of life (Posadzki et al., 7; Singh et al. 4-6; World Health Organization, “Physical Activity”). To take care of one’s mental health also means to take care of social well-being, such as connection with other people, having positive relationships, and feeling a sense of community. Our social relationships benefit our physical and mental health and even go so far as to reduce premature mortality (Umberson and Karas Montez; Cacioppo and Cacioppo). Taking care of mental health also means coping with stress, having a good sense of self, finding enjoyment in life, and feeling a sense of purpose (Scottatmachine; CDC Archives). Mental well-being means something different for each individual, though it can be achieved through adhering to good mental and physical health focuses.

Research shows that physical, social, and mental health are intrinsically linked. One could visualize this as a never-ending cycle, where mental, social, and physical health work in tandem and a continuum: always changing, constantly feeding into each other.

2.1.4 Full health and well-being: A discussion

We have looked at the three different aspects of what the WHO would define as "Full or "complete" health or well-being. But there is criticism to this definition. To reiterate, the WHO defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity." (World Health Organization, 1). However, this definition has been criticized for being "impossibly abstract, philosophically utopian and misleading, and static" (Antonovsky 1979, p. 55). The definition is also exclusionary, especially to those with disabilities. Those who have diseases or disabilities may find that they are indeed, despite the disease or disability, in a good state of health. What about someone with limited mobility or function? Who defines "complete" physical health, and does this group fit this utopic definition of "complete" physical health? Who defines complete mental or social health? What group of people fit within these definitions, and are all others deemed "unhealthy?" A criticism from sociologist Aaron Antonovsky sums up the outdated definition: "In other words, health includes everything that can possibly be regarded by someone, or in some culture, as desirable" (Antonovsky 1979, p. 68).

In a 2019 report, the WHO implicitly infers that this original definition of health, dated back to 1948, is indeed utopic and misleading and makes steps towards (or, I argue, backpedal to) a more realistic and inclusive health discussion. In that report, the WHO states:

> "Complete health and well-being may not be everyone's goal. For example, the presence of a chronic mental or physical illness is not necessarily a sign of being ill but may be something that can be managed. Management is shaped in part by resilience and whether individuals can adapt with their health: whether they can restore their physiological homeostasis (balance) and feel they have the capacity to cope and fulfil their potential with a degree of independence and opportunity to participate socially. Health is, therefore, a dynamic process that, at its core, is about having the capacity to self-manage" (Fancourt and Finn).

It clarifies the original definition and is now more realistic and inclusive. Though this new expansion of the definition of health is better than the original, one can still have some criticisms about the attainability of "health," as explained further by the WHO. This has to do with the word "complete." What is "complete" health? The WHO does not expand on or explain this aspect of the definition, though it is present in both the original definition of health and in the 2019 report on the discussion of the definition. For this thesis, the term “complete” or “full” health and wellness will go beyond a set of requirements to be measured. Instead, I propose the term to be circumambient, meaning that “full” or "complete” health encloses the existence of all areas of health (physical, mental, social) and focuses on a perceived presence and quality of *all* areas rather than achieving them to a certain degree on an imaginary scale. In terms of this research, focusing on “full” or “complete” health means focusing on all aspects of health, not just physical health and the absence of sickness or disease.

The individual is responsible for achieving the degree of health and wellness in these areas, which comes to this idea of *perception*. When the question posed in 2.1: “How can people with physical disabilities live a full and healthy life that will allow them to thrive and achieve full health and well-being?” I am proposing “fullness” to be the synthesis of all aspects of health, not just physical or mental health. “Full” or “total” health may sound altruistic and naive because we will soon discuss that achieving “full” or “total” health is based on our ever-changing state of physical health and our perceptions of our health. In this research, we will look at full health and well-being as a discussion about not only managing our illness but also being content, happy, and fulfilled in different ways. It is important to note that the term “full” health and well-being is used synonymously with the terms “total” health, “complete” health, and even “high level” health. The research will use these terms interchangeably, though they all mean that mental and physical health is perceived to be high for an individual. To avoid being misconstrued, I am not implying that physical, social, and well-being are not meaningful on their own or that the research from 2.1.1-2.1.4 is not essential. For this research, “full” health and well-being is something holistic, combining all aspects of health, and the individual perceives those aspects as fulfilled. “Full” encompasses physical, mental, and social well-being, all aspects of well-being rather than the impossible task of being “completely” healthy and free from disease or physical ailment, which, unfortunately, is shown to be the primary focus within healthcare settings.

Another thing to note is that in section 2.2 leading up to Chapter 3, the discussion is almost exclusively about mental and physical health. Not because social health is not essential but because social health is typically achieved outside of a medical setting (with friends, family, co-workers, community, etc.). As we find out later, social health could be a by-product of good mental and physical health and a by-product of the design outcomes discussed in Chapter 6. This thesis discusses social health as an element that is shaped and interacts with physical and mental health.

2.2 Pathogenic Focus in Healthcare

Let us look at how physical and mental health are typically treated within the healthcare system. One could visualize it as two separate islands: physical health island and mental health island. They are separated. If one would like to address their mental health, they must go over to the other island. Currently, staff and practitioners do not have enough time or resources to bridge both islands together. Healthcare staff are experiencing burnout universally (Montgomery et al., 1; De Hert; Singh et al. 2024; Bridgeman et al.) and connecting and communicating between the two islands could be tricky and convoluted, as practitioners "often train and practice in their own professional 'silos'" (Chamberlain and Partridge). As the research has discussed, the focus is placed on the 'island' of physical health island within the healthcare setting such as the hospital or clinic, and mental health is in the distance. It does not mean that there are no resources on the mental health island (such as therapy, psychologists, social workers, etc.), but the separation between the two may prove challenging to bridge together for some patients. Training for medical practitioners and staff has been positioned to focus on disease, preventing sickness, and preventing death (Dunn). This focus on physical health in hospitals and clinics means making sure that people are able to function for survival, in which they are cured of illness or sickness. They are then sent on their way to make room for the next patient. Healthcare, as such, is focused on what is called 'pathogenesis' (Antonovsky 1979, vii; Mittelmark et al., 245). Pathogenesis is defined as "the manner of development of disease" (Pathogenesis definition & meaning) and how a disease or illness affects and spreads around the physical body (Baron et al.). Pathogenesis and physical health will be used synonymously for this study since they are explicitly tied.

2.2.1 Disability devices and arm prostheses

In the scope of this research on disabilities of the hand, there is proof of the pathogenic focus when it comes to disability devices and prostheses that are commercially available. For instance, arm prosthetics, according to the Medical Center for Orthotics and Prosthetics, can range anywhere from 5,000 USD to 100,000 USD. The prices are dependent on the –albeit limited –desired function and aesthetic. Someone without insurance can anticipate a cosmetic arm prosthesis to be around $5,000, up to $10,000 for a body-powered prosthetic with a hook, and between $20,000 to $100,000 for a myoelectric (bionic) arm (Medical Center Orthotics & Prosthetics). Arm Dynamics is a company based in the United States that focuses on upper limb rehabilitation (amputation or congenital limb differences of the arms, hands, and fingers) and gives examples of what each category looks like at the given price points.

Figure 1 shows an example of a passive/cosmetic prosthesis, estimated around the $5,000 (USD) range. Passive prostheses are purely for aesthetic purposes, mimicking the skin tone and look of the wearer's other arm to look “life-like.” Though it is passable as a realistic arm, it is entirely non-functional, meaning it does not move or perform any function as another limb or device would. Figure 2 shows a body-powered prosthesis with a hook “hand” estimated at around $10,000. These prostheses open and close to help hold and grab items. It is harnessed to the wearer, and specific movements of the arm or shoulder help open and close the grip of the hook or hand. Figure 3 shows an example of a hybrid (body-powered and electric) myoelectric prosthesis that can be anywhere from $20,000 to $100,000. Myoelectric/bionic arms (purely electric) would be on the steeper side of this range. They can open and close the hand or, in some cases, individual fingers through the wearer's commands by reading electric signals from the nerves in the surrounding muscle of the residual limb.

Fig 1. Example of $5,000 passive prosthesis. (Image from armdynamics.com)

Fig 2. Example of $10,000 range body-powered hook prosthesis. (Image from armdynamics.com)

Fig 3. Example of $20,000-$100,000 electric arm prosthesis. (Image from armdynamics.com)

Again, these prices depend on the company and available prosthetic devices. It is also essential to determine whether one has the medical insurance to cover these prices and if the insurance policy will cover it. For example, those in Canada who have Pharmacare can expect coverage for a functional prosthesis but not for one that "exceeds basic functionality" ("Prostheses Covered by BC PharmaCare"), which limits not only prosthesis options but also the ability or aesthetics of the user. This is true especially for those in the United States, which has a more significant population without any medical insurance. As of 2022, the CDC reported that 27.6 million Americans do not have health insurance ("U.S. Uninsured Rate Dropped 18% during Pandemic") and, therefore, may have no affordable options for prostheses.

Whether covered by insurance or not, the options typically available to people are limited due to the pathogenic focus: functioning for survival. For instance, a patient may be "cured" or "fixed" by a necessary amputation and then receive a prosthesis that can only open and close a claw hand (or mimicked hand). They are no longer in danger of death –they are most likely able to survive and live life with this basic functioning –but there is nothing further for them. The pathogenic focus in healthcare means there is no need to look beyond basic functionality. One can survive by holding a cup or gripping to open a door. There is a lack of commercially available devices for those who want something beyond body-powered prostheses to achieve more functionality, and they are aesthetically minimal as well.

If one were to wear one thing for the rest of their life, wouldn't they want it personalized to their life and personal aesthetic tastes, like a pair of shoes or a jacket? Who is willing or able to spend $20,000 to $100,000 for something not truly personalized? From this research, it is evident that the commercial prosthetics available are a pathogenic solution to a pathogenic problem and miss the mental aspects of being a person with a missing a limb: still a person with values, interests, and lifestyles. Perhaps a person who has had an amputation already has issues with body image, social anxiety, preference for aesthetics, or was involved (or wants to be involved) in hobbies and activities. What would this lack of access and lack of prosthesis options do to their physical, mental, and social health?

If pathogenesis is the origin of disease in the physical body, is there something that can describe the origins of mental health and well-being and even social well-being? Is there a framework or concept that can shift the perspective from the objective body to the person inside the body?

Chapter 3. Introduction to Salutogenesis

3.1 The Genesis

A new concept was introduced in 1979 by Sociologist Aaron Antonovsky (1923-1994). Antonovsky studied sociological aspects of health and medicine. Later in his career, he shifted his work to medical sociology, a subject he taught to medical students at Ben-Gurion University of the Negev, where he was also head of the Department of Sociology of Health (Lindstrom, 2006, p. 240). Antonovsky did numerous research projects and studies on multiple sclerosis, coronary artery disease, menopause, and other neurological disorders and diseases (Mittelmark et al., 24), and noticed a link between diseases and stress and became more interested in psychological stressors as a consequence of, or contributor to the disease, rather than the disease itself (Mittelmark et al., 25). Eventually, through his studies, he became interested in stress research, specifically the links between different diseases and stress.

In a very hard-to-obtain, almost elusive 1979 book called "Health, Stress, and Coping," Antonovsky explores the origins of health, how one is able to have mental resilience, and how one navigates one's world based on one's values, experiences, upbringing, and personal complexities in order to stay healthy. In recent years, the term has evolved into frameworks and expanded into an umbrella term for other psychological concepts. This term is called '**salutogenesis**'. '*Saluto*' meaning health, and '*genesis*' meaning the origination (Antonovsky 1979, vii). Simply put, salutogenesis is the origin of health. This term came about when he posed the question, "What makes people healthy?" However, it looks at something much deeper than the health of the physical body. In a book he co-wrote called "Poverty and Health" (Kosa et al.) he posed another question: Why were impoverished people less likely to cope with stressors related to their health? As the studies within the book discussed, especially one by Marc Fried, the answer was simply that impoverished people did not have the financial means, resources and access to take care of the stressors (Antonovsky 1979, p. 3). Another important question popped into Antonovsky's head. "If two people were confronted by an identical stressor… but one had the wherewithal to successfully meet the challenge and the other did not, how could this situation best be conceptualized?" (Antonovsky 1979, p. 3). Antonovsky began researching the concept of adaptability related to psychology, sociology, and culture as a way to figure out how to cope with stressful events (what Antonovsky calls "tensions") and stress itself (Antonovsky 1979, 5). The most important breakthrough of his thinking which led to the origination of the term salutogenesis was the study of WWII concentration camp survivors. Despite living through the most severe and horrific conditions, he observed that some of the holocaust survivors were able to go on and live good, healthy, and fulfilling lives (Antonovsky 1979, 6). The questions that emerged from this were "Where do people get the strength?" (Antonovsky 1979, p. 6) and "How do people manage to stay reasonably healthy?" (Antonovsky 1979, p. 7). These questions were not asked concerning pathogenesis (about the physical body) but rather, oriented in a way that looked at the individual, the human, as a whole person. Salutogenesis, in contrast to pathogenesis, "opens up, or even compels us to examine, everything of importance about people who are ill, including their subjective interpretations of their state of health" (Antonovsky 1979, p. 37).

3.2: Ease/*Dis*-ease Continuum

Antonovsky proposes in his 1979 book that we should look deeper than the physical body regarding health. As a professor to medical students, Antonovsky knew that healthcare is pathologically oriented, as medical professionals are trained to focus on curing diseases and survival (Antonovsky 1979, p. 33, 220; Bhattacharya et al., 16). Antonovsky looked beyond pathogenesis to argue that there is a person inside the body, to understand that the person has feelings that can "also cause suffering," just as physical pain can. Antonovsky thereby proposed that the physician should also try to alleviate the *feelings* of suffering just as much as physical suffering (Antonovsky 1979, p. 36). However, in healthcare, the focus is on the pathology rather than the emotions and feelings of the person with whom the pathology is concerned. Healthcare forgets that behind the pathology is an intricately emotional person with a distinct personality, perspectives, values, and needs.

> "The issue has a moral face. It is, I believe, impermissible to identify a rich, complex human being with a particular pathology, disability or characteristic. I submit that, working with a pathogenic orientation, one is pushed in this direction, pressured to forget the complexity" (Antonovsky 1996, p. 14).

Antonovsky further says that the pathogenic paradigm is a dichotomy between diseased and fully healthy (Antonovsky 1979, p. 39). In a 1972 public presentation, he proposed the idea of looking at a person's wellness beyond the pathogenic level, on what he calls the 'ease/*dis*-ease continuum' (Antonovsky 1979, p. 64), rather than a solely physical health scale of diseased/non-diseased of the person's body. There is a clear distinction between disease and *dis*-ease, though Antonovsky acknowledges the terms get mixed up or seen as the same term (Mittelmark et al., 25, 28). There is a distinction between disease and *dis*-ease, as they belong to two different concepts. To explain this concept of the ease/*dis*-ease continuum in simple terms: the 'easiness' (ease) or 'difficulty' (*dis*-ease) of which someone navigates their well-being and perceived health. By looking at salutogenesis rather than exclusively pathogenesis, we would look at a multi-dimensional continuum, ever-changing over time, instead of pathogenic poles of absolute health or illness. Salutogenesis asks, "what are the factors pushing someone towards this end or toward that end of the ease/*dis*-ease continuum?" (Antonovsky 1979, p. 37).

> "If, then, we can begin to understand this mystery– the mystery of survival, the mystery of why some people's health is such that they go through life for some of the time with relatively little pain and suffering– we might begin to think about applying this understanding to reduce pain and suffering among the rest of us." (Antonovsky 1979, p. 36).

To understand the salutogenic model better, we must look at its principal concepts that pertain to its framework. What factors push someone towards ease or *dis*-ease?

3.3 Stressors and Tension

Just like there are viruses, diseases, wounds, or other pathological occurrences that push us towards ill health, Antonovsky argues that there are also "psychological pathogens" that can cause us harm in different ways (Antonovsky 1979, p. 14). These psychological pathogens are what Antonovsky defines as "stressors," which lead to "tension." Due to what he calls "medical imperialism" and the pathogenic focus in healthcare, the idea of "pain" is related to pathogenesis. Nevertheless, pain is also something we use for psychological and emotional purposes as well. We are in emotional pain when a loved one dies, our sports team loses, we miss someone, etc. (Antonovsky 1979, p. 58). Stressors such as natural disasters, bombings, wars, relocation, death in the family, and job loss can result in an emotional response (psychological pain) in the body and cause this tension (Antonovsky 1979, p. 74). This psychological pain as a response to a stressor can bring on emotions such as frustration, anxiety, sadness, anger, worry, hopelessness and despair that put stress on the body, which causes a state of "tension." A stressor does not have to be catastrophic; a stressor could even be a small daily hassle (Antonovsky 1979, p. 80). Antonovsky defines a stressor as "a demand made by the internal or external environment of an organism [person] that upsets its homeostasis, restoration of which depends on a nonatomic and not readily available energy expending action" (Antonovsky 1979, p. 72), and that "Stressors are omnipresent in human existence. In response to a stressor, the organism responds with a state of tension. This state can have pathological, neutral, or salutary consequences. Which outcome results depends on the adequacy and efficiency of tension management" (Antonovsky 1979, p. 70, 71). He explains that humans like psychological homeostasis, just as the physical body keeps body temperature, blood calcium, blood pressure, and other bodily functions in a specific balance. Stressors can be physical occurrences that disrupt this balance, such as sickness, disease, and injury, or emotional occurrences, like job loss or the death of a friend. The disturbance of the stressor can be internal or external, physiological or psychological or all of the above. What each person defines as a stressor varies from person to person and can mean different things to each individual. It is the instance when we cannot manage stressors; our body is placed under tension. In Antonovsky's words, a stressor is a "demand made on one for which one does not have an automatic and readily available response capacity" (Antonovsky 1979, p. 117). These stressors result in not just emotional or psychological tension, but they manifest as physiological tension as well. Numerous studies have been conducted on how psychological stress manifests itself as physical illness, worsening existing illness, and even linked with premature death (O'Connor et al.; Yaribeygi et al.; McEwen; Keller et al.; Chu et al.).

> "By the very nature of the human organism at the biochemical, physical, and psychological levels and by the very nature of all human cultures, there is a wide sphere of consensus about what would be perceived as a stressor. Second, and even more crucial to my argument, is the observation that even if we do different labeling phenomena as stressors, the overwhelming number of human beings

> are, most of the time, in throes of confronting what they define as stressors" (Antonovsky 1979, p. 73).

Stressors initiate a movement along the ease/*dis*-ease continuum, even small stressors people face in everyday life (Super et al., 870). Stressors can be minimal and last a short amount of time, or very serious and lifelong. Antonovsky explains that he acknowledges that groups of people can be classified by stressors or groups of people living in the same stressful situations (Antonovsky 1979, p. 91). However, it is up to the individual how they respond to that stressor, whether they can manage the stress response or enter a state of tension. When Antonovsky looked at the holocaust survivors –survivors of a cataclysmic level stressor– and saw that they were able to survive that event and live relatively healthy lives after, is where his questions and the origins of salutogenesis arose. Antonovsky learned that "in the study of stressful life events, it is that what is important for their consequences is the subjective perceptions of the meaning of the event rather than its objective character" (Antonovsky 1979, p. 93). Simply put, people's perception of the event rather than the objective event determines how stressful it is.

Perceptions are essential in how people can cope and not succumb to the stressor or the tension. It is about the perception of the stressor and not the stressor itself. Antonovsky (or I) cannot deny that the Holocaust or any other genocide or the impact of war is less of a stressor just because there are people who managed to survive. However, it is essential to note that every day, people face stressors, minuscule to catastrophic, and perceive them in ways that are either manageable or detrimental. In the scope of this research, oriented to today, a stressor concerned with the research is, broadly, a stressor with disability. Here is where perception comes in. One may not perceive a hand disability as a stressor at all, or maybe one where it is entirely manageable. On the contrary, there may be some who view a disability of the hand as a catastrophic stressor, where one does not have the capacity to manage it, turning it into psychological stress and tension. Amputation could be a catastrophic stressor to someone who once knew how to operate with both of their hands or arms in daily life. Someone born without a limb could view this as a minor stressor but run into obstacles that cause stress, such as the potential inability to participate in activities meant for two hands and dealing with perceptions of others. It is nuanced because perceptions of stressors are complex and unique to each individual. The next question is, what shapes perception and manages stressors before they become tension?

3.4 General Resistance Resources (GRRs)

Antonovsky has defined a stressor as “a demand made on one for which one does not have an automatic and readily available response capacity” (Antonovsky 1979, p. 117). How does one have a readily available response to a stressor? Where or how does one obtain this “readily available response”? In Antonovsky’s model of salutogenesis, he outlines these responses as something similar to a set of resources/tools. Within one's hypothetical toolbox, these are tools to overcome or manage a stressor and prevent it from becoming a state of tension. Antonovsky calls these tools General Resistance Resources, or GRRs, for abbreviation. He introduces this important component of salutogenesis and defines GRRs in his 1979 book as “something which, in the possession of a group or individual, makes possible either the avoidance of stressors or the resolution of tension generated by stressors that have not been avoided or both. I have seen a GRR, then, as something that one has, as something that characterizes one.” (Antonovsky 1979, p. 119). Simply put, “The crucial role of GRRs is in overcoming the stressor and thereby resolving the tension” (Antonovsky 1979, p. 194). If GRRs are something that one has or characterizes one, what exactly are General Resistance Resources (GRRs)? Antonovsky outlines these GRRs as Physical, Biochemical, Artifactual-material, Cognitive, Emotional, Valuative-attitudinal, Interpersonal-relational, and Macrosociocultural resources. Antonovsky and Bhattacharya et al. (Bhattacharya et al, 3) touch on some examples of each of these categories of GRRs:

Physical: Housing, clothing, food
Biochemical: Neurological and immune system, healthy behaviours
Artifactual-material: Money, material objects
Cognitive: Intelligence, knowledge, education, experience
Emotional: Self-esteem, ego identity
Valuative-attitudinal: Coping styles/strategies
Interpersonal-relational: relationships, social support, interaction, status
Macrosociocultural: Culture, religion

They are called General Resistance Resources because they manage a wide variety of stressors. This is not a complete list, as there can be numerous things that can help with tension management, however, this short list are common examples. Each GRR is powerful in its own way but is also interconnected. For example, money is an extremely powerful general resistance resource. In many societies, money is of great importance, and the mere recognition of having money directly facilitates coping with stress (Antonovsky 1979, p. 106). Moreover, money can acquire other material/physical GRRs, with possessions such as housing, food, and power. Money can also provide access to increase cognitive GRRs such as education, experience, and perhaps even strengthen interpersonal-relational GRRs like access to social supports. Though money directly facilitates stress management and provides access to other GRRs for managing stressors, it is not the only important one. All GRRs are important in managing stressors, interconnecting with each other, and preventing stressors from leading to tension. Antonovsky includes a helpful mapping-sentence definition of GRRs:

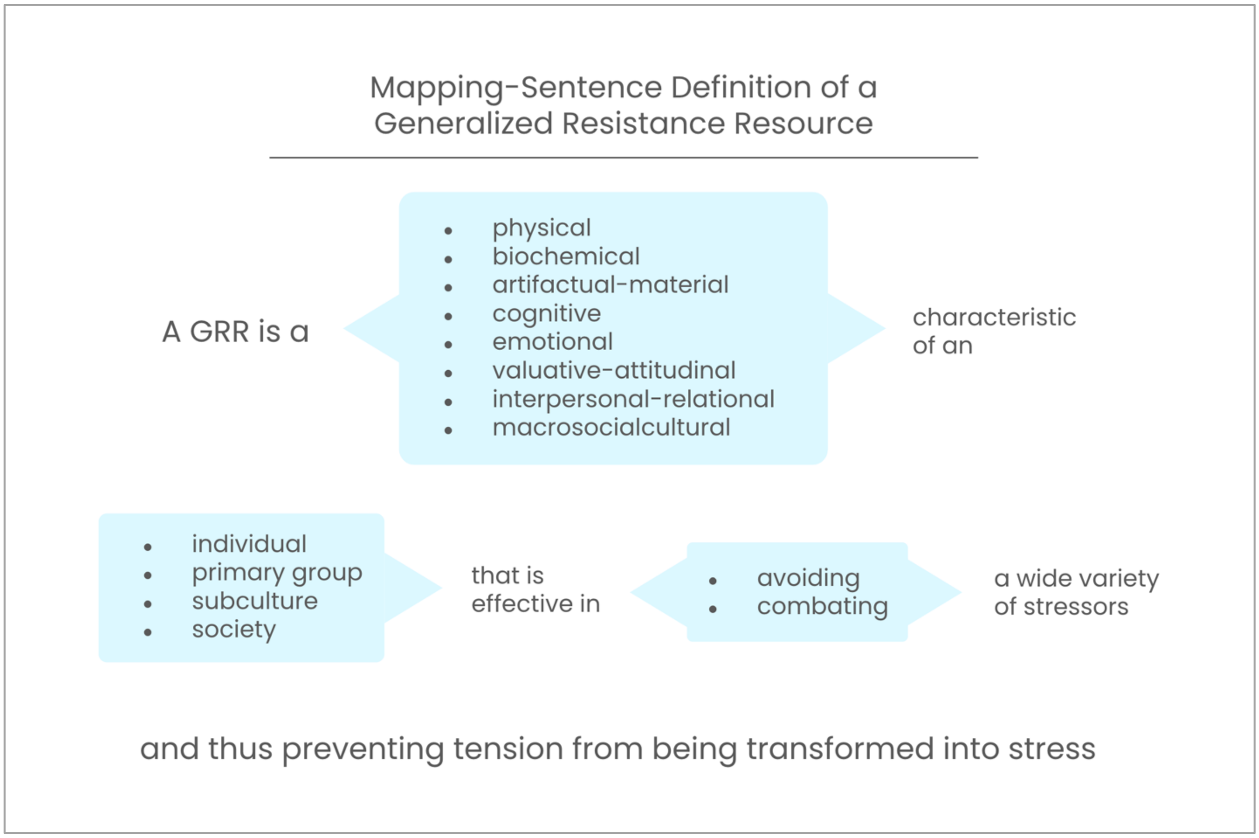


Fig. 4 Redrawing of Table 6 GRR sentence mapping definition (Antonovsky 1979, p. 103)

GRRs vary from person to person. Each individual may have different levels of each of these GRRs. Some may be very strong, and some may be weaker. Antonovsky acknowledges that even culture may play a role in how effective or important these GRRs are, as in one culture, physical strength may be an effective weapon in coping with stress. At the same time, in another, money may be more effective (Antonovsky 1979, p. 107). The absence of money, relationships, or self-esteem may affect someone far more than the absence of education. Acquiring social ties may be far more valuable to someone than money.

Antonovsky notes that General Resistance Resources (GRRs) can vary in strength and importance for each individual and even across different cultures. However, while GRRs can effectively cope with a wide range of stressors, Antonovsky also introduces the importance of Specific Resistance Resources, or SRRs, for dealing with particular types of stressors. SRRs do not stand on their own, as Antonovsky explains: “it is the GRR that determines the extent to which the specific resistance resources are available to us.” (Antonovsky 1979, p. 99). Specific Resistance Resources are used in particular situations of tension through a GRR, such as access to a telephone (GRR) to call a specific lifeline (SRR) for suicide prevention (Antonovsky 1979, p. 99). Mittelmark et al. explain another great example of an SRR being available through a GRR: The internet (Mittelmark et al., 69). Having access to the internet, especially in today’s day and age, may be seen as a GRR for a wide range of people. Specific internet pages or articles about specific sickness symptoms may be an SRR since it may be useful to an individual and a handful of people. The specific stressor is combatted through this SRR (specific internet page) accessible through the GRR (access to the internet). “It is the GRR that determines the extent to which specific resistance resources are available to us… being literate or being rich… opens the way to exploitation of many specific resistance resources…” (Antonovsky, 1979, p. 99, 100). It is much easier to identify a GRR, hence “generalized” resistance resources. SRRs are hard to pinpoint for each individual since they are so specific to one’s strength or access to a GRR, and even then, are specific to each scenario of a stressor. Nevertheless, the possession of GRRs and SRRs is important when determining how one combats or avoids stressors from turning into tension in the body.

Though the acquisition of GRRs in our conceptual toolbox eases the stressor, however, the lack of a GRR can also cause or contribute to a stressor. Antonovsky again provides the simplest example of money:

> "Although having money obviously does not solve all problems, it helps with many. But not having money is not simply a matter of not having a given resource at one's disposal. Being in such circumstance often directly and immediately is a stressor. Not only is access to need satisfaction blocked. But also the knowledge that one is penniless is a source of anguish in and of itself" (Antonovsky 1979, p. 119).

A great example of a stressor brought on by missing emotional GRR of ego-identity is discussed through Antonovsky's discussion of Dr. Ernest Schatchtel, a psychoanalyst who discussed the extremes of a non-identity in a 1961 article titled "On Alienated Concepts of Identity". Schatchtel discusses Holocaust survivors' identities being reduced to and marked with a number, in which he states that these people were robbed of meaningful purpose and dignity (Schachtel, 120). Schachtel contends that, even in not extreme cases, people who lack a sense of identity feel like imposters, like they lack possession of a personality or identity, further feeling meaninglessness. Furthermore, the search for identity will alienate it from the person because it is seen as an outside concept rather than something within that develops with the person (Schachtel, 121, 122). Antonovsky adds that appropriating a fixed role of identity or wanting to have a personality or identity makes it impossible to deal with stressors (Antonovsky 1979, p. 109). This is why personhood, identity, and sense of self is important.

It is not just a person's lack of possessions or ego-identity but also external relationships that can cause stress for many individuals. Antonovsky discusses a study done in California (1977) that showed people with many social relationships (marriage, close friends, relatives, church peers, and group associations) had the lowest mortality rates, which he concludes that such relational ties can be appropriately viewed as a GRR (Antonovsky 1979, p. 115). This is shown in the research in 2.1.2 about social well-being and the disease and mortality linked with high-quality relationships (GRR) or low-quality relationships and lack thereof (lack of GRR). The absence of interpersonal-relational GRRs such as social support and interaction is confidently shown to lead to stressors, therefore tension in the body, and ultimately lead to heightened levels of disease and mortality.

It is crucial to understand that while having a robust set of Generalized Resistance Resources (GRRs) can help individuals cope with stressors, the absence of a GRR can also lead to stress. In other words, lacking a particular resource can create a vulnerability that makes an individual susceptible to stressors. Therefore, it is not just the acquisition of GRRs that is crucial; it is also important to identify and address any gaps in one's resources to prevent stressors from arising and causing tension.

One may think that as long as they have those GRRs in their hypothetical, conceptual toolbox, they can resist all stressors and be healthy. Alas, here is another kicker: just because one has a GRR does not mean they are automatically free from a stressor. One has to activate it themselves. For example, one may have bandages, but one must open the packaging, peel off the adhesive side, and apply it to the wound to be effective. One may have a hammer and nails in their toolbox, but the door frame will not fix unless they apply the force of the hammer upon the nail. This same simple concept applies to general (and specific) resistance resources. Antonovsky submits that GRRs existing as a resource does not automatically produce health; rather, one has to actively and purposely use the GRR to apply it to a stressor (Bhattacharya et al., 3; Super et al., 873).

How does one know when or how to use a GRR or SRR? Antonovsky outlines this concept as the last but crucial element of the salutogenic model.

3.5 The Sense of Coherence (SOC)

Now that we understand the importance of GRRs and SRRs in the salutogenic model, let's delve deeper into the last key component: The Sense of Coherence (SOC). Antonovsky defines the sense of coherence as “a global orientation that expresses the extent to which one has a pervasive, enduring though dynamic feeling of confidence that one’s internal and external environments are predictable and that there is a high probability that things will work out as well as can reasonably be expected” (Antonovsky 1979, p. 123). Furthermore, the sense of coherence is a “generalized, long-lasting way of seeing the world and one’s life in it,” and it is a “crucial element in the basic personality structure of an individual and in the ambiance of a subculture, culture, or historical period” (Antonovsky 1979, p. 124). To reiterate his definition, the sense of coherence refers to an overall outlook that reflects one's confidence in the predictability of one's internal and external surroundings, and the likelihood that things will turn out as expected. Someone with a strong sense of coherence will see life as understandable, controllable, and significant; in which they are flexible and able to adapt well to life's challenges, and that they are able to effectively cope with adverse experiences to maintain good health." (Bhattacharya et al., 2). As Mittelmark states, the "Sense of Coherence (SOC) reflects a person's view of life and capacity to respond to stressful situations. It is a global orientation to view the life as structured, manageable, and meaningful or coherent" (Mittelmark et al., 130).

The sense of coherence refers to an individual's perspective on their life; furthermore, a contribution to this perspective is shaped by the perception of their ability to identify and access resources and the way they actively and effectively use the identified resources, which in this salutogenic model these are GRRs and SRRs. Antonovsky structures this concept of the sense of coherence with three aspects upon which it is built: comprehensibility, manageability, and meaningfulness. Someone with a strong sense of coherence can comprehend what is going on in their life, see it as manageable by applying GRRs and SRRs, and view their life as meaningful enough to see the worth in combating these stressors. In other words, when someone with a strong sense of coherence is challenged with a stressor, ideally, they will be motivated and have a desire or want to cope (meaningfulness), understand the challenge and what they need to do (comprehensibility), and believe that they have the resources they need to endure or withstand the stressor (manageability) (Antonovsky 1996, p.15). When confronted with a particular stressor, a strong SOC enhances one's ability to recognize and activate the most appropriate GRRs (and even SRRs) from those they identify as available (Mittelmark et al., 67). This activation in GRRs leads to seeing life as predictable and anticipating that things will turn out well, or at least in a way that is manageable. Alternatively, Antonovsky refers to a weak sense of coherence, where in this instance, one will anticipate that things will go wrong, turn out negatively, and think that things are unpredictable for them and find that their needs will not be fulfilled, other than by "sheer luck or blind chance" (Antonovsky 1979, p. 126). Antonovsky informs his readers that the writing of "strong" and "weak" sense of coherence may seem to be a dichotomy.

Though referencing these two words may be misleading, this is not the case. To make this clear, just as the salutogenic model strays from the Western medicine dichotomy of “sick” and “healthy,” so does the concept of the sense of coherence. Antonovsky illustrates that the “strong” and “weak” SOCs are on a continuum, and everyone is “located” somewhere within this continuum (Antonovsky 1979, p. 158). This continuum implies that one is not always or completely at a strong SOC, the same as one is not always or completely at a weak SOC. One can constantly move up or down on this continuum. To reiterate, “strong” and “weak” SOC refers to both ends of a continuum, not a dichotomy between the two.

3.6 Development and Movement Along the SOC Continuum

The fluctuation in this location on the continuum is caused by two major things: child-rearing patterns (upbringing) and the nature of life (events). No one would have a perfect sense of coherence unless they lived in a non-fluctuating, perfectly predictable world (Antonovsky 1979, p. 183). Life naturally contains dynamic events, stressors, and surprises that move us up and down the SOC continuum. Antonovsky points out that the sense of coherence is paradoxical. Suppose one experiences their whole life as comfy and predictable. In that case, minor events/stressors, later on, can drastically change the SOC, where one finds that this minor or unpredictable event proves to be challenging and, therefore, lower one’s SOC (Antonovsky 1979, p. 188). Someone who has faced hardship, uncertainty, and challenges in childhood may have developed a set of GRRs that helped them cope with those challenges and strengthen their SOC. A child with a challenging upbringing may be able to adapt to life changes and challenges easier than a “privileged” child due to mere expectation or prediction that life will be unpredictable or challenging. The child who faced no hardships in youth may have been used to a cozy and predictable life. However, life challenges later on are unpredictable and hard to adapt to due to the lack of experience in facing challenges; there was no need to develop GRRs. To add to the complexity of the paradox, alternatively, perhaps the privileged child has greater access to material and interpersonal-relational GRRs such as housing, money, access to social support, etc., to help them overcome a stressor and increase the SOC. Perhaps that unprivileged child does not have money or interpersonal-relational GRRs and has to develop other GRRs, such as emotional and evaluative-attitudinal, for them to be able to cope with life fluctuations. Upbringing and child-rearing patterns affect one's set of GRRs and, therefore, influence how someone sees life as comprehensible, manageable, and meaningful. Each child in a specific social or cultural setting, with specific personality traits and relationships, develops complex and individualized GRRs and SOC. What gives one comprehensibility, meaning, and manageability varies greatly from one individual to the next (Antonovsky 1996, p. 15).

To recapitulate, if our whole life was predictable, then minor changes or unpredictable things can lower SOC. If we had some unpredictability thrown at us in childhood, we are better equipped to handle it later and strengthen our SOC. Through growing up we experience life events in which uncertainty can happen and modify our SOC. Personal stressors, death of loved ones, war, natural disaster, migration, loss of job, etc. are unanticipated and bring on a variety of unpredictable experiences and "inevitably, then, they result in a significant weakening of one's sense of coherence" (Antonovsky 1979, p. 188). Overcoming these stressors by using GRRs eventually strengthens the SOC. The SOC constantly fluctuates, weakens and strengthens; we are constantly moving along the continuum. Life experiences shape the SOC, and GRRs shape life experiences. Life experiences build up one's GRRs, and "a GRR provides one with sets of meaningful, coherent life experiences." (Antonovsky 1979, p. 188). As one can see, these concepts are interconnected, constantly feeding into one another.

> "What I trust has become clear...is that specificable social conditions –certain specificable childrearing patterns and subcultural and cultural patterns of social organization –provide a continued series of experiences that build up the GRRs that are crucial to a strong sense of coherence: a strong constitution, money, a clear ego identity, a flexible coping style, social supports, and so on. Over and over again, these GRRs allow us to see our internal and external environments as meaningful, predictable, and ordered. With this perception, we can reasonably hope that we can emerge victorious much of the time, though not necessarily in every encounter. It allows us to develop an orientation that whose core is 'I (or we) can overcome'" (Antonovsky 1979, p. 152).

3.7 The Full Salutogenic Model

Before proceeding with a further detailed discussion of this concept, it would be helpful to present a table outlining the key components of SOC. To better illustrate this concept, we can examine two hypothetical scenarios in Figure 5: one in which someone is located on the strong end of the sense of coherence and another in which someone is located on the weak end.

Strong SOC	Weak SOC
↑ Meaning ↑ Manageability ↑ Comprehensibility = Strong SOC	↓ Meaning ↓ Manageability ↓ Comprehensibility = Weak SOC
=	=
↑ Activation of GRRs	↓ Activation of GRRs
=	=
• Hopefulness • Predictability • Adaptability • "I'll make it work out" • Move towards "ease"	• Hopelessness • Unpredictability • Unadaptable • "Things will not work out" • Move towards "*dis*-ease"

Fig 5. Table comparing 'strong' and 'weak' SOC

With this understanding, we know that people who are located at the strong end of the SOC continuum are better equipped to deal with stressors by using resources (GRRs) and activating them (Super et al., 870). Antonovsky adds two important points to the SOC. Firstly, having a strong SOC does not mean that there are no "ups and downs" in life. Any experience or situation, whether good or bad, can cause a shift in one's SOC, either temporarily or long-term (Antonovsky 1979, p. 124). Secondly, a strong SOC does not imply that one is always in control, though it does involve an active role in shaping one's destiny and daily experience (Antonovsky 1979, p.128). Antonovsky further illustrates two ends of the SOC by stating, "The adult with a strong sense of coherence is…certainly capable of mobilizing resources to cope with the adaptive demands of life changes, positive or negative. The person with a weak sense of coherence meets the adaptive requirement with a sense of helplessness, which becomes a self-fulfilling prophecy; he or she sees the life change as not making sense and therefore is incapable of successful adaptation" (Antonovsky 1979, p. 177).

The sense of coherence is built off of one's ability to understand a problem (comprehensibility), knowing a stressor can be managed with GRRs that are available to them (manageability) and finding something meaningful from the stress (meaningfulness) (Bhattacharya et al., 2). Meaningfulness may be the most ambiguous concept within the SOC. Bengt Lindstrom, a professor of salutogenesis and health promotion at the Nordic School of Public Health, Gothenburg, defines this aspect of the SOC clearly when he states, "Meaningfulness refers to the extent to which a person feels that life makes sense emotionally, that problems and demands are worth investing energy in, are worthy of commitment and engagement, seen as challenges rather than burdens. This is the motivational component of the SOC" (Lindstrom, 2005, p. 2). Meaningfulness may be the heaviest factor to the SOC, to the extent that without meaningfulness, there is no point in comprehending or managing anything. Nevertheless, following the flow of SOC in Fig 5, all three components make up the sense of coherence, whether strong or weak. A strong sense of coherence will allow for better appropriate activation of GRRs to manage the stressor before it leads to tension and, therefore, again increase the SOC, which ultimately (in an idyllic scenario) leads to movements towards ease on the ease/*dis*-ease continuum. With the simplified SOC table (Fig.5) in mind, it is also important to visualize the salutogenic model –albeit tremendously simplified –as this:

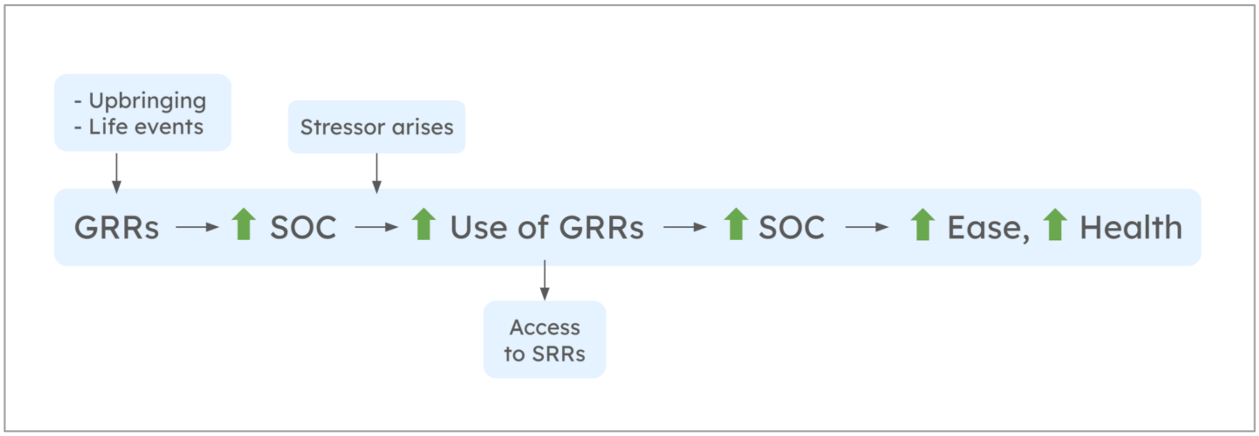


Fig 6. Simplified redrawing of the salutogenic model from "Health, Stress and Coping", Antonovsky, 1979

For clarity, if this salutogenic simplified model in Figure 6 was to be written it would be as such:

"Upbringing and life events shape one's GRRs which can increase and shape one's SOC. When a stressor arises, one will activate their GRRs and potentially SRRs to deal with the conflict. Overcoming the conflict increases one's SOC and in turn moves positively along the ease/*dis*-ease continuum, overall increasing their health and wellbeing."

While the complete salutogenic model, introduced by Antonovsky in 1979, can be referenced in Appendix 3.0, the reader is cautioned that it is intricate, convoluted, and challenging to comprehend due to its sheer complexity in two ways: It is complex in the sense that it contains many concepts, and secondly, the visual representation can be bewildering. For this research, it is better to opt for a simplified version such as Fig 6. to avoid overcomplicating the concepts.

3.7.1 Importance of SOC and the salutogenic model

Antonovsky urges the shift in healthcare to the salutogenic model rather than solely focusing on the pathogenic paradigm. The salutogenic approach can lead to discovering what people need for preventative care rather than reactive care when people are already sick and need help. Antonovsky calls for a change in the healthcare system as a salutogenic outlook "expose[s] the 'bias of the downstream focus', i.e. the devotion of the disease care system to saving swimmers drowning downstream by heroic measures, rather than asking 'Who or what is pushing them into the river in the first place?'" (Antonovsky, 1996 p. 12). Unfortunately, this complex, prospective, and exciting salutogenic model was left without a figurehead only 15 years after its emergence when Antonovsky died in July 1994. However, there are two sources of good news: first, despite the concept's infancy, it was not left completely unrealized and has even been –though slowly –expanded upon and built up. Secondly, as we see in the upcoming chapters, it is a rich, complex, important, and thought-provoking theory that can be applied and expanded to different disciplines of study. To substantiate the first point, some studies and articles show the importance of the salutogenic model in healthcare and psychological practices. In 1987, just seven years before Antonovsky's passing, he developed a questionnaire that one could use to measure their sense of coherence called the "Orientation to Life Questionnaire" (a copy of the version is in Appendix 4.0). It would contain questions on comprehensibility, manageability, and meaningfulness for a total of 29 questions (Mittelmark et al., p. 90). Shorter versions have since been developed with only 13 questions, and multiple versions were created for applications such as for families and children (Lindstrom, 2005, p. 2). Having a tool to measure the SOC meant that the concept could be used in real-world applications and finally determine what it means to have a "high" or "low" sense of coherence. For instance, the orientation to life questionnaire (SOC scale) has been used in studies that show dietary habits, in which it is shown that people with a healthier diet have a higher SOC (Lindmark et al.; Ahola et al.; Riera-Sampol et al.) and even show a stronger SOC in those who are physically active (Ahola et al.; Peker et al.; Bhattacharya et al.) and even lower rates of smoking are linked with a higher SOC (Bernabé et al.; Peker et al.). It has been used in areas like cancer intervention programs (Lindstrom, 2005, p. 3) and drug recovery programs, where those who score high on the SOC scale have lower risk behaviours (Bhattacharya et al., 3). Antonovsky's SOC theory of its link with health and disease has been validated by studies that have shown that a higher SOC is linked with decreased risk for cardiovascular diseases (Haukkala et al.; Riera-Sampol et al.) and overall all-cause mortality risk (Surtees, 1205; Haukkala et al.). While physical health is connected with a strong SOC, there have been far more studies done on the link between SOC and mental health and well-being, which exhibits that a high sense of coherence is linked with lower rates of mental illness and increased well-being (Carlén et al.; Moksnes et al.; Pallant and Lae; Malinauskienė et al.; Eriksson; Bhattacharya et al.; Haukkala et al., 432; Riera-Sampol et al.) and overall higher quality of life (Lindstrom, 2005, p. 2).

3.7.2 Implementation of salutogenesis in a healthcare setting

The previous studies show the link between physical health, behaviours, and mental health and well-being with a sense of coherence. It is apparent that Antonovsky's theory has some validity to it and shows the importance of someone's perceived comprehensibility, manageability and meaningfulness and how they view their health and ability to make choices towards their health, and display resilience. However, the studies presented in 3.7.1 are to measure people on the SOC scale and its relation with risks and diseases, rather than how a salutogenic model is implemented to prevent these diseases from the start, or as Antonovsky analogizes, to discover "who or what is pushing [people] into the river in the first place." One could think the obvious solution to this problem could be the way that healthcare practitioners conduct exams and care for patients. Antonovsky suggests that healthcare practitioners themselves are GRRs by virtue of curing sickness and physical ailments (stressors) to overcome these illnesses and, in turn, can increase the sense of coherence. However, again, it goes further than the patient's physical body. Patient-doctor interaction can further increase the SOC if the encounters are positive and the patient feels trust towards the doctor and the care they are receiving. A poor relationship with the doctor could potentially decrease the SOC if the patient does not feel they are getting effective care and does not trust their well-being in the hands of the doctor or that things will turn out for them. Healthcare practitioners have the ability to structure a potentially important exam or hospital stay experience that can reinforce the patient's SOC (Antonovsky 1979, p. 200). Antonovsky warns that if the patient's perceived behaviour from the doctor shows nothing, but the total interest of the patient, it is "bound to weaken the SOC" (Antonovsky 1979, p. 207). The doctor plays a significant role –or even in control –of the patient experience, whether the patient is being cured of an illness or treated for physical trauma on a scale anywhere from minor to catastrophic. Incorporating a salutogenic approach could help increase the patient's SOC, trust in the healthcare system, and quality of care for each individual.

It can be safe to say that incorporating a salutogenic approach is a no-brainer. However, this is not as easy as one can think. Antonovsky points out that practitioners are not trained to deal with ill people but rather the illness itself (Antonovsky 1979, p. 40). Furthermore, salutogenesis is not applied in medical practice due to the fixation on pathogenesis and curing people of physical illness (Dunn). This is unfortunate, as the salutogenic model calls on preventative care from the standpoint of looking at the patient as a complex human with individualistic qualities and, therefore, individualistic needs. It is thought that physicians can incorporate concepts of the salutogenic model in exams or check-ups by asking about variables not concerning the physical health of the patient (other aspects of well-being) while also recommending treatment in the form of –as an example –positive social relationships, just as they would recommend diet and exercise (Holt-Lunstad and Smith, 50, 51). Though optimistic, it is a utopic scenario that will require far more effort to implement than a conversation in the exam room. As Mittelmark et al. points out, Dorland's Illustrated Medical Dictionary has no record of the term "salutogenesis," nor has it made its way into social science as of 2017 (Mittelmark et al., 7). At the time of this thesis, 2024, Dorland's Illustrated Medical Dictionary still has no entry for salutogenesis. As mentioned time again, healthcare is pathogenically focused and is rigid in practice, policy, and training, all oriented towards pathogenesis. Mittelmark et al. in the Salutogenesis Handbook (2017) note that integrating Salutogenesis in an already complex healthcare practice would also mean that clinical research on Salutogenesis must be done, along with a changing the underlying healthcare policy, and a "radical change of clinical outlook" (Mittelmark et al., 246). Not only would practice, outlook, and policy have to change, but also the medical education and curriculum (Mittelmark et al., 263) due to the fixation on pathogenesis and curing people from physical illness (Dunn). Putting the strain on the physicians to incorporate this into the exam room would also be unrealistic and unfair, as medical staff and practitioners are already experiencing burnout from their jobs. (Montgomery et al., 1; De Hert; Singh et al. 2024; Bridgeman et al.), and time in the exam room is already limited (Antonovsky 1979, p. 216).

All these barriers are troubling since a shift or incorporation of a salutogenic model would be an extremely beneficial and powerful tool in healthcare. Antonovsky acknowledges that the practitioner cannot expect to carry on the weight of this shift. It would simply be too much. Antonovsky poses this question –without answer –in his 1979 book: "Can the medical profession and the individual physical engage in activities beyond the patient-doctor encounter that affect the sense of coherence?" (Antonovsky 1979, p. 217). The salutogenic model may never evolve from the embryonic stage without looking outward from the hospital or exam room. That said, one may have to look further into unexpected disciplines, even deviation from healthcare itself, for the salutogenic model to escape dormancy and reach its full potential. This chapter ends with a series of questions: If salutogenesis cannot be implemented directly in healthcare by practitioners and policy, what other area can it be powerful and valuable? By whom else can it be implemented? The questions posed are similar to those of Antonovsky in 1979, though this time with potential answers in Chapter 4.

Chapter 4. Design and Personhood

4.1 Role of Design, Design Methodology, and the Designer

When answering the questions at the end of Chapter 3 on how salutogenesis can be utilized, design may not have been the first approach that comes to one's mind. However, if one were to dive deep into both concepts of design and salutogenesis, there appear to be areas of overlap. For instance, the salutogenic model was a concept that Aaron Antonovsky proposed to uncover why people stay healthy and resilient to life's stressors and possibly how uncovering that could benefit others. In its essence, the salutogenic model looks at the complexity of each individual, acknowledging the person inside the body and, thus, in need of personalized care. The driving factor in this thesis, through design, is the call to action of personalized solutions to cater to the complexity of an individual. Design could actually provide solutions rather than just talk of theory. Design –more specifically, Industrial Design (ID) –takes on many different forms, many definitions and therefore many different applications. One may find that industrial design is difficult to encapsulate into one definition due to its constant expansion and growth within many fields, applications, methods, and tools. For example, the Industrial Design Society of America outlines a definition, stating it is "Our definition of Industrial Design" as:

> "The professional practice of designing products, devices, objects, and services used by millions of people around the world every day. Industrial designers typically focus on the physical appearance, functionality, and manufacturability of a product, though they are often involved in far more during a development cycle. All of this ultimately extends to the overall lasting value and experience a product or service provides for end-users. Every object that you interact with on a daily basis in your home, office, school, or public setting is the result of a design process. During this process, myriad decisions are made by an industrial designer (and their team) that are aimed at improving your life through well-executed design" ("What is Industrial Design?").

Another substantial definition of Industrial Design is from the World Design Organization, where they display a “renewed” version of the definition:

> “Industrial Design is a strategic problem-solving process that drives innovation, builds business success, and leads to a better quality of life through innovative products, systems, services, and experiences. Industrial Design bridges the gap between what is and what’s possible. It is a trans-disciplinary profession that harnesses creativity to resolve problems and co-create solutions with the intent of making a product, system, service, experience or a business, better. At its heart, Industrial Design provides a more optimistic way of looking at the future by reframing problems as opportunities. It links innovation, technology, research, business, and customers to provide new value and competitive advantage across economic, social, and environmental spheres” (“Definition of industrial design”).

Though these definitions cannot fully encapsulate the breadth of industrial design, they do a good job of outlining important concepts. One overarching theme in these definitions (and many other sufficient ID definitions) is the human factor, designing for the betterment of others. This idea is present in both the definitions from the IDSA and WDO, which is the idea of improving quality of life. This is where salutogenesis, industrial design, and the driving force of this thesis overlap: focusing the *person* and improving quality of life. Designers would be needed and valued in this instance because, according to Sanders and Stappers, designers “hold highly developed skills that are relevant at larger levels of scope and complexity. By selection and training, most designers are good at visual thinking, conducting creative processes, finding missing information, and being able to make necessary decisions in the absence of complete information” (Sanders and Stappers, 15).

4.1.1 Design Methodologies

Design could be a vessel for utilizing and incorporating a salutogenic model in healthcare and other disciplines. This idea may not be as far-fetched as one may originally think, as it is already being used in healthcare settings. However, a proper methodology should be considered for the outcome to be worthwhile. Design implementation in healthcare, and for the scope of this research in incorporating a salutogenic model, needs to use a design methodology that fits within the salutogenic problem. For example, using the “universal design” model, though very beneficial in other settings and problems, would not be the best model to use in this scenario. Universal design is frequently used in designing products, systems and services that cater to the widest range of users possible, making it the most accessible design. Contrarily, trying to make something the most accessible may inversely make it inaccessible for a specific group of people because of its “one size fits all” approach. Universal design is a good model to use when looking at a majority of people but falls short when it comes to smaller demographics with particular and individualistic needs, such as the older or disabled population.

Another methodology commonly used in design that would be far more advantageous with the salutogenic model is called user-centred design. User-centered design “puts the users’ needs and wants at the center of the design process from start to finish” (Still and Crane, p. xiii). Designers that use this methodology will focus on the user by conducting user interviews, thoroughly investigating the problem at hand through secondary and primary research, and frequently asking the users for feedback and validation. “Instead of waiting until the end of the design process for users to validate a nearly completed product, user-centered designers consult with representative users and let them test multiple prototypes throughout the process. Each time, the design is revised until the product is molded to the users’ needs, desires, and situations” (Still and Crane, p. xiii). User-centred design lets the problem define the parameters of the demographic. For instance, if designers are using user-centred design methods to come up with solutions to a problem with Alzheimer's patients and dehydration, then that is indeed the specific demographic that the design is concerned with. This methodology would be beneficial in a healthcare setting instead of universal design because it focuses on a specific demographic or end-user rather than a one-size-fits-all approach to an unnecessarily wide audience.

Another highly focused end-user methodology that has proved to be useful for healthcare is Co-design. Co-design is the process of collaborating with non-designers in the design process to work creatively together to develop ideas and solutions (Sanders and Stappers, 6). “Non-designers” refers to the user group of the proposed design problem or other stakeholders. Co-design facilitates an interdisciplinary and collaborative environment. In a healthcare setting, suppose the designer, patient, and practitioner would work together in an interdisciplinary and collaborative environment to find a design solution. The designer's expertise and the practitioner's medical knowledge working together could potentially yield new and creative solutions to a patient's problem. In the case of co-design, the role of the patient would be vital and arguably the most important. In this setting, the patient uses the end product or outcome, so being part of the design process would be critical in ensuring the solution works for the end-user/patient. Patient care should be a priority; therefore, the solutions should be tailored to their needs. A more specific methodology that dives deeper into the importance of the end-user is called “experience-based co-design,” where the user (in this case, the patient) is the expert of their own experience (Castro et al., 1302). When considering the codesign methodology as experience-based, this would be a critical element as the end user’s health and well-being are at stake, and no one knows the patient’s needs and feelings as much as the patient themselves. Co-design and user-centred design are very similar models. They both focus the solution on the end user, though the only difference is the extent to which the end user is involved. Co-design goes a step further by including the end-user in the design process more frequently than user-centered design, where, in some cases, user-centered design just interviews and validates the design with the end-user. However, the line between co-design and user-centered design is blurred and sometimes used interchangeably, as interaction can be subjective. Projects and studies have used “user-centered design” but show that co-design was happening in the process. It is safe to assume that all co-design is user-centered design, while not all user-centered design is co-design.

Numerous case studies have outlined the importance of design methodology in healthcare. “RED Paper 02: Transformation Design” outlines a case study where a design team is co-designing with a woman with type II diabetes, Angela, who struggled to take steps to help her condition despite knowing what those steps are. The design team included designers, health policy experts, social scientists, psychologists, economists and doctors. Angela “wasn’t simply the subject of research but an active part of the RED design team” (Burns et al., 12). In this scenario, Angela is the “expert by experience”. The outcome of the design process with Angela was the development of agenda cards with different discussion and problem prompts for diabetic patients to use during their appointment with a doctor, in which “the cards provide patients with a means of putting their own ‘agenda’ first, rather than that of the health service” (Burns et al., 13). This case study is an example of the effectiveness of a user-centred and co-design approach that leads to a more personalized intervention where people can put their own human needs, agendas, wants, and worries at the forefront of their care. This solution might not have come about if it were not for design intervention with a user-centred methodology such as co-design. The designer, or design team, facilitated the project, and the doctors were there to be able to put input and be part of the process while not being the ones to lead the process and bear the weight of the project. The agenda card development is just one example of a healthcare solution brought on by co-design and design thinking. Cross-analyses of many studies show that user-centred design and co-design are helpful in numerous healthcare settings (Silvola et al.; Sanders and Stappers, 15; Altman et al.), such as utilizing co-design for improving bedside handovers for mental health care (Van De Velde et al.), creating self-assessment checklists for geriatric patients (Chamberlain and Partridge), improving the experience of care for breast and lung cancer patients (Tsianakas et al.), creating a system to alert practitioners of drug-drug interaction on patients records (Luna et al.), and even designing an object for signalling social cues to increasing communication for those using augmented and alternative communication devices (Valencia et al.). More studies have been done using co-design and user-centred design approaches in healthcare settings and have shown a positive impact on healthcare practitioners and patients (Altman et al.; Sanders and Stappers, 9).

User-centred design, (experience-based) co-design, and salutogenesis have concepts and driving forces that are very similar: looking at the perspectives and special needs of a specific demographic or even an individual. Further, the driving force of this thesis and a concept that interconnects design and salutogenesis is personhood. The idea of a human inside the body, an intricate personality with values, wants, and needs. Why is the human so important? Why should we focus on the individual?

4.2 Personhood

The concept of personhood is closely linked to the salutogenic model, as the salutogenic model talks about upbringing, life events, and personal resources (such as ego identity, knowledge, experience, and social relationships) that are different for each individual.

Designing for health with a salutogenic orientation could ensure that solutions in healthcare are truly personalized to each individual. The term “personalized medicine” is used in healthcare. However, it is again, unfortunately, only concerned with pathology as it looks at genetic profiles and stratification of data with other profiles to predict disease and interaction with drugs (Abettan and Welie, 3; Pokorska-Bocci et al.; Fiala et al.; Nuffield Council on Bioethics). This is not to say that research on genomics or stratification of genetic data is not valuable, but the term “personalization” could also be shifted in a way that relates to the person rather than the body. Focusing on someone's genetics for personalized solutions can actually depersonalize them (Abettan and Welie, 3) as they are reduced to their biological data. This echoes Antonovsky’s grounds on the salutogenic model when he states, “It is, I believe, impermissible to identify a rich, complex human being with a particular pathology, disability or characteristic.” (Antonovsky 1979, p. 14). The term “personalization” should shift from a purely pathogenic approach to treating the patient or individual as a “whole person.” A person that has wishes, views, and lifestyles (Pokorska-Bocci et al., 206; Nuffield Council on Bioethics, 30).

Personhood is important, but why is it important? Cambridge Dictionary defines Personhood as “A state of being a person” (Cambridge Dictionary, “Personhood”), while Merriam-Webster dictionary also defines “personality” as the “quality or state of being a person” (Merriam-Webster Dictionary, “Personality”). They are similar and used interchangeably, though personality does have more quantifiable definitions, such as “the type of person you are, shown by the way you behave, feel, and think” (Cambridge Dictionary, “Personality”) and “the enduring characteristics and behavior that comprise a person’s unique adjustment to life, including major traits, interests, drives, values, self-concept, abilities, and emotional patterns” (“Personality”). The topic of personhood and what it means to be human beyond the body is a philosophical discussion that has been debated for millennia among countless philosophers, dating back to Plato (428/427-348/347 B.C.E) and Aristotle (384-322 B.C.E.). To cover all philosophical aspects from the perspectives of all philosophers would result in an insurmountable number of pages and is much beyond the scope of this thesis. Therefore, this thesis refrains from discussing select philosophers and their ideas. However, a philosophical question and contemplation are not out of the scope. The concept of personhood and what it means for someone to have an identity and personality is convoluted, perplexing, and impossibly abstract due to its subjective nature (proven by how many perspectives there are on the topic). However, the concept of "personhood" proves its philosophy by being just that: subjective to each individual. This subjectivity in defining personhood, or what makes you 'you,' demonstrates that personhood and personality are unique to oneself and how one sees oneself. This translates to different wants, needs, values, emotions, behaviours, fears, interests, ways of thinking, and other psychological and philosophical characteristics of each individual. Antonovsky does not explicitly talk about personhood, though he touches implicitly on the idea of personhood and personality by looking at the complexity of an individual through GRRs, SOC, upbringing, and life events. In recent years, Bengt Lindström, a professor in salutogenesis in the Department of Public Health and Nursing at the Norwegian University of Science & Technology, and who is referenced throughout this thesis, has expanded the concept of salutogenesis into an "umbrella term" which holds other theories and elements tied to personality and personhood such as resilience, coping, empathy, gratitude, humour, and more.

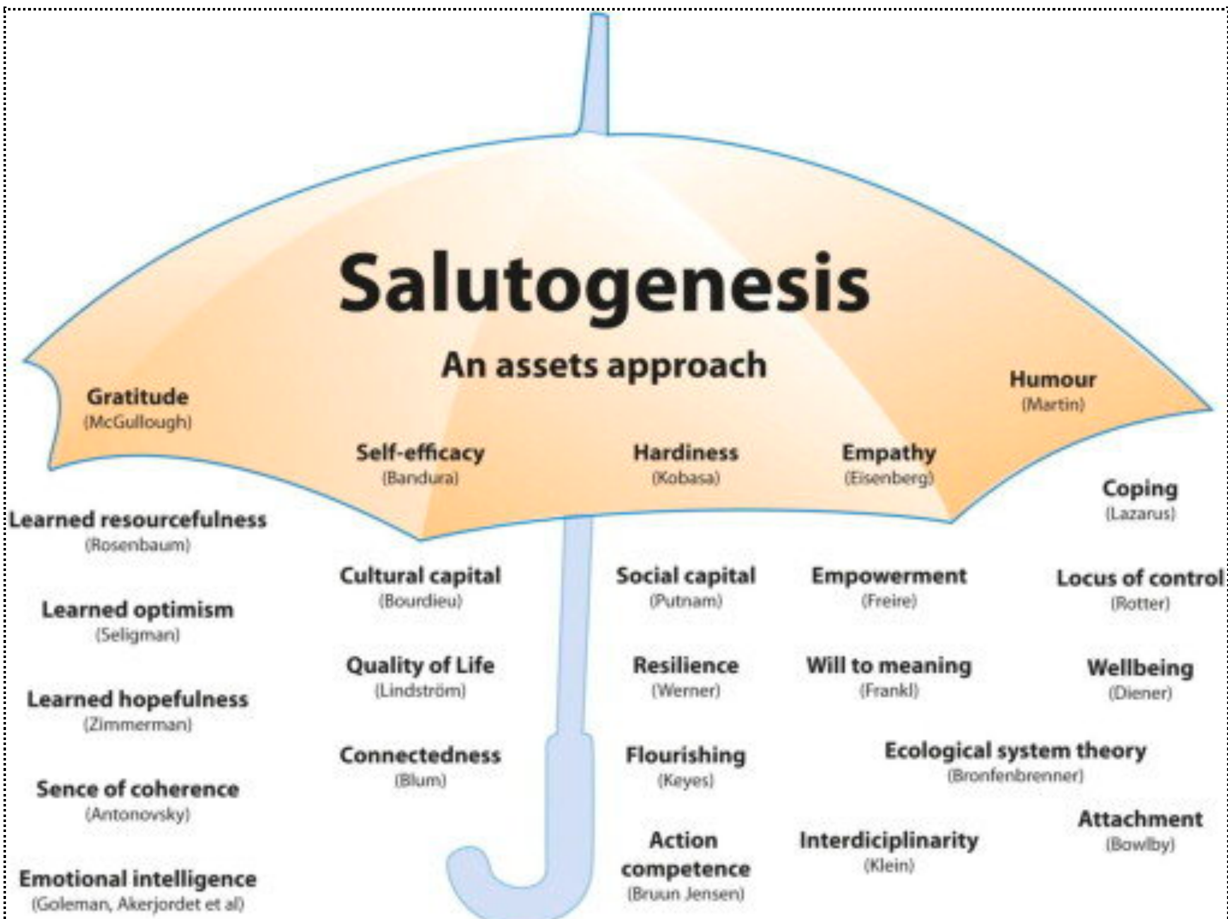


Fig 7. "Salutogenic Umbrella" (Lindström and Eriksson, 2010.)

This is where the thesis must turn informal, address the reader, and ask, what makes you a person beyond your physical body? Contemplate your lifestyle, hobbies, interests, routine, social circles, education, ability, accomplishments, and anything else that makes you who you are. Your unique identity and personality. Now, recall the Introduction to this thesis when the scenario illustrates that one day, you have the ability to go about your day, complete tasks, engage in physical activity, partake in hobbies, and decide on clothing for a night out to socialize with your friends. The next day you are unable or limited in the ability to do all those activities. One must consider how this would affect them. Would it change who you are? To what extent would this affect your life? Would it be self-shattering? Or would it be manageable? These answers depend on your values, lifestyle, needs, relationships, dreams, fears, way of thinking, and emotions. It would uniquely impact everyone because everyone has a distinct personality and sense of personhood, just as Antonovsky theorizes in the salutogenic model.

Further, consider the prices for prostheses or assistive devices, or lack thereof. Consider the limited functionality. Consider how other factors, such as body image, social and self-perceptions, and stigma, would affect you. Would you be satisfied with pathogenically focused care with pathogenically focused outcomes? To echo Antonovsky once more, but this time to the scope of what this research advocates, it is indeed impermissible to identify a rich, complex human being with a particular disability. It is impermissible to reduce someone to basic functionality, and impermissible to reduce someone to their physical body just because they are able to survive. What about thriving and living a full life that encompasses physical, mental, and social well-being? The components of personhood, salutogenesis, health, and design create a strong basis for moving past the pathogenic paradigm. A designer integrated within the health sphere tasked with incorporating a salutogenic model within one's healthcare outcomes would ease the burden off the overworked staff and stringent healthcare system and could ultimately be a resource for patients. The designer could be an unexpected player in helping people move from *dis*-ease to ease by incorporating a salutogenic orientation through design methodology into design outcomes. How can design integrate all these ideas and concepts into solutions for disability of the hand?

Chapter 5. Function, Aesthetics, and Devices

5.1 Identifying the Intersection and Narrowing the Scope

Chapters 1-4 discussed topics like disability, stigma, barriers to healthcare, barriers of access to medical devices, physical health, mental health, social well-being, salutogenesis, personhood and personality, and design. There have been many topics, all across different disciplines, though now they will –thanks to design –converge together. If the designer is integrated in the healthcare setting, tasked with integrating salutogenesis into care, it could potentially help take the load off the practitioners to find solutions to help people thrive rather than survive. Finding solutions for all disabilities, mental, physical, and cognitive, though important topics, would be nearly impossible to cover in the span of a thesis project. As discussed in Chapter 1, the scope of this research has narrowed down to disabilities of the hand, which could be through amputation, congenital disabilities, illness, disease, or situation that prevents one from using their hands to their full functionality. The scope has been narrowed to hand disabilities due to their highly visible and functional properties. It is hard to hide hands as they function in almost all our daily activities, even in daily social settings such as pointing, gesturing, shaking hands, waving, “talking with your hands,” etc. Due to the highly visible and functional properties, design would be good tool for solutions in both realms of function and aesthetics. Industrial design can create products, systems, services, and experiences (PSSEs), however, it is most appropriate that physical products in the form of disability devices will be designed based on the concerns of aesthetics and function of hands.

5.2 Function vs Aesthetics

Function is a tremendously important component in industrial design. The functionality of a product is the "opportunities for actions which are afforded by a product" (Han et al., 289). In other words, function dictates whether the proposed design or product works for the demographic or user group it was intended. Functionality is a critical principle in industrial design as Cambridge Design Technology states that "[functionality] involves ensuring that the product fulfils its intended purpose efficiently and effectively.

Designers must thoroughly understand user needs and develop solutions that address them while also considering factors like ergonomics, usability, and ease of maintenance" (Plumb). Functionality is vital for assistive devices due to its ties to ability. As one refers to Chapter 2, 2.2.1, we see that commercially available prostheses have limited function, and increasing function (though still limited) correlates directly with an increased price. The function is essential because it facilitates what someone can do and accomplish; chances are, someone with limited mobility, amputation, or congenital limb difference of the hand would prefer not to be reduced to the functions of gripping and holding. Increased functionality could mean increased mobility, which is essential not just in completing tasks but taking control of one's physical health. The increased ability could mean that a particular exercise is attainable. Of course, as Chapter 2 discussed, physical health, in turn, helps mental health. Increased functionality would be vital to one's hobbies and lifestyle as people typically identify with certain lifestyles or hobbies. For example, if someone were a proficient violin player and faced a tragic accident leading to amputation of the hand, what would this loss mean for their sense of identity? Would they lose a piece of themselves if they could never play violin again? The commercially available prostheses would not fix this problem because they do not enable the specific dexterity that would allow them to hold a bow properly. Personalized/specialized functionality of the disability device or prosthesis is crucial when considering a salutogenic framework in the design of prostheses.

The argument for aesthetics is more nuanced than the rationale for function. The discussion is more philosophical and requires personal reflection. Design is also concerned with creating aesthetics or aesthetically pleasing things, but why is this important? Regarding product design, aesthetics is the visual representation of a product (such as colours, form, and texture) and how it elicits a cognitive reaction or emotional response (Han et al., 290). Visual representations are essential in the way that one perceives and experiences things. Paul Hekkert, professor and head of the Industrial Design department at the Delft University of Technology, explains that we attach experiences, meanings, feelings and emotions to the aesthetics of a product and assign personality and expressive characteristics to a product which hold "personal and symbolic significance" (Hekkert, 160). We gravitate towards and choose products based on characteristics and aesthetics; in turn, the product reflects ourselves. An article called "Self-affirmation through the choice of highly aesthetic products" talks about a consumer's sense of self when choosing a product while arguing that the product's choice affirms one's innermost personal values (Townsend and Sood, 415).

In other words, aesthetics are essential to people in how they identify and see themselves. Aesthetics are unique to each individual in what one's 'personal taste' is or what one is drawn to, but there is also social importance to aesthetics. Hekkert gives an example with jewelry products: "For example, on seeing a bracelet a person may experience desire because she expects that possessing it will fulfil her concern of being admired" (Hekkert, 160). The idea of aesthetics playing into social desirability makes sense when we think of high-end brands and products as a form of status and popularity. Sports products from Nike, Tech products from Apple, Cars from Porsche, and fashion from Versace are desirable products because they reflect social status and therefore social desirability. We perceive others based on aesthetics but also identify ourselves through aesthetics. Aesthetic desirability in products echoes section 1.2 of social stigma and desirability in humans, yet aesthetics are far from the focus for products such as assistive devices and prostheses. Factoring out luxury brands, the choice of aesthetics in clothing, shoes, accessories, and products reflects identity and influences how one is perceived. One may not be concerned with aesthetics, but someone else may find this of great importance. It is about choice. If one were to lose a limb and find that the prostheses available lack aesthetically pleasing options, what would this do to someone's identity and sense of self?

Prostheses and disability devices should be personalized to the wearers' needs, wants, values, aesthetics and lifestyles. People identify themselves with who they are and what they do. If someone identifies with particular aesthetics, hobbies, and lifestyles, should they never be able to associate with those things in the case of a tragic accident or illness? Furthermore, should those with congenital limb differences be robbed of an opportunity to learn a new hobby, skill, or activity that can build and further shape their sense of identity? Should there not be solutions that cater to personal aesthetics and function? The questions cannot be answered through healthcare practitioners or the healthcare system. Rather, it is an interdisciplinary problem that requires interdisciplinary thinking, methods, and approaches. If a doctor is considered a generalized resistance resource (GRR) in a pathogenic orientation, then perhaps a designer could –in a utopic scenario –also be a GRR; however, oriented in a salutogenic approach where emotion, interests, needs, wants, dreams, and fears, are the focal point of care. The designer is a GRR because they can apply the skills and methods to a wide range of problems. In this case, the design solutions would be considered specific resistance resources (SRRs) since they are tailored to an individual or a specific application. What SRRs can be designed to combat stressors and move someone towards ease on the ease/*dis*-ease continuum and ultimately increase overall health and well-being? What SRRs can allow one to thrive? Before introducing the case studies and design of potential SRRs, it would be helpful to see if there are existing devices and prostheses that look at aesthetics and function.

5.3 Analysis of Existing Companies and Products

5.3.1 Fillauer TRS

Some steps have been made toward prosthetic devices with specialized functionality and aesthetics. For instance, Fillauer TRS is a company that specializes in body-powered prosthetics and orthotic devices that are function-specific. The founder, Bob Radocy, was involved in a car accident when he was 21 that resulted in the amputation of his left hand. He found a lack of prosthetic options for athletic activities he was interested in and formed the company TRS in 1979. He wanted to create designs that "get closer to duplicating human biomechanics to achieve improved bimanual, functional performance in a vast arena of activities" (Experience body power 2023 product catalog - fillauer TRS prosthetics). They have an extensive variety of prosthetic devices and attachments ranging from attachments for sports like golf, skiing, and biking and recreation like gardening and photography to musical attachments for drumming, violin, and guitar. Fillauer TRS also creates prostheses for children to hold toys and soothers.

Fig 8. “Drumstick Adapter” by Fillauer TRS. (Image from trsprosthetics.com)

Fig 9. “Amp-U-Pod and “Ski-2” by Fillauer TRS. (Image from trsprosthetics.com)

The products vary in materials such as metals such as aluminum, nylons, rubber polymers, and hard plastics depending on the intended use and required durability. Fillauer TRS is an excellent example of activity-specific functional prosthesis attachments, which lets the wearer partake in activities they may not have access to without these attachments. Participating in photography, drumming, and skiing is not concerned with survival but is vital to one’s lifestyle and sense of self. The price of these attachments is hard to pinpoint since they include a wide range of materials and pricing options are not disclosed on the website ("Purchase Options - Fillauer TRS Prosthetics"). Fillauer TRS products are available throughout the United States in certified professional prosthesis facilities, which coordinate insurance and billing for services. For Canadians, one would have to look for prosthetic facilities served by Myrdal Orthopedic Technologies in Winnipeg, which coordinates the arrangements and imports of prostheses from Fillauer TRS. There are options to purchase through Fillauer TRS directly, though all prostheses ordered this way are final sale, and there are, again, no prices listed.

5.3.2 Open Bionics

Open Bionics is a UK-based company that creates low-cost arm and hand prostheses by utilizing 3D printing technology. They can produce a functioning bionic arm for under 5,000 pounds (8,000 CAD) while "empowering the aesthetics" of the user (Openbionics.com). They are customized using 3D printing technology, which enables the designs to be personalized and fit the aesthetics of the wearer. Figure 10 shows an example from the Open Bionics website, where they created a bionic prosthetic arm to mimic the aesthetics of the Marvel superhero Iron Man. 3D printing technology allows for different textures and colours, which the company has designed interchangeable magnetic covers (Figure 11) that include styles such as Az-Deco (Aztec and art deco inspired decoration), mandalas, and even covers that mimic the aesthetics of the video game Metal Gear Solid. Functionality is a consideration for Open Bionics, as the user can choose between different grip functions, lights, and bio-feedback vibrations (Openbionics.com). Open Bionics has also created lightweight, breathable, and adjustable sockets so that wearers can be comfortable while wearing the prosthesis. Open bionics is an excellent example of creating lightweight and cost-effective prostheses that cater to the aesthetics of the wearer. However, functionality for their "Hero Arm" is minimal, with only six grip functions, as shown in Figure 12. This is not to say that Open Bionics is not concerned with more functionality; rather, the lack of function is due to the limitations of bionic technology in general.

Fig 10. “Hero Arm” by Open Bionics (Image from openbionics.com)

Fig 11: Custom Prosthetic Arm with Interchangeable Covers, Hero Arm, by Open Bionics (Image from openbionics.com)

Fig 12. 6 Grip Functions of the Hero hand by Open Bionics (Image from the Open Bionics Brochure)

In November 2023, during the writing of this thesis, Open Bionics launched the Flex Arm: an aesthetic socket and cover that allows for the attachment of Fillauer TRS products. The socket is 3D printed with a unique cut-out pattern that is visually appealing. The 3D printed material and cut-outs help keep it lightweight and wearable for long durations. It is also waterproof, which makes it suitable for watersport Fillauer TRS attachments such as kayaking and surfing, and it also means that it is cleanable when it may get dirty from sports like biking and baseball. This recent coalition of products from Open Bionics and Fillauer TRS creates a space in the prosthetics industry that focuses on functionality and expansion in someone's ability, personal aesthetics and visual identity. As of 2024, no other prosthetics company for arm prostheses has focused as intensely on function and aesthetics as Open Bionics and Fillauer TRS, thanks to their recent partnership.

Fig 13. Examples of Open Bionics "Hero Flex" arm using Fillauer TRS attachments (Image from openbionics.com)

Fig 14. Open Bionics "Hero Flex" arm with Fillauer TRS attachments (openbionics.com)

5.3.3 Unlimited Tomorrow

There are other examples of companies creating arm prostheses that are trying to bring down costs and create a variety of aesthetics in different ways. Unlimited Tomorrow is a US company that creates 3D-printed myoelectric prostheses. They offer a device called the True Limb that is 3D printed out of PA12 nylon and then covered in a rubberized coating that matches the skin tone of the wearer ("Unlimited Tomorrow"). The device is less than $8,000 (USD) and has six grip functions. The company offers hundreds of skin tones and colours like black, white, silver, and gold. The process includes a 3D scanner that ships to the client, in which the wearer will scan their other arm, return the scanner, and then a 3D model of the mirrored hand is printed ("How we create personalized prosthetics"). This process makes the prosthesis unique to each wearer, as it directly mimics the knuckles, hand shape, and veins of the other hand, which is a great option for people who would like a functional prosthesis while keeping it close to the aesthetics of the body. As of 2021, they have expanded their services into Canada.

Fig 15. "True Limb" by Unlimited Tomorrow. (Image from unlimitedtomorrow.com)

5.3.4 Esper Bionics

Esper Bionics is a US company that uses AI and machine learning to create lightweight and "smart" bionic hands. They focus on human augmentation to "transform the way we live, enhancing our physical abilities and unlocking longer lifespans" ("Esper hand"). They created a sleek and lightweight design that has customizable grip functions. Esper

Bionics uses machine learning so that the hand can predict the movement based on the surrounding environment and patterns of electric signals, which makes for a fast response from the prosthesis. The hand starts at $20,000 and only has one design option, black, that comes in only two sizes. This company is focused mainly on artificial intelligence, machine learning, and technological advancement of prostheses rather than on creating aesthetic options.

Fig 16. Hand prosthesis by Esper Bionics. (Image from esperbionics.com)

5.3.5 Victoria Hand Project

The Victoria Hand Project partners with healthcare providers to help people in developing countries access prosthetic arms ("The Project | Victoria Hand Project"). They utilize 3D printing and 3D scanning technology to create prosthetic limbs and establish 3D printing centers in the countries they assist so that prostheses can be manufactured within the respective countries. Victoria Hand Project has helped people in developing countries access low-cost arm prostheses who would not be able to access prostheses otherwise. They have a few options for hands that only offer full open and close functions for gripping and holding things and offer options for those who want something cosmetic (non-functional). The prostheses are aesthetically limited to basic form and colour, though they show the importance of 3D printing technology associated with low cost, easy manufacturability, and accessibility.

Fig 17. Prostheses from Victoria Hand Project. (Image from victoriahandproject.com)

5.4 Disability Devices

Some companies are making significant steps towards arm prostheses that are more aesthetic, functional, and accessible. One may wonder why the many examples and analyses throughout the thesis are of limb loss and prostheses while prostheses and disability devices were also mentioned. Prostheses are indeed disability devices, but some devices are made for disabilities that affect the hands yet do not include the total loss of a limb. Disabilities such as arthritis, diabetic neuropathy, cerebral palsy, Parkinson's, carpal tunnel syndrome, muscular dystrophy, fibromyalgia, and even physical wounds can affect the use and functionality of one's hands. Most would have a satisfactory idea of what an amputation or lack of a limb looks like; therefore, they can identify the implications of limb loss and the solutions needed. Pinpointing what disabilities of the hand there are, what conditions lead to such disabilities, and what solution each disability needs would be vast and highly nuanced since there are so many illnesses, diseases, and conditions, and each affects people differently. However, it would be beneficial to briefly look at 'disability devices' alongside prostheses to show that looking through a lens of salutogenesis and user-centred design could benefit other healthcare areas. The reason not to focus solely on prostheses for hands is so that the essential concepts and ideas of design and salutogenesis are not reduced to just one area, as it would be a disservice not to create a conversation about how it can expand to other areas of healthcare.

There are accessible disability devices that are on the market for a whole host of disabilities. For some examples of devices for grip and strength issues of the hand, ImaginAble Solutions is a company based in Hamilton, Ontario, that has created the "Guided Hands" device that allows people with decreased mobility of the hands (from cerebral palsy, arthritis, and other conditions) to draw, paint, and use tablets again (“ImaginAble Solutions”). This device features a flat or spherical handpiece (which seems to be 3D printed due to identifiable layer lines) that can attach a stylus or pencil which is set on an apparatus that users can move up, down, sideways, and diagonally. The hand pieces allow for the hand to rest and navigate the pencil or stylus without needing fine-tuned finger use or gripping strength.

Fig 18. “Guided Hands” device from ImaginAble. (Image from imaginablesolutions.com)

The “Liftware” products from Verily are examples of devices for hand disabilities, although they showcase products that are a necessity rather than recreational. Liftware is an assistive eating device that allows for accessible and useable tableware for those trying to feed themselves but experience tremors or limited mobility of the hands (“Eat with confidence”). They have two different products depending on the needs of the user: the first one is called “Liftware Steady,” which is a widened handle equipped with stabilizing technology to reduce the effect of tremors so that tremors of the hands will not knock or spill food off the fort or spoon. The second product is called “Liftware Level,” which always has a computerized handle that keeps the spoon or fork horizontal, no matter what angle the handle is held, which is helpful for those with limited mobility in the wrist and who cannot angle the tableware effectively. These products would be essential for everyday use in those with grip and mobility issues.

Fig 19. The Liftware Level and the Liftware Steady by Verily. (Image from liftware.com)

Active Hands Company focuses on disability devices for those with grip and strength issues in their hands. They have numerous products for different kinds of activities like cooking, gardening, and sports (“Limited mobility gripping aids”). They sell very particular devices for specific and even “mundane” tasks, such as cardholders for those who want to participate in card games but cannot fan out their cards, and table-top nail clippers so one does not have to hold and apply pressure to small nail clippers. There are many devices on their website, and they show just how important adaptive devices are in many small areas of life.

Fig 20. Card holder and table-top nail clippers from Active Hands Company. (Image from activehands.com)

Taking a look at the landscape of prostheses and disability devices gives one a better interpretation of what is available, accessible, and perhaps even needed for those with disabilities of the hands. It also makes clear that there may need to be advancements in both aesthetics and function as prostheses and devices progress to fit the functional and aesthetic requirements of the wearers. Chapter 6 will show four case studies where research, a salutogenic orientation, and design come together to create prototypes for prostheses and disability devices. Before introducing the case studies, it is worth discussing the rationale for the methods of prototyping the proposed solutions.

5.5 3D Printing as a Method for Customization and Personalization

A great tool to keep up with innovation and even aided innovation in areas discussed in 5.2 and 5.3 is 3D printing technology. 3D printing is an innovative technology that is rapidly advancing yet becoming widely accessible and used in various disciplines and applications. The 3D printing process includes exporting a 3D model file as an STL file into a program that slices the file into layers. Specifications for the print, such as infill, layer height, and thicknesses, can be defined in the program before being exported into a code of coordinates that the printer reads and follows during printing.

The specifications of the settings can determine the quality, robustness, and even how much material and time it takes to print a particular piece. Smaller layer height will equal a higher quality print but increase printing time. The infill determines how much material is used inside the print, resulting in more or less material based on how much infill is needed. The thickness determines the thickness of the perimeter walls, in which thicker walls will create a more robust print but add more printing time. Other detailed specifications and settings can be changed and manipulated in the slicing programs, but these settings are the most significant to the process. There can be different forms of 3D printing, such as fused deposition modelling (FDM) printing, where plastic is melted and extruded to be built up layer by layer to create a model, or stereolithography (SLA), where the hardening of resin via ultraviolet light builds the model from a vat or resin. Research on utilizing 3D printing and its applications (Chen and Do; Singare et al.; Nguyen et al.) show that FDM printing is the most common printing process, which is due to the FDM printers being cheaper than resin printers and the accessibility of materials such as ABS (acrylonitrile butadiene styrene), PLA (polylactic acid), and PETG (polyethylene terephthalate glycol), which are typically cheaper than resin.

3D printing is being utilized increasingly in healthcare, not just for prostheses and disability devices but also for surgical planning, reconstruction, and bioprinting (Chen and Do, 1, 2). An example of utilizing 3D printing for customization in patient-specific pieces is presented in the article "3D Printing Hip Prostheses Offer Accurate Reconstruction, Stable Fixation, and Functional Recovery for Revision Total Hip Arthroplasty with Complex Acetabular Bone Defect." In this study, printing technology is used to create patient-specific hip prostheses. The customization of each piece depended on the acetabular defect, and a customized piece was printed using 3D printed porous titanium alloy of patients A, B, and C, with different hip defects from failed total hip arthroplasties (Hao et al.). Typically, total hip arthroplasty prostheses use pre-designed metal femoral stems and ceramic or polyethylene cups, depending on patient measurements (Varacallo et al.). Using the pre-designed metal presented problems for patients, as they were not as precise as possible, even if the measurements were done correctly. 3D scanning means that even the most minor details, deviations in shape and measurements are physically recorded.

The process utilized CT scans, construction of each model using digital software, and a 3D printing process to create a functional and customized solution for a very complex and different bone defect of patients A, B, and C, which resulted in their improved physical condition after the procedure (Hao et al. 1287-1289). There have been other applications of 3D printing in healthcare, such as the customization of ear prostheses (Singare et al.), stem cell printing (Tasoglu and Demirci), facial reconstruction (Nguyen et al.), and even the creation of educational and surgical planning models (Chen and Do). 3D printing has great potential due to the variation in materials, methods, usages, and applications. 3D printing is a rapidly advancing tool utilized for precision, customization and personalization, and it is becoming more accessible. FDM and resin printers are available to purchase online and are becoming more inexpensive yearly. Due to its increased usage in healthcare, accessibility for those at home, and extensive customization capabilities, it is appropriate for 3D printing as a method of prototyping in Chapter 6 case studies. Before the case studies are introduced, it is essential to reiterate the importance of the research:

- Personhood and people living well are the driving forces of the research.
- Salutogenesis and design are the lenses through which the problem is being looked at.
- Now, we have discussed 3D printing technology as a method of creation that enables low cost, function, and aesthetic capabilities.

5.6 Discussion

Prostheses and disability devices should shift from a pathogenic focus to a salutogenic focus, as it is an interdisciplinary problem that requires interdisciplinary thinking, methods and tools rather than just a purely pathogenic problem that requires pathogenic solutions. The analysis of companies and products throughout 5.2 and 5.3 shows the importance of choice, function, and aesthetics, yet are potentially not products covered by insurance due to them exceeding "basic functionality." Despite the lower costs of 3D printing, some of these devices are still thousands of dollars. Should it be fair that someone who was born without, or had lost a limb not be able to get the prosthesis they want because it exceeds “basic functionality?” How could it be permissible to reduce someone’s lifestyle, hobbies, aesthetics, and activities to basic functions of grabbing and holding? How could physical, mental, and social well-being be accessible when one is reduced to basic functionality?

Price aside, people may still struggle to access these devices for other reasons. For example, even though these companies collaborate with clinics and clinicians to distribute their products, they still need to be fully integrated into the healthcare system. One must come across the select clinic that is partnered with the company to know about these products. There is also a chance that people may not have the self-efficacy to search out these companies themselves; as the saying goes, "You don't know what you don't know." Some may find that these products ship to somewhere other than their country or that the company does not operate in their country. It is with hope that the case studies in Chapter 6 further the conversation about why these devices are essential, as they focus on the complex person inside the body and help people live life with more ease, ability, and fulfillment. Chapter 6 will create SRRs that utilize a salutogenic orientation, user-centred design thinking, and technology to promote the necessity for these devices and a salutogenic approach in healthcare.

Chapter 6. Case Studies

6.1 Design Intervention

This chapter outlines the design process of four case studies for different hand disability solutions: two prostheses and two disability devices. Each case study will explore and discuss a specific scenario and determine through a salutogenic lens whether the solution concerns function, aesthetics, or both. The case studies aim to improve disability devices and prostheses in areas that have not been focused on (both aesthetically and functionally) and orient the design opportunities and interventions through salutogenic concepts. This means considering the emotions, wants, needs, lifestyle, dreams, fears, and other factors of a complex human being. The design process will follow a 5-stage method outlined in Figure 21 by Rikke Friis Dam and Teo Yu Siang. Many methods differ slightly, though this 5-stage method would be most appropriate due to the "empathy" stage at the beginning, which would overlap concepts from the salutogenic and user-centred approach.

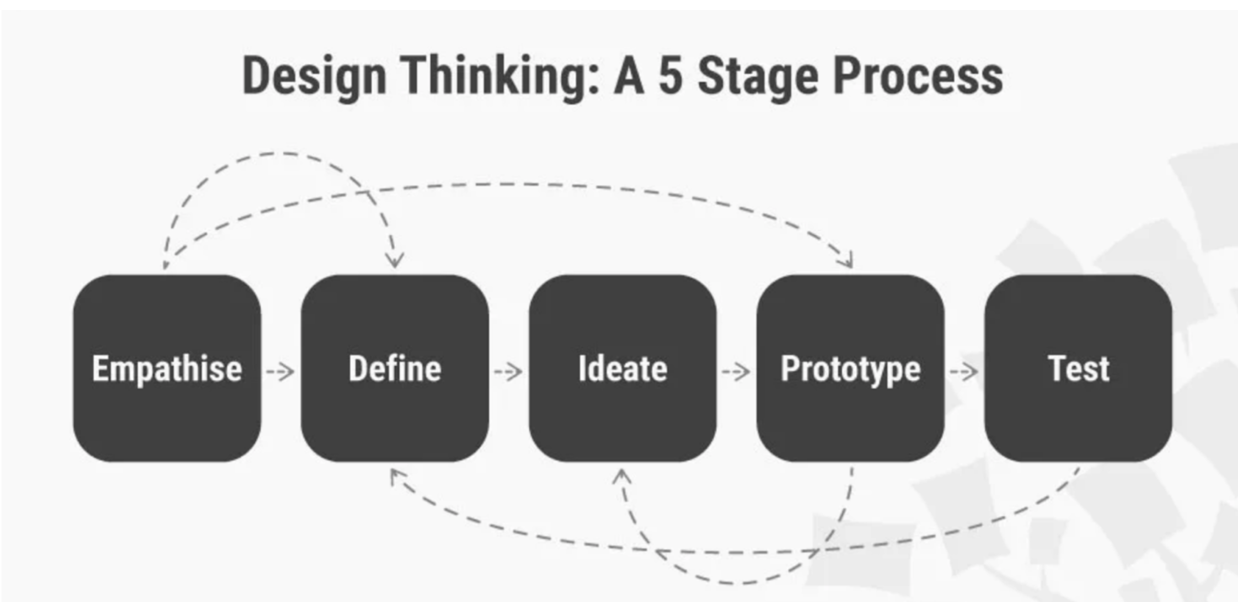


Fig 21. 5 Stage Design Thinking Process (Rikke Friis Dam and Teo Yu Siang)

1. Empathise

The first step will be to Empathise. This initial stage is to "gain an empathetic understanding of the problem you are trying to solve" (Rikke Friis Dam). Empathy is critical to both user-centred design and salutogenesis, as empathizing with the end user is to put them at the center of the solution and understand their needs.

2. Define

The second step is to define the core problems that have been identified (Rikke Friis Dam). Throughout this research, four fundamental problems are identified:

- People with disabilities face a healthcare system that is pathogenically oriented, therefore only focusing on their physical functioning for survival.
- People with disabilities face higher rates of obesity, illnesses and diseases, social stigmas, and mental health problems.
- People with disabilities face higher poverty and unemployment rates and, therefore, do not have the funds to access the devices and aids that they need.
- There are limited choices of prostheses and devices and limited function and aesthetics of those devices.

A general "How might we" statement can be formulated from these identified problems:

"Utilizing a salutogenic approach and user-centered design, how might we create personalized disability devices and prostheses that are low-cost, accessible, and truly personalized to the individual's wants, needs, and lifestyle?"

To define the problem in each case study, one must look at stressors, which Antonovsky also refers to as "psychological pathogens." Just like there are pathogens and physical threats to our health, there are also psychological pathogens (stressors) that cause us stress, frustrations, anxiety, social change, and alienation that can cause us harm (Antonovsky 1979, p. 14). Defining the problem by looking at stressors that cause harm in today's world would be beneficial. It is essential to ask, "What are the emotional and psychological pathogens, or stressors, of 2024?" Topics to explore and contemplate today are body image, the impact of social media, social status, friendships, anxiety, social isolation, identity crisis, etc., which are prevalent in today's society, especially for those who have disabilities.

3. Ideate

After defining the problem, the third stage is ideation, where solutions are identified (Rikke Friis Dam). This stage will involve rough brainstorming, thumbnail sketches (quick, rough sketches), and more refined drawings as ideas evolve. With the designer as a GRR, what kind of SRRs can be created to solve the defined problems and stressors?

4. Prototype

The fourth stage is to bring 2D sketches into the physical realm by prototyping inexpensive physical versions to investigate solutions for the problems identified in the last three stages (Rikke Friis Dam). Prototyping is critical in experimenting with ideas and pinpointing things that are working and not working. In these case studies, 3D modelling and 3D printing will be highly beneficial tools by bringing the sketches/ideas into physical prototypes.

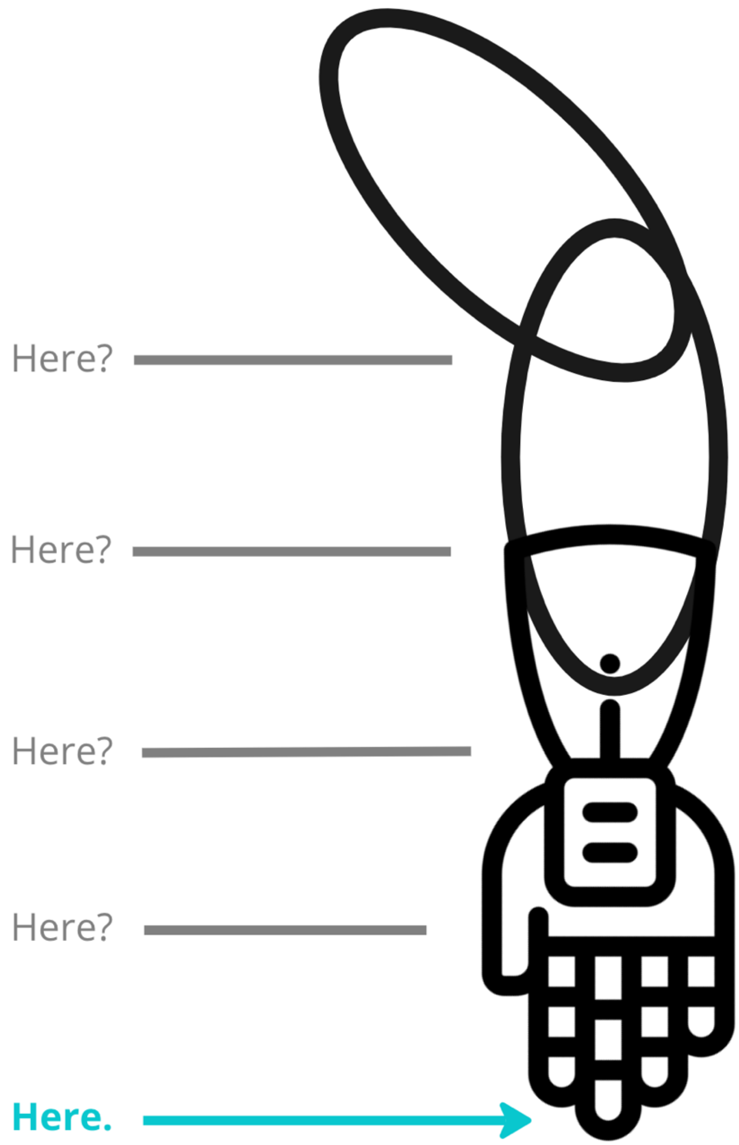
5. Test

The final stage of this model is to test the prototypes to ensure that they work for the intended problem. However, it is essential to note that this model is not linear, meaning that there must be testing with each prototype. This means revisiting the prototyping, ideation, and even defining stages throughout the whole process. With each iteration, the solution becomes more refined. One may find that the ideation and prototyping stages blur or meld together.

Objectives:

- Create functional prostheses and devices that facilitate specific activities or function
- Create aesthetic prostheses that incorporate the wearer's identity and personality
- Utilize 3D printing to emulate 3D printed devices, which are lower-cost and, therefore are more accessible

Utilizing the 5-stage design method, a user-centred approach, and a salutogenic orientation, these case studies aim to create personalized disability and prosthesis devices. This thesis aims to explore questions: how would a hand disability affect one physically and mentally? What would it do to one's sense of self and identity?" Answering these questions requires a look into case studies where industrial designers can help starting right from the fingertips –Literally.



Case Study I: Prosthesis Nails

When introduced to a design problem, designers sometimes have to identify the "lowest hanging fruit," which means "What is the most obvious or simplest problem or solution?" This low-hanging fruit was identified by looking at the hand prosthesis companies (as shown in Chapter 5). The images on the company's websites showed people who appeared on the websites wearing their innovative, 3D-printed prostheses, yet I was still drawn to their other hand. Most of the women in the images had painted nails or long acrylic nails.

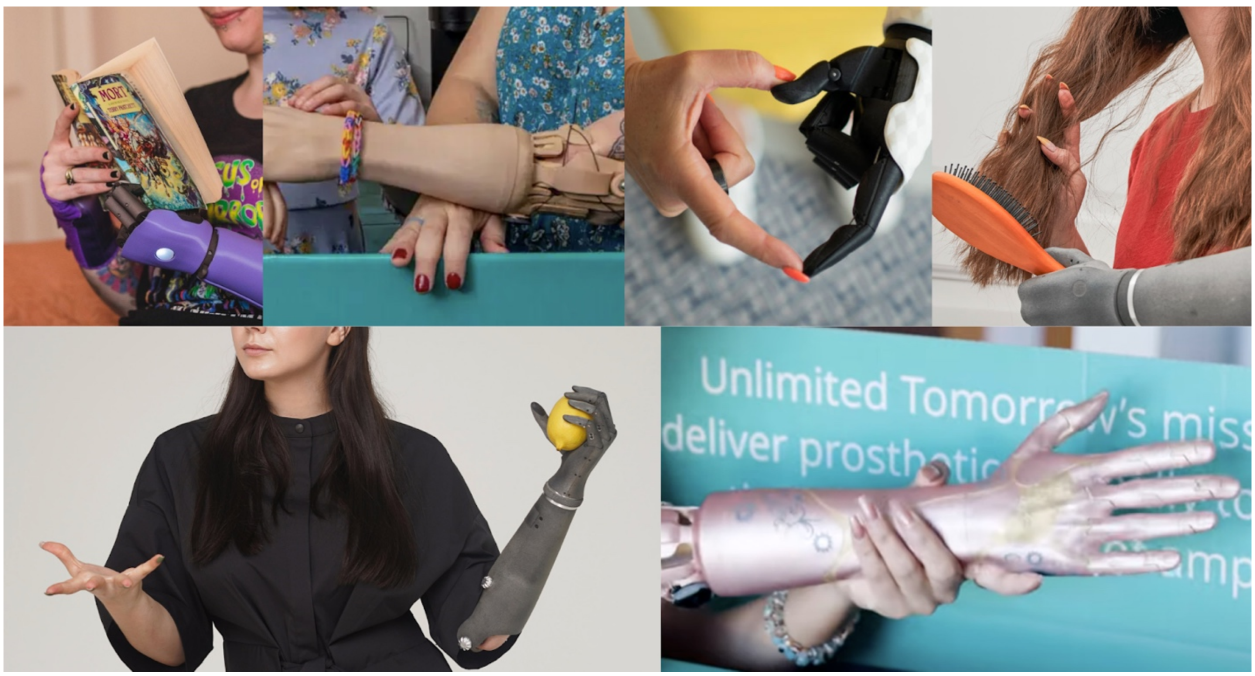


Fig 22. Collage of images from Unlimited Tomorrow, Open Bionics, and Esper Bionics

As shown in Figure 22, all these women have their nails done, yet their prostheses do not reflect the aesthetics of their nails. Unlimited Tomorrow (bottom right picture) shows a slight outline of nail beds due to 3D scanning details, yet the nail beds are shallow, and the nails are fixed to a short length. In a pathogenic-oriented system, this would not be of any concern. However, in a salutogenic-oriented approach, this is something worth investigating.

Empathizing

Why do people paint or get their nails done in a salon? This answer depends on each person. It may be simply because they like the way the nails look. Self-expression through colours and textures, matching particular aesthetics or clothing, dressing up for social events, or even the relaxing experience of getting nails done at a salon could be a simple driving force as to why someone would like their nails done. Whatever the case, it is certainly one that is concerned with aesthetics. Perhaps these aesthetics are linked with a sense of femininity. Not to exclude anyone other than women or imply that anyone else does not get their nails done. However, the majority of people who get acrylic nails are women. While nail painting in men is becoming more popular as a form of self-expression, women most often get acrylics to elongate the nail shape. Today, long nails are considered ‘feminine’ and create a desirable look to the hands, which many women like. It is a small but potentially important consideration for prostheses. Besides Unlimited Tomorrow, where scanning the other hand is part of the process, most prostheses are visually more gender-neutral or masculine in appearance (reference Figure 23).

Fig 23. Examples from Esper Bionics, Open Bionics, and Victoria Hand Project

This masculine or gender-neutral look may not be an issue for some people. But perhaps someone would indeed like to paint their nails or prefer more “feminine” aesthetics and hand shape.

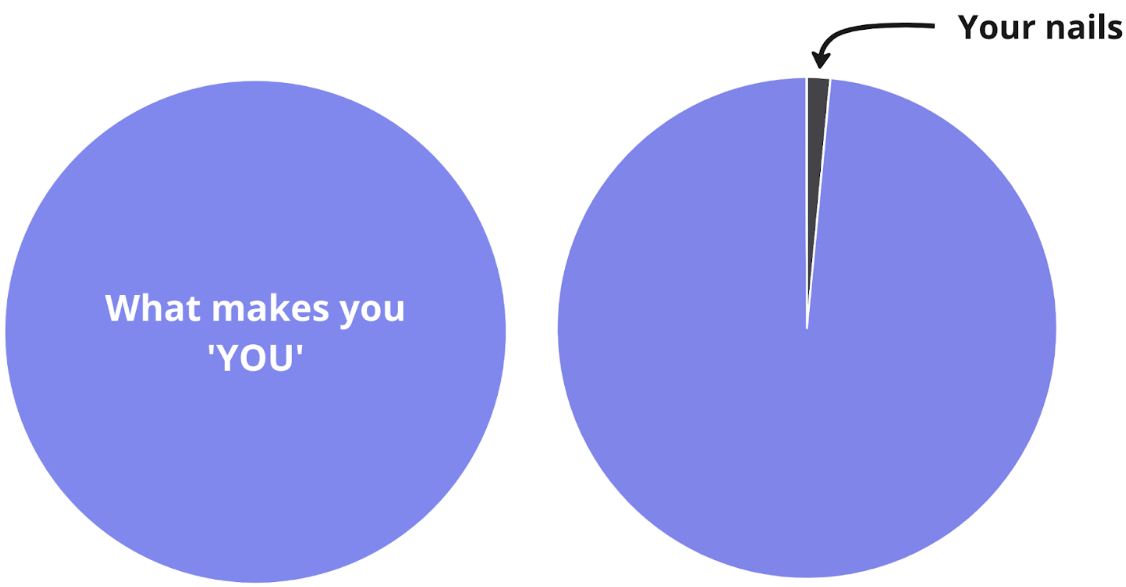


Fig 24. Consider all the things that make you, ‘you’

One could ask, "why would nails make a difference?" This minor consideration of the aesthetics of the hands may be significant to someone. If you imagine your whole self (your interests, needs, wants, dreams, fears, emotions, and lifestyle) in a pie chart, how vital would nails be to you? Perhaps for some people, it is zero, but maybe for someone else, nails are a portion of who they are. You may know someone who has their nails or acrylics done every month, which may be an essential part of their aesthetics, preferences, body image, and idea of social experience or self-care. Reference Figure 24. If nails were important in only a tiny sliver of someone's whole life or sense of self, would it still not be worth exploring? Finding a way for prostheses to incorporate this very small issue could mean a world of difference. This small area could affect how someone sees themselves, feel like they can take part in experiences like everyone else, and feel like they have choices.

Fig 25. Moodboard (Images from classicallycait.com, mersicosmetics.com, nailsbyrikki.s, brushedbyb_, and haily_naillicious_nails)

Define

Prostheses today do not consider the shape of fingers and nails or the ability to paint/do nails on the prostheses. The problem with the fingertips and nails for prostheses is one concerned purely with aesthetics. However, this could be important to one's sense of self and personhood. The stressors or psychological pathogens that people face tied to this aesthetic issue could be:

- Body Image
- Social media influence
- Status
- Feeling "left out"
- Lack of self-expression

These stressors are not detrimental to someone's health but can still be impactful and meaningful. Starting with this minimal intervention from the fingertips, how might we create prostheses that let wearers customize or choose their hand and nail shape?

Ideate & Prototype

If we want to solve the problem of creating hands that look more feminine, it may be a matter of simply rounding out the fingers for a more slender aesthetic. For example, Figure 26 shows the hands of a woman and a man. In this example, the woman's fingers are slender and taper off into sharper points, while the man's fingers are broader and rounded off at the ends. Of course, not everyone's hands follow these shapes, but the difference in shapes could be something to consider when considering prostheses, should this aesthetic difference be significant to someone.

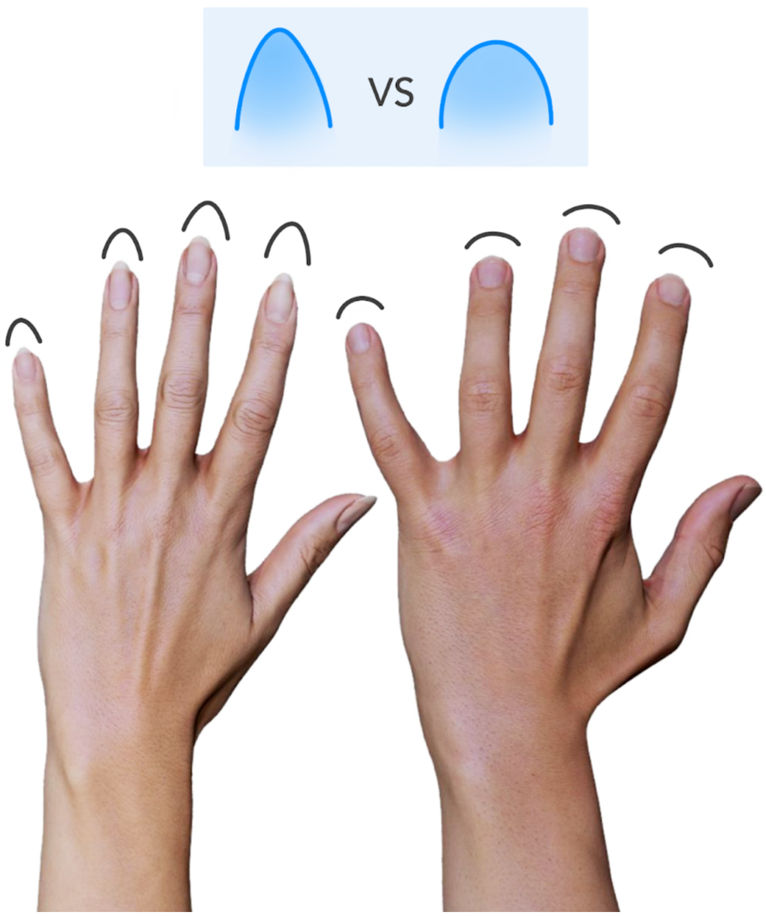


Fig 26. Hand models from 3dscanstore.com

Figure 27 uses Open Bionics' "Hero Arm" as an example of how changes in the fingers change the overall aesthetic of the hand. Simply tapering the fingers into a sharper point makes the overall aesthetics of the hand more feminine. Changes like these would mean the manufacturer must create two sets of fingertips for assembly. This small change does not require new electronics or engineering; it is a slight change in superficial aesthetics. The change could be relatively easy to execute for companies like Open Bionics, which utilizes 3D printing technology.

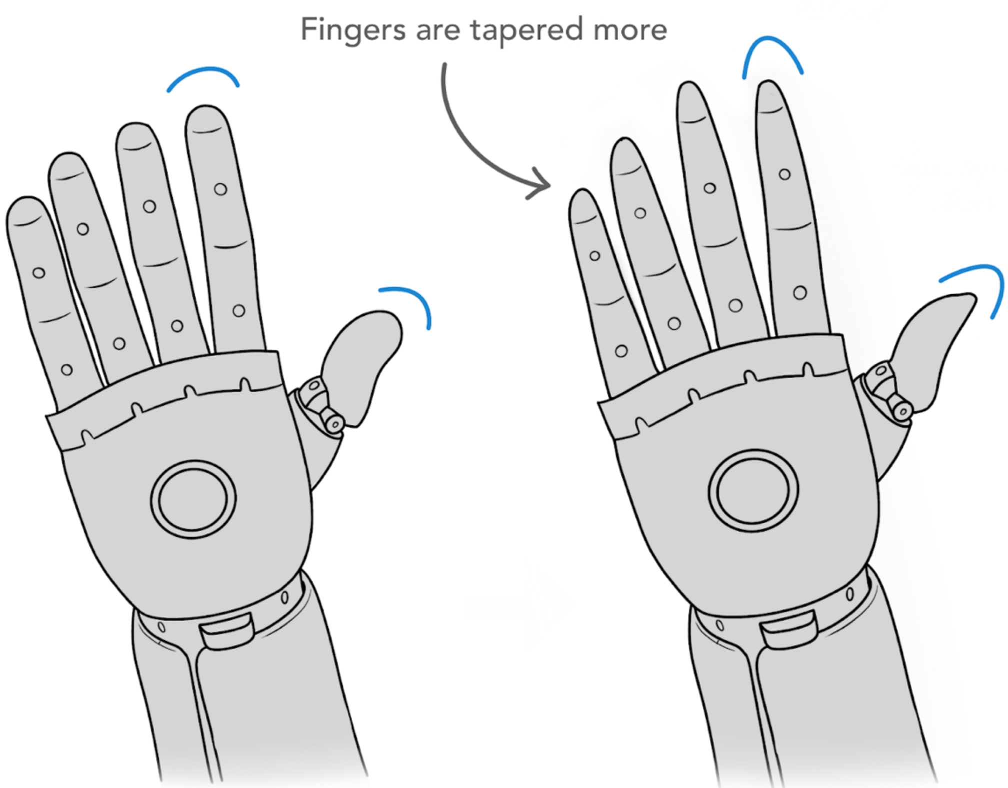


Fig 27. Changes in finger shapes using Open Bionics "Hero Arm" as a model

Another idea referencing a prosthesis model from Unlimited Tomorrow is having swappable finger caps, which could include different nail options and finger shapes (Figure 28). Though having interchangeable fingertips would be helpful for someone wanting long or short nails, it may interfere with the hardware inside the prosthesis. In this scenario, the wearer would choose the type of fingers they want before the company manufactures the prosthesis.

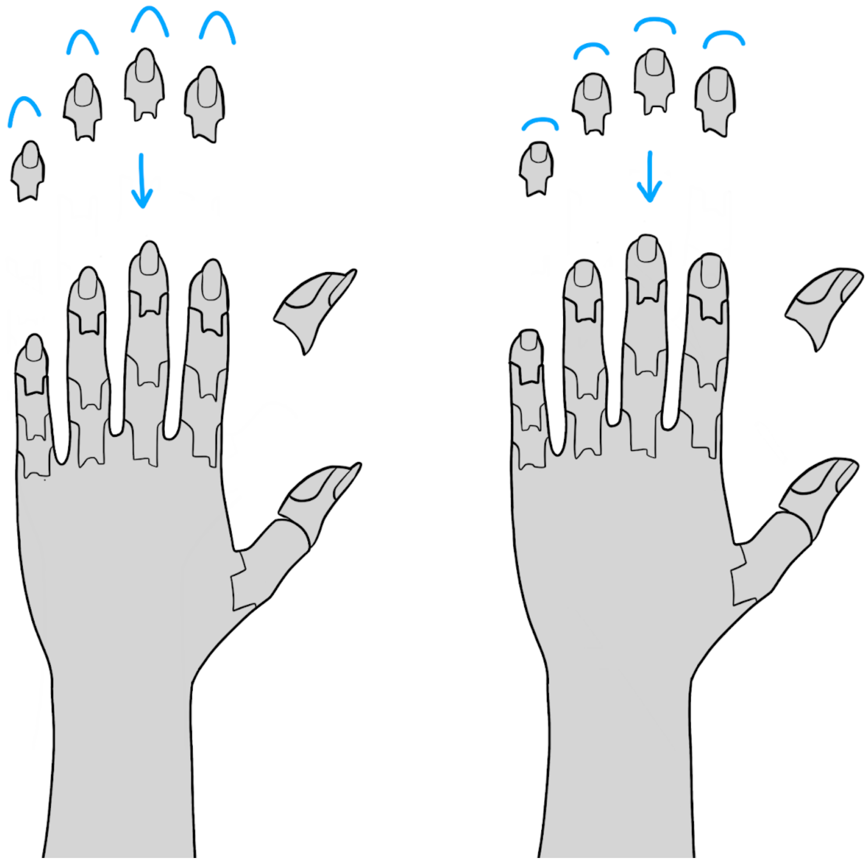


Fig 28. Swappable finger shapes using the Unlimited Tomorrow prosthesis

This small change in finger shape could benefit people, giving them even more control and choice in how they would like their other hand to look. It could also help with overall body image. After all, a prosthesis can be considered an extension of someone's body, so why not have options that suit their needs, wants, and values?

With this first set of ideations, the problem of finger shape is explored. When referencing Figure 22 (collage of pictures showing women and their prostheses) and Figure 25 (mood board of acrylic and painted nails), there is still a need for matching acrylics and colourful nails. Perhaps someone would like a matching set on both hands. I wanted to sketch and test out the "low-hanging fruit" for this first nail ideation. Having interchangeable nails would be an interesting concept since many people can choose different nail shapes at the salon or purchase a variety of press-ons. In this idea, magnets could be used instead of nail glue so that the nails can snap on and off and be easily interchangeable. One magnet sheet would be attached to the nail bed of the prosthesis, while the other magnet would be attached to the nail.

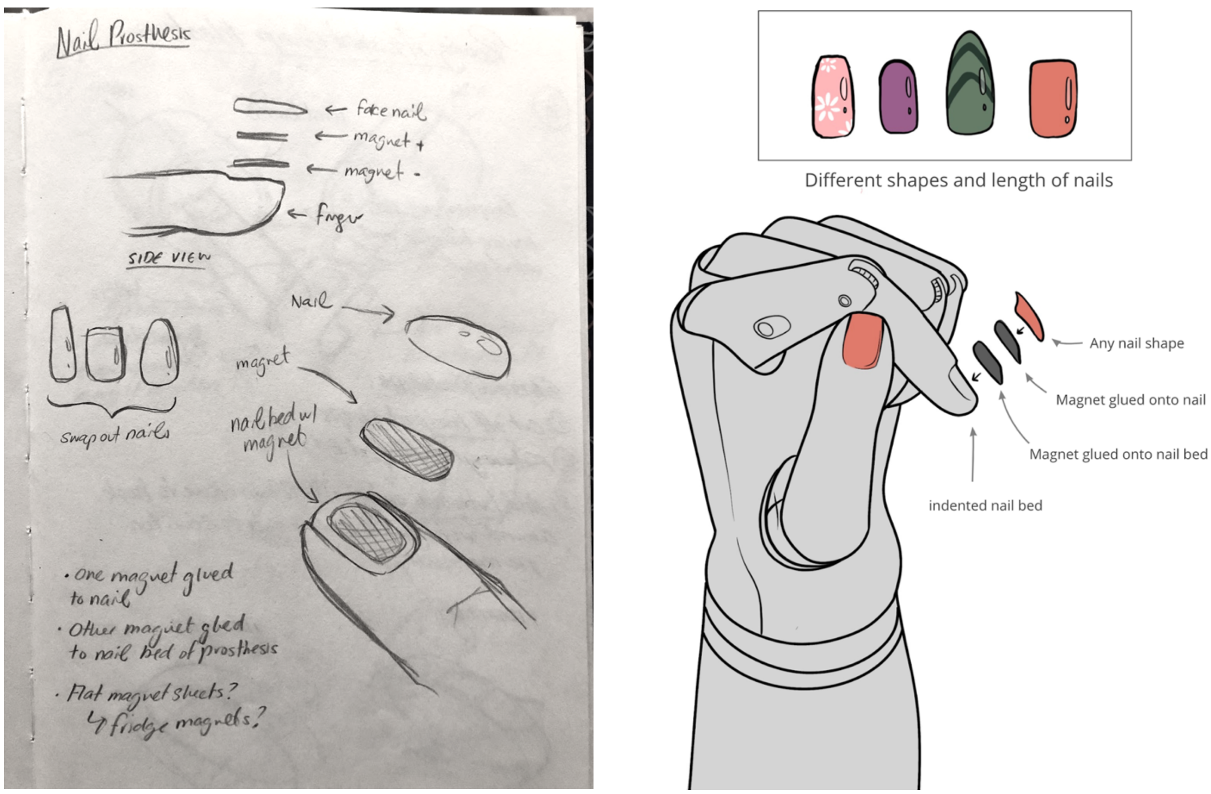


Fig 29. Rough sketch and refined sketch of the magnetic nail bed and nails

This initial idea was a simple and easy first iteration. This solution could allow someone to change nail shape and colour to match the nails, on the other hand, while also taking them off entirely for a "bare" nail bed. I wanted to prototype this idea physically to test the strength of magnets and also see if this idea was a good starting point for different iterations. After ordering flat sheet magnets, I found they were quite weak and would not be strong enough to move forward. Any small amount of force would make the nails fall off. I decided that small cylindrical magnets would work better. To 3D model a hand from scratch would be time-consuming, so I turned to Ultimaker Thingiverse to search for a basic model. Thingiverse is an open-source website that allows users to upload and download 3D modelling and STL files. I found a model called "Jointed Hand," which was uploaded by BQ Educacion (Thingiverse.com Jointed hand by bqeducacion). This model was a great starting point, as each finger joint was moveable and reminiscent of the realism that Unlimited Tomorrow prostheses mimicked. I uploaded the STL file of "Jointed Hand" into Rhinoceros (Rhino) 6, a 3D modelling software, and used the boolean difference tool to cut out a hole in each nail bed for the magnet.

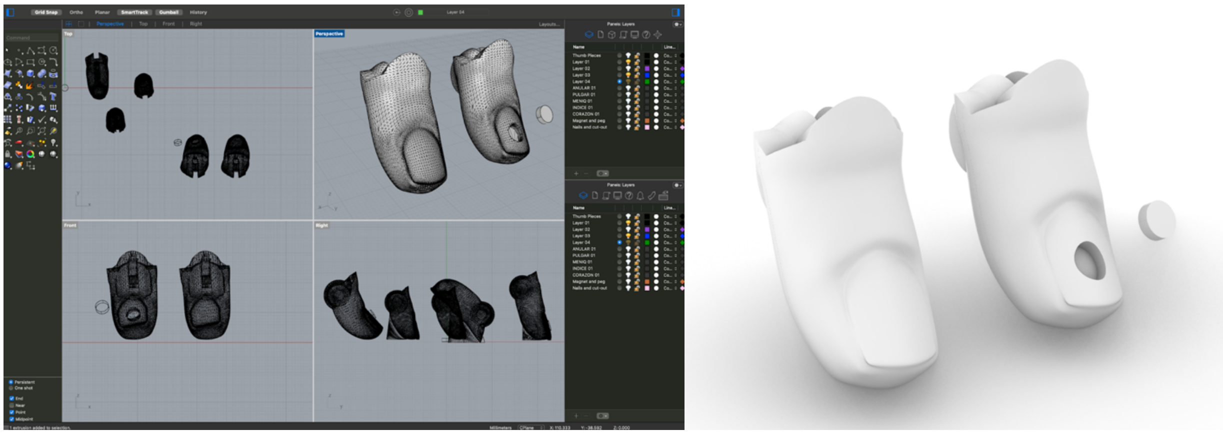


Fig 30. Boolean Difference of the magnet in Rhino 6

Each piece of the Jointed Hand model was exported as an STL and put through a slicing program called PrusaSlicer. I placed settings on infill (20%), layer height (0.10), perimeters, raft, and nozzle size (0.5mm) so that the pieces would be printed quickly, use less material, but still be somewhat high quality. The nozzle was kept at 0.5mm to keep the printing time low. Since these were the first set of prototypes, extremely high quality with a smaller nozzle was unnecessary. Infill was set at 20% in a grid pattern to keep the material usage and time low, as durability and strength were not a concern for this prototype. All files were exported to G-code and printed on an Ender 3 Pro with black PLA. The smallest size file (file of third knuckle pinky) took 1 hour and 13 minutes to print, while the most extensive file (the palm) took 18 hours and 19 minutes.

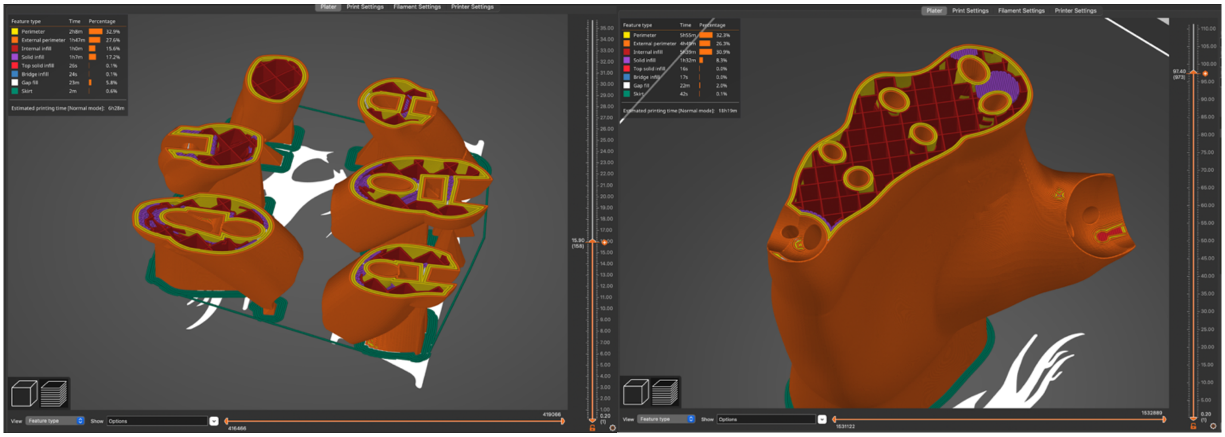


Fig 31. Jointed Hand files in PrusaSlicer

Once all the pieces were printed, the support material was removed, and they were roughly sanded. Using elastic rope, I strung all the pieces together by feeding the rope through the holes in each of the joints and coming back around at the fingertips.

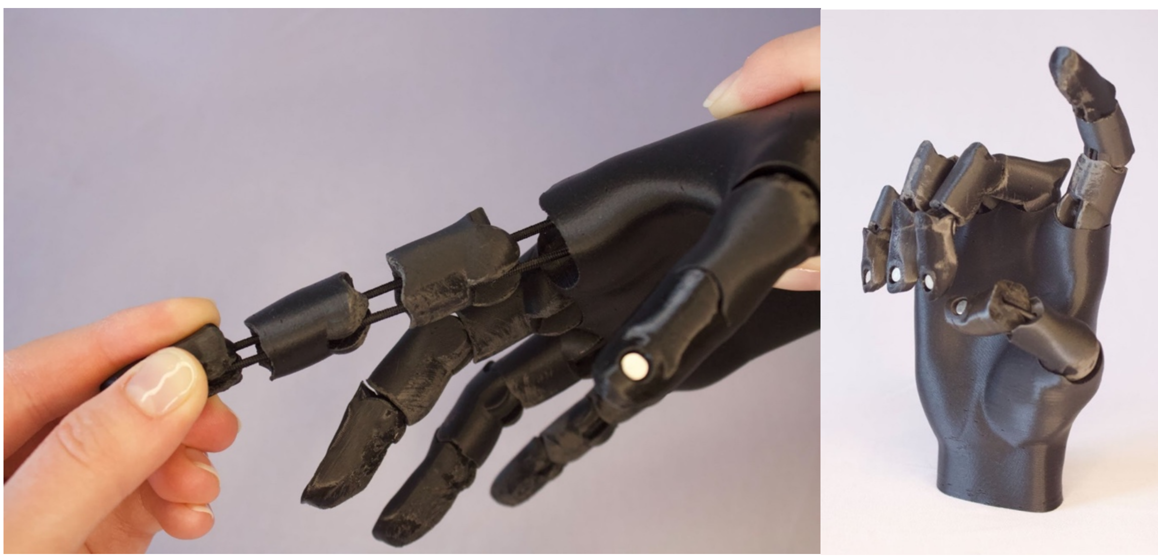


Fig 32. 3D print of Jointed Hand Model in PLA

The rope was tied and cut at the bottom of the hand. This elastic rope allowed the fingers to move around in different positions while holding tension. 5x3 mm magnets were glued into the holes of the nail beds. Another set of magnets were glued onto different colours and shapes of drugstore plastic press-on nails.

Fig 33. Close-up of magnetic finger and magnetic nail

The magnets were strong enough that the nails snapped onto the prosthesis nail beds without any issues. The different nail shapes, lengths, and colours changed the aesthetics of the hand. However, in a real scenario, someone would have these on during the day or on a night out, and the nails would most likely not stay on if they accidentally brushed up or knocked against something.

Fig 34. Different set of nails

In the next ideation, there would have to be a component that would keep the nails from falling off the nailbed –a system that holds down the top of the nail yet still allows for the nails to be interchangeable. The following iteration sketch has a sliding and 'locking' system that allows for the nail to slide into the nail bed under two rails, which would prevent the nail from being knocked off, and the 'lock' would come from a magnet component on the nailbed and the nail itself.

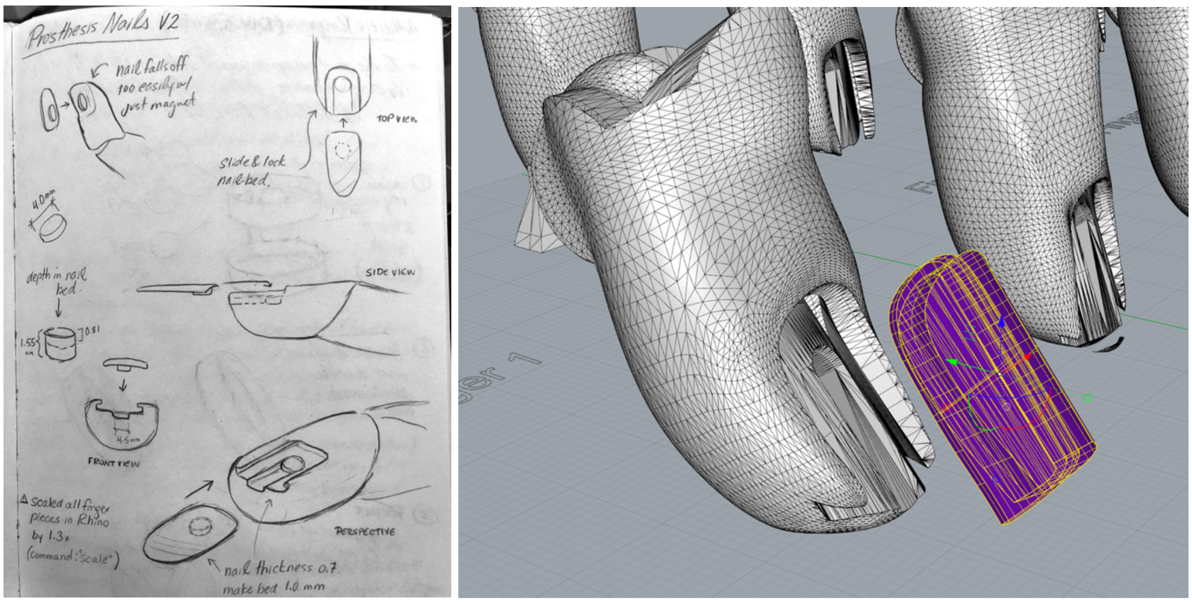


Fig 35. Rough sketch and Rhino model of nail slot.

In Rhino, I created a cutting object (purple object in Figure 35) that included a shape for the nail to show through and a larger shape underneath that would create a slot for the nail to slide into. The cutting object was boolean-differenced from each nail bed. A 'divot' was also boolean-differenced for the magnet to sit into the slot of the nail bed. One finger was printed in PLA on an Ender 3 Pro to roughly test out the validity of the idea. The rough prototype showed that FDM printing with PLA was not the best material choice or method for this ideation, as the nail slot had fragile and sharp corners that could easily break with too much use. However, the slot with the magnet worked, as the nail did not fly off or fall out of the nail bed.

Fig 36. Nail Slot prototype printed from PLA

This rough prototype showed some substantiality to the iteration yet would not hold up due to the material choice. This idea would be best prototyped with a more robust material, allowing more intricate details. Resin is a good option because it is durable and allows for a higher print resolution. Resin prints use Stereolithography (SLA) printing, where a laser selectively hardens the photosensitive resin. SLA leaves no visible layer lines, allowing for higher accuracy and detailed prints. This printing method is necessary for this prototype, as the slots and edges of the nail beds need to be well-defined for the nail to slide in seamlessly. Elko Engineering Garage at the University of Alberta offers printing services with a wide range of plastics and resins. The files were submitted to Elko and printed with standard resin in black on a Formlabs Form 3+ SLA.

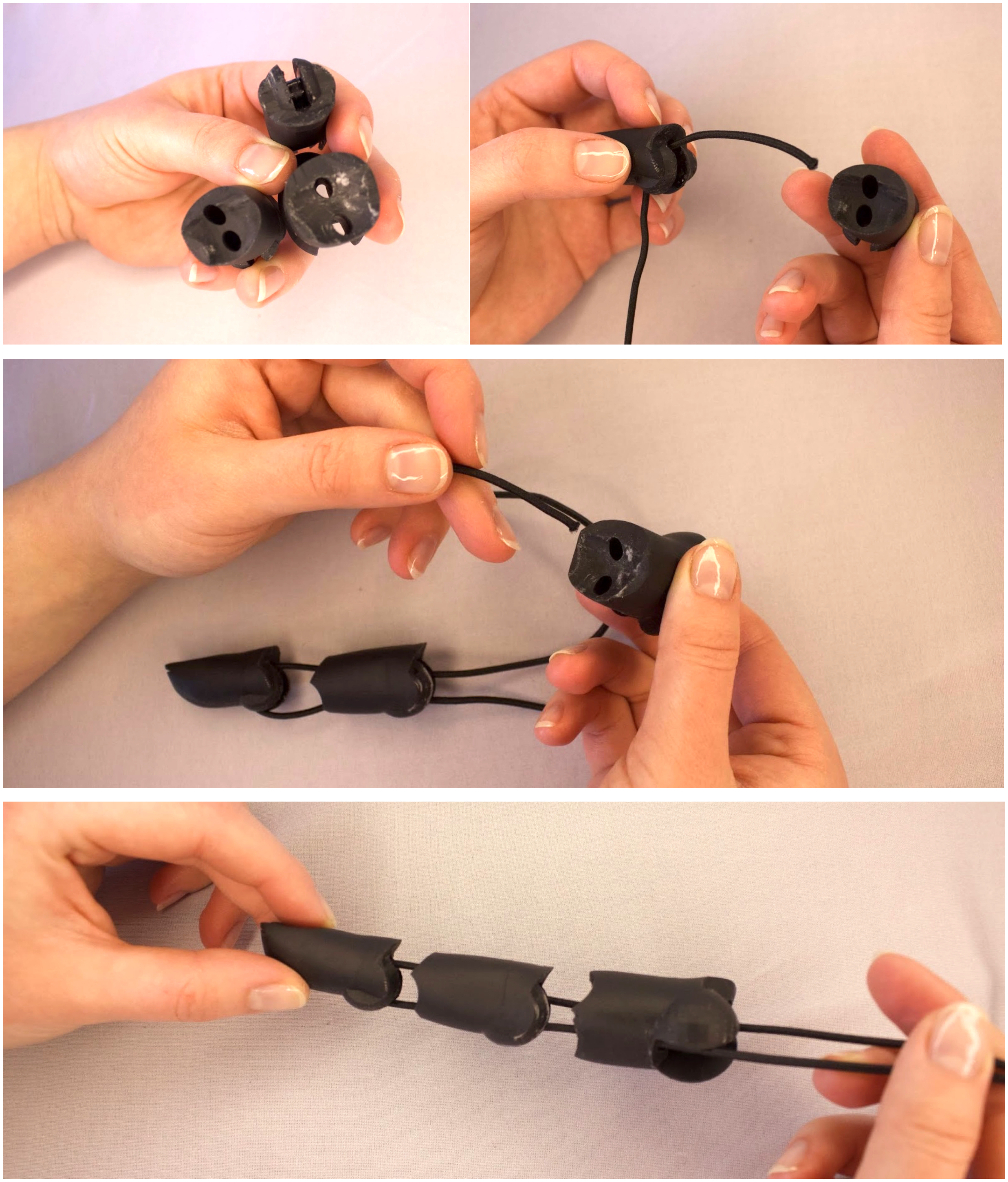


Fig 37. Process of building Jointed Hand for the slotted nail prototype. Printed in resin.

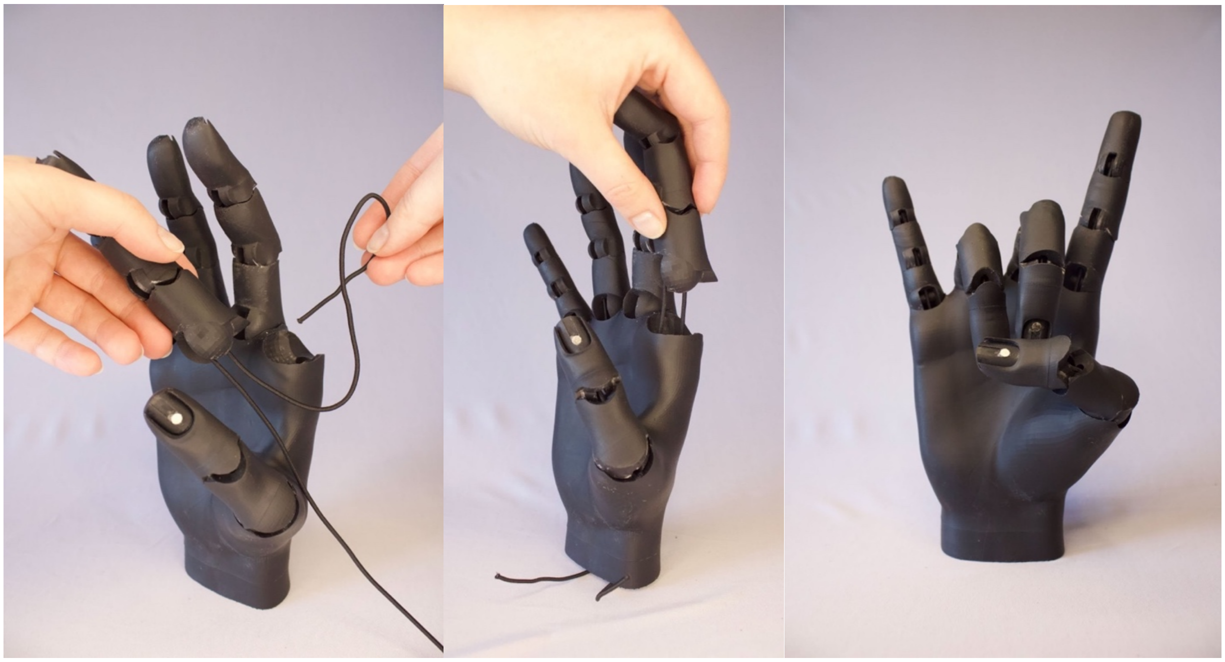


Fig 38. Finished prototype with slotted nails

The outcome of the prints was high resolution and far more durable than PLA. Stringing the pieces together was the same process as the first prototype using elastic rope. Despite being relatively thin, the edges of the nail beds were robust, and the nails slid into the slot and held in place nicely. 5x3mm magnets were glued to the base of the nail beds and different styles of plastic nails.

Fig 39. Close-ups of Slotted Nail prosthesis

Fig 40. Details of the prototype

The nails did not fall out and held in place tightly, yet were easy to switch out. The interchangeable nails displayed different aesthetic options depending on the selected nail set. However, if this design solution were integrated into a real prosthesis, the wearer would have to purchase nails and glue on a magnet system themselves. Alternatively, the prosthesis company would have to manufacture compatible nail sets and sell them to the wearers. This could be an issue, as the user should not expect to be left to their own devices to buy magnets and figure out how to glue them properly, nor should they have to pay an extra charge for each set of nails that the prosthesis company sells. Overall, the design of this iteration works well, but there are barriers for its implementation in a real-life scenario.

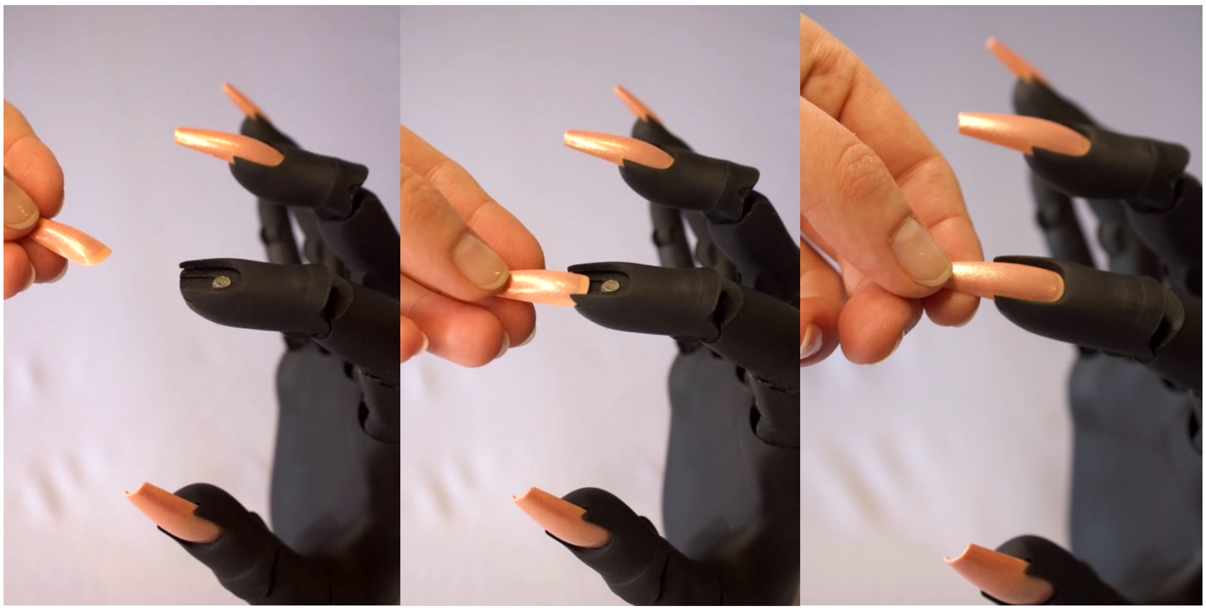


Fig 41. Sliding the nails into the slots of the finger tips

Fig 42. Showing different shapes and colours of nails on the prototype

The third iteration of prosthesis nails referenced the first ideas with the swappable fingertips. In this iteration, rather than the whole knuckle being interchangeable, the last knuckle would be sliced in half, allowing different fingertips to be made without interfering with inside hardware.

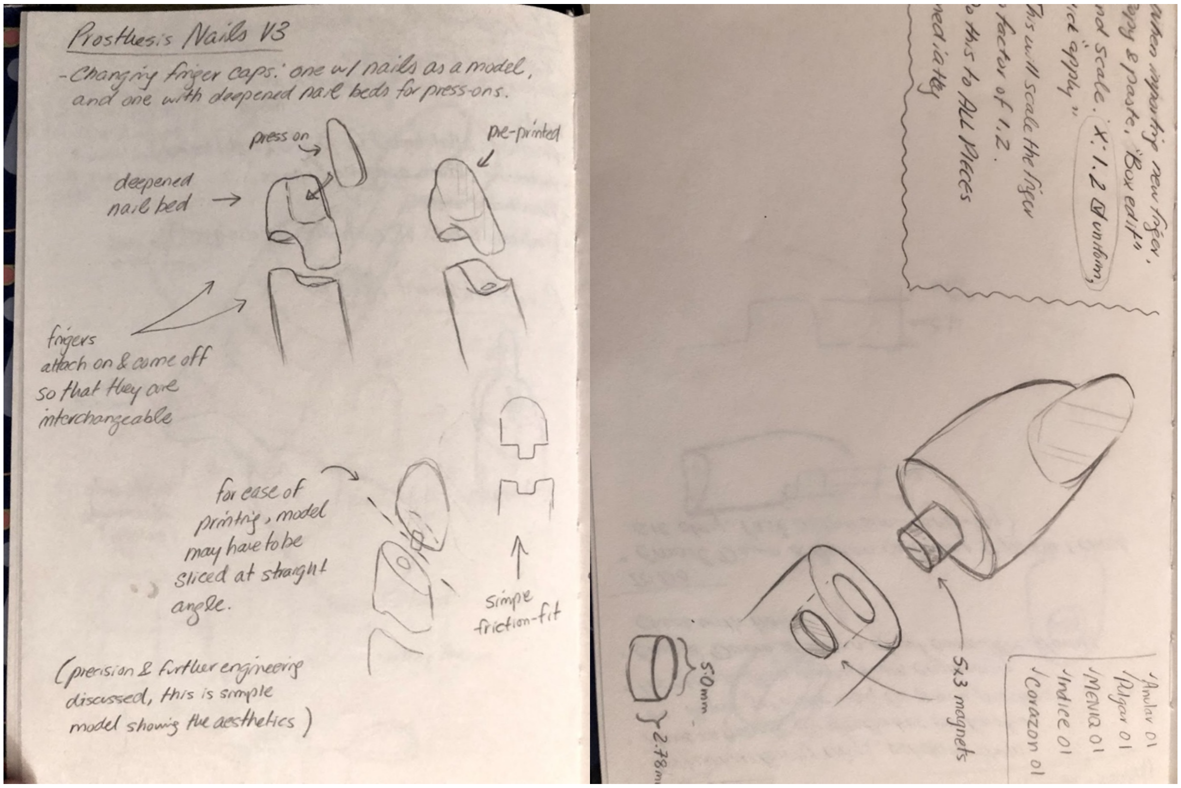


Fig 43. Sketches of version 3

Each finger was made with three finger caps for three different options of nails: a long nail, a short nail, and an indented nail bed. The indented nail bed would allow for adequate space for users to apply press-on nails, where they could pick the length, shape, and colours of these nails. The other two caps would have the nails printed into them. The three nail variations were created in Rhino by slicing the third knuckle of each finger in half. Two new nails, short and long, were modelled and boolean-unioned (joined) onto two finger caps. One nail was boolean-differenced to create the nail bed. Each knuckle and finger cap had a ‘positive’ and ‘negative’ end where two magnets would go. The tips would friction fit and stay ‘locked’ with a magnet. In a real scenario where these prostheses are manufactured, a more robust system could be engineered to ensure that the fingers have a more sophisticated locking system. Due to limitations, this prototype will stay away from the engineering and hardware portion of prostheses.

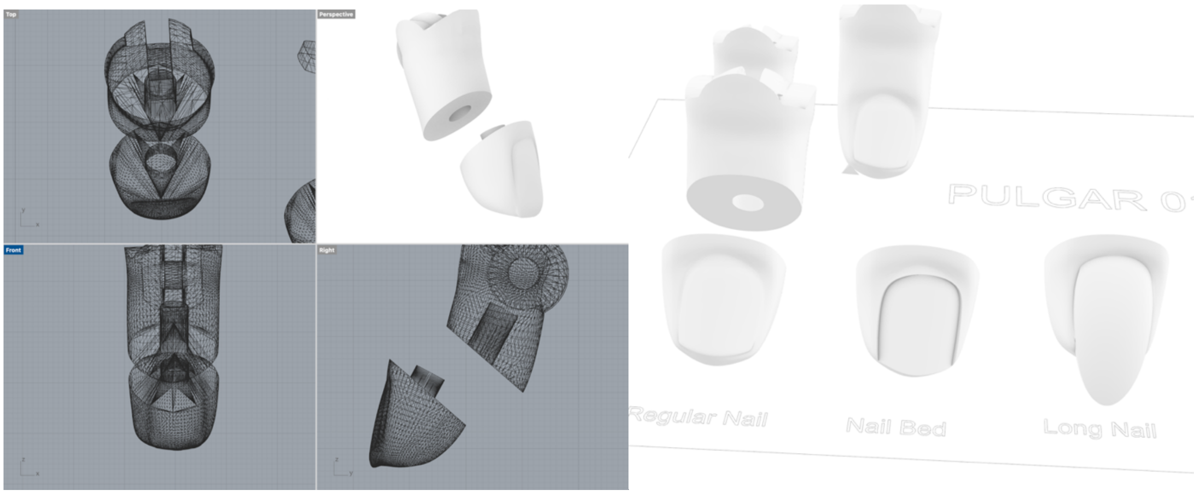


Fig 44. Version 3 Rhino models showing different sets of finger caps

One knuckle with each fingertip –a short nail, a long nail, and a nail bed –was printed in PLA as a rough prototype. The magnets were very strong, and the pieces fit together perfectly. This rough prototype showed that the swappable pieces could be an option for someone who wants their prosthesis to have different nails.

Fig 45. 3D printed PLA prototype of finger caps

The files were then sent to the Elko Engineering Garage to print in standard black resin. The outcome of the prints were very high resolution, and each piece friction-fit together nicely. Magnets were glued onto each finger cap and knuckle and were strong enough withstand external force (like knocking against the nail/finger or tapping the finger on a surface). It takes a considerable amount of force to take the caps off of each finger.

Fig 46. Close-ups of magnets inside the last knuckle

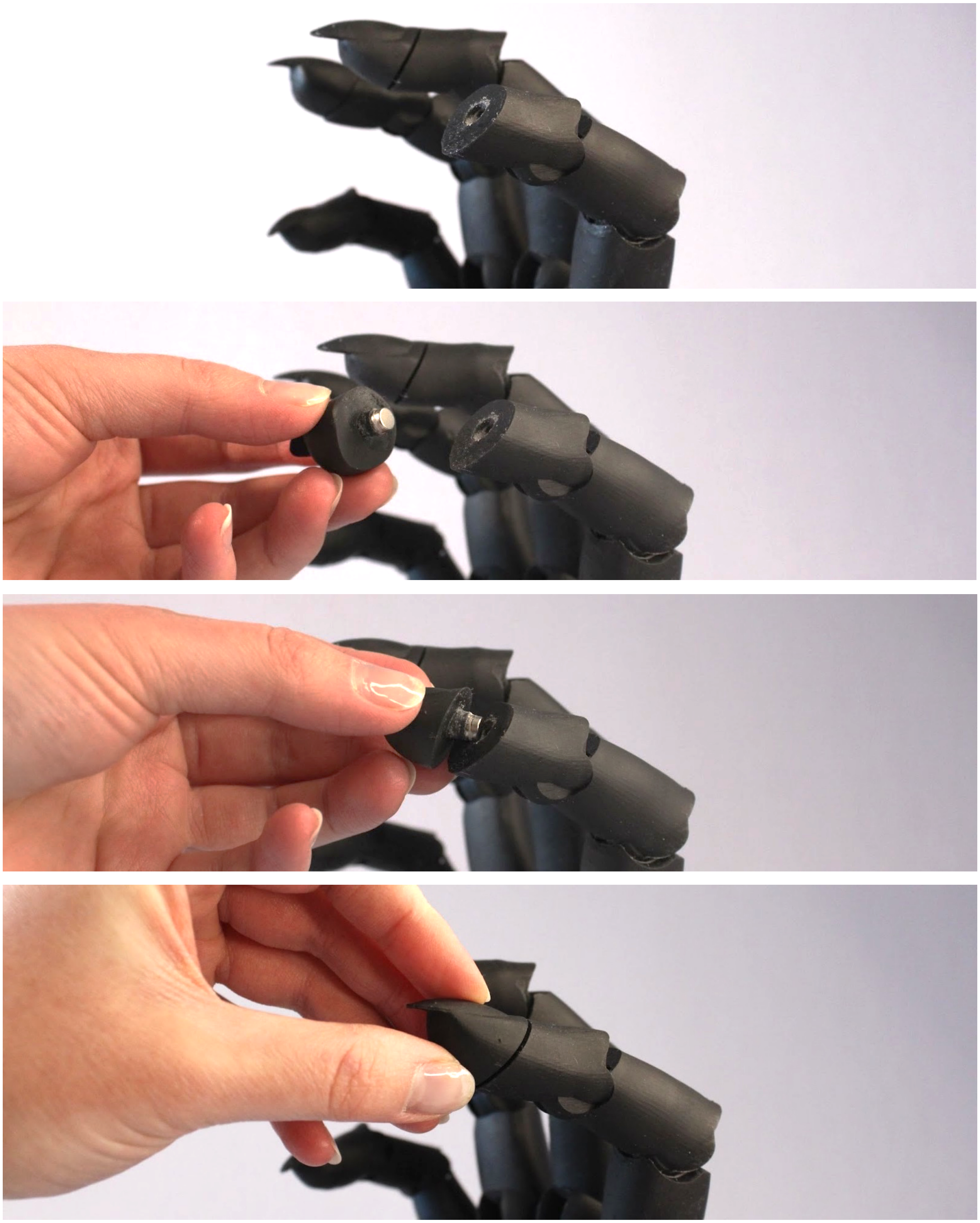


Fig 47. Demonstration of the magnetic finger caps

Fig 48. Prototype with long nail caps and close-up of nail caps

I placed drug store sticker adhesives onto the caps with the indented nail beds and then pressed on a plastic nail. The adhesive is very strong, and the nail does not move or budge any more than it would for a natural nail bed. Though strong, the nails are easy to take off with some prying around the edges, and the adhesive does not damage the resin underneath. The wearer of this prosthesis could purchase drugstore press-on nails and apply them with this prototype, allowing for accessible personalization.

Fig 49. Process of putting drug store gel nails on the ‘nail bed’ cap

Fig 50. Process continued

This prototype was the most robust out of all the iterations and showed a good variety of options from which the wearers could choose. A significant component of this design is that the wearer can use regular nail adhesives and drugstore press-on nails. In a hypothetical scenario, this prosthesis may help with body image, self-expression, and a sense of inclusion and choice for those with a hand prosthesis.

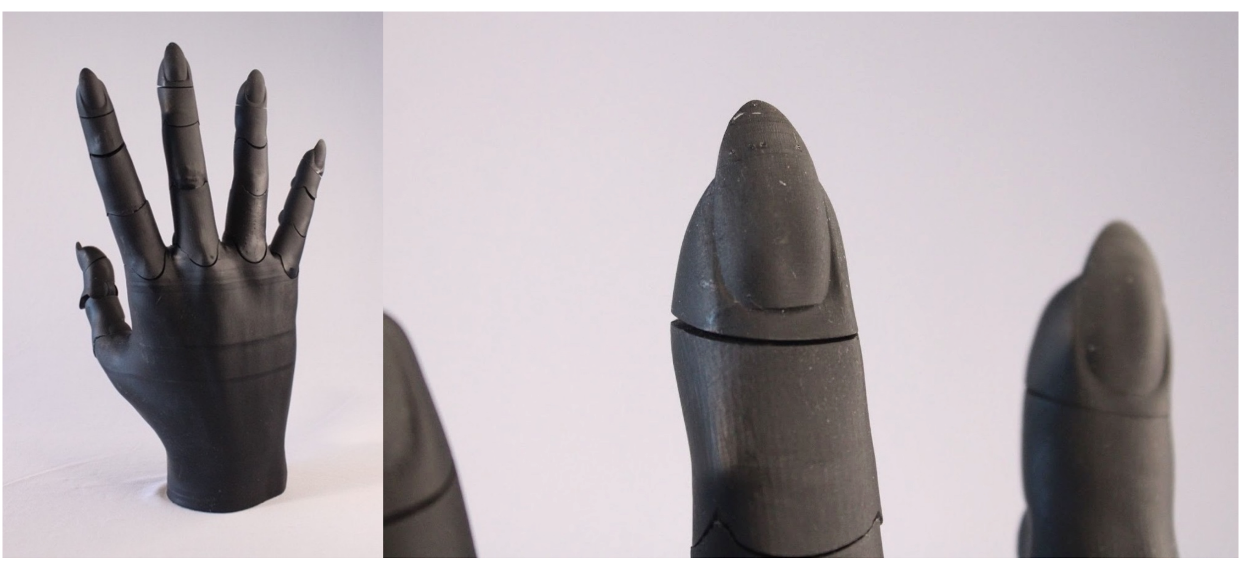


Fig 51. Close-up of caps with long nails

Fig 52. Close-up of caps with short nails

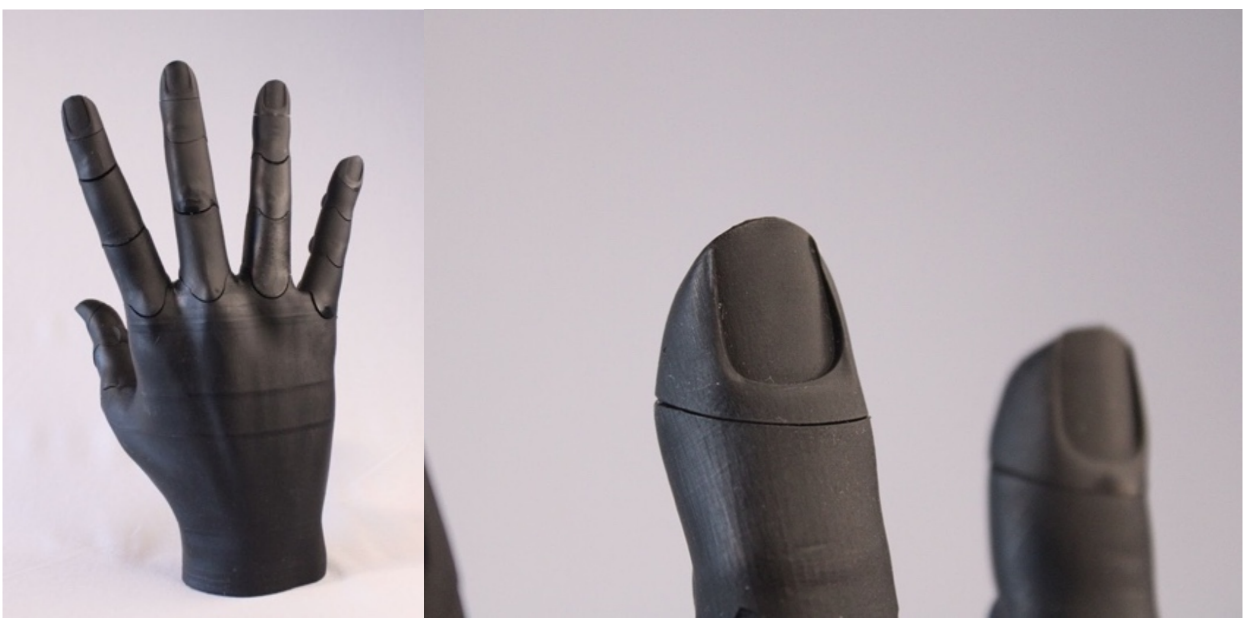


Fig 53. Close-up of caps with indented nail bed

Fig 54. All three versions of the hand prototypes for nail prostheses

Fig 55. All three versions posed

Takeaways

Further research and ideation on this prototype are needed. There would need to be prototyping with a model that closer resembles a hand prosthesis to make sure that some of the proposed solutions, like interchangeable caps and nails, do not interfere with the hardware, electronics, or structural integrity of the prosthesis. However, the solutions with already-fabricated nails could be a very simple solution. This case study exemplifies that simply having nails can be easily incorporated into prosthesis designs yet have a valuable and emotional impact. Self-esteem, identity, body image, and social perception tie directly to mental well-being. As Professor Kenneth R. Fox states, "Self-esteem is important when studying mental wellbeing because of (a) its close association with emotional stability and adjustment, (b) low self-esteem features in many forms of mental illness and (c) low self-esteem is associated with poor health behaviours" (Fox, 1999, p. 413). Even in the salutogenic model, emotional GRRs such as ego-identity and self-esteem are powerful tools to overcome stressors such as body image and negative social interaction. Overcoming these small stressors can increase one's SOC. As also mentioned in Chapter 3, the lack of GRRs can also cause stress and lead to tension. Creating a device (SRR) that can help someone simply take part in small activities like going to a nail salon, decorating nails to match an outfit, and wearing a nail shape that suits the wearer, can provide someone with GRRs to overcome situations of stress such as poor body image, social perception, and self-esteem. Orienting the problem to salutogenesis rather than pathogenesis, exposes small areas of opportunity that would otherwise remain irrelevant.

Case Study II: Piano Prosthesis

After focusing solely on improving a minor detail for aesthetics in prostheses, I shifted the focus to functionality. I wanted to explore how we may enhance prostheses concerned with ability and lifestyle. The commercially available prostheses are either passive or have open-and-close grip functions for the hand. More sophisticated and innovative bionic prostheses, such as Open Bionics, Esper Bionics, and Unlimited Tomorrow, allow for more functionality with six different hand/finger positions. However, more than this will be needed to give someone the ability to regain a specific function they once knew or desired. The added function also facilitates fostering new skills for someone born with a congenital limb difference. Fillauer TRS does a better job of developing function-specific prosthesis attachments than any other company researched. Their products help people return to the activities, sports, and lifestyle they once enjoyed and promote trying new activities for those with congenital limb differences. Although they offer many attachments, many hobbies and activities still need to be included.

Empathize

When considering the topic of this thesis on prostheses and disability devices, I could not help but think about my own mortality and fragility as a human being. What would it mean for me to become ill or face tragedy in such a way that I could not use my hands as I do now? What would I be losing? What hobbies, interests, and activities would be forever changed, and what would this do to me? Of course, these questions are contemplated from a sense of ignorance, as I do not know what people with congenital limb differences and amputations genuinely feel or go through. Nor is it to be patronizing or mock them. However, I argue it is a fair question for anyone to reflect. When one can reflect, feel empathy, and put themselves in the -albeit limited - perspective of others, the importance of issues becomes more apparent. Should issues only be important when we experience them ourselves? Why should we disregard things only until they come to fruition? After all, no one is exempt from tragedy or illness.

Self-reflection could result in further discussion and advocation for why disability devices and prostheses should be improved and innovated. Subconsciously thinking about what a disability of the hand would mean to me, I instantly thought about the piano. I have played piano for nearly eighteen years, took eight years of lessons and exams, and consider it a large part of my life in self-expression, hobbies, upbringing, and overall identity. I thought about the "life-shattering" effect it would have on me if I was physically unable to play. For those who experienced amputations, why should someone never be able to partake in their hobbies again due to an amputation? Moreover, why should someone miss out on learning instruments and developing hobbies just because they were born without a limb?

Define

Fillauer TRS has attachments for a guitar pick, violin bow, and drumsticks but nothing for the piano. While researching to find prostheses for the piano, I stumbled upon a 2018 YouTube video titled "Musician plays the piano with a prosthetic hand" ("Musician plays the piano with a prosthetic hand") that shows a man doing just that. The video description states that the man is a musician who lost his arm in an accident. The Georgia Institute of Technology developed the prosthesis, which detects fine muscle movement with an ultrasound sensor. These small muscle signals determine which finger moves, and the finger then responds by pushing downwards on the key.

Fig 56. Screen shots from the YouTube video “Musician plays the piano with a prosthetic hand”

The prosthesis allows individuals to play the piano again. However, there are still limitations to this prosthesis. Firstly, the response time for the prosthesis is very slow. The video shows the man playing a simple melody very slowly, which is probably different from the speed at which he is used to playing, considering he was a pianist before he lost his arm in the accident. Secondly, this prosthesis could be a solution for the right hand, but perhaps not for the left hand. In higher-than-beginner-level piano, the right hand typically plays the melody, while the left hand plays arpeggios, chords, and notes that require more than one note at a time. While the right hand also plays multiple notes, it can “get away” with single-note melodies. Many pieces are written with single notes in the right hand, while the left hand supplements the music with full chords. Finally, there is no sideways movement of the fingers, which is very important, especially for the left hand. This sprawling motion of the fingers allows octaves (range of 8 notes), chords, and progressions to be plaid simultaneously and quickly.

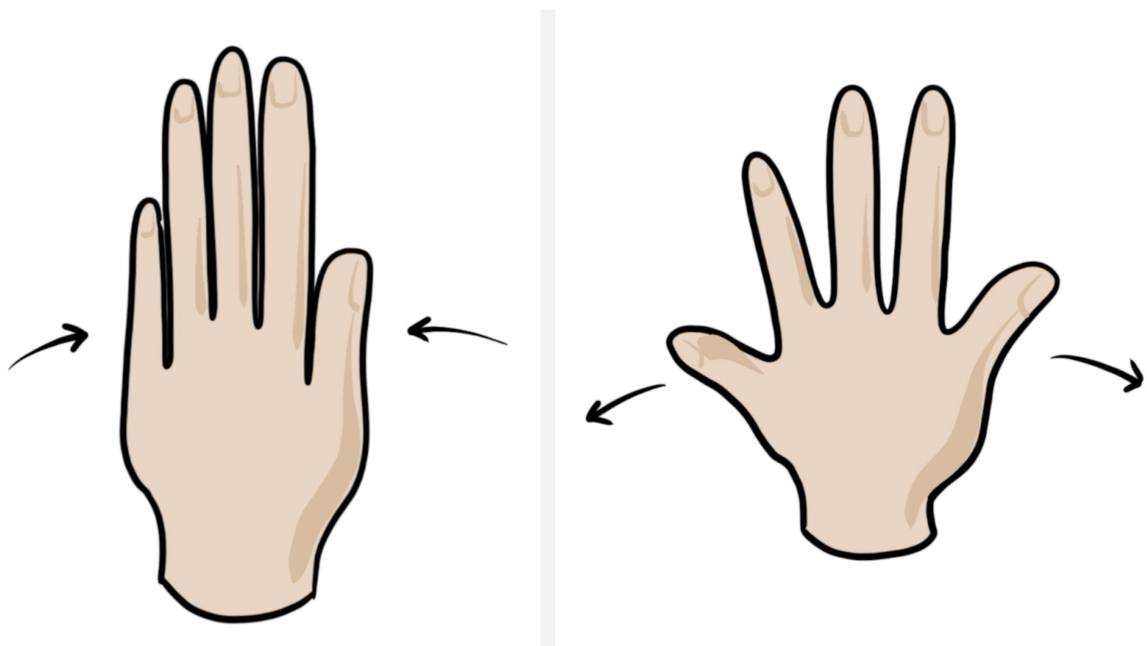


Fig 57. Prostheses can’t spread fingers outwards

While the prosthesis from the Georgia Institute of Technology provides some ability, it is slow due to its moving parts and response time, may not be adequate for the left hand in playing octaves or chords, and cannot create enough down-force to play with dynamics. The video shows the prosthesis used on a keyboard, which usually has very touch-sensitive keys (very easy to push down). This prosthesis is also not widely accessible yet due to all the technology involved with it not being broadly available. The stressors involved with being unable to participate in activities such as playing the piano can be devastating to someone who once played before. The potential stressors involved with this scenario are:

- Feeling "left out"
- Lack of self-expression
- Feeling like they "lost" an ability (for those who lost a limb)
- Feeling like they do not have an opportunity to pick up this new skill (those with congenital limb differences)
- Job loss, if playing piano was part of someone's income
- Sense of identity or lifestyle may be lost

The problem of the lack of prostheses that can facilitate playing the piano concerns function and physical ability, though it can affect the mind significantly. If researchers are creating intricate prostheses that can play single-note melodies, "how might we create a hand prosthesis of the left hand that is fast, reliable, and plays more than one note?"

Ideate and Prototype

I was drawn to the left hand to figure out how someone with a limb difference in the hand could play the piano beyond a single-note melody. The Georgia Institute of Technology prosthesis is a very complex system with many moving parts. Watching the YouTube video of the musician using the hand showed that because there were so many pieces, hardware, and parts to the prosthesis, it looked very fragile. The hand looks very delicate, and therefore, it might be unable to withstand much force from the movement of the fingers and the downforce of the rest of the hand to push down keys. The more hardware and moving parts, the less durable, the slower, and perhaps even more fragile the prosthesis becomes.

For this reason, I wanted the left hand piano prosthesis to have as few moving parts as possible to be easily used with appropriate force (for dynamics and expression) and withstand jumping from key to key. The easiest and lowest-hanging fruit is to look at the importance of octaves. Octaves are a stretch of 8 notes, where the first note is the same as the eighth note. For example, the note/key C has seven keys above or below it, which is another C. This is an octave. Octaves are commonly written in music. Though there are two of the same notes, they can create a more lush-sounding bass than one note on its own. With octaves in the left hand and a melody line in the right hand, the song played can still feel full-sounding and complete, despite missing some of the notes.

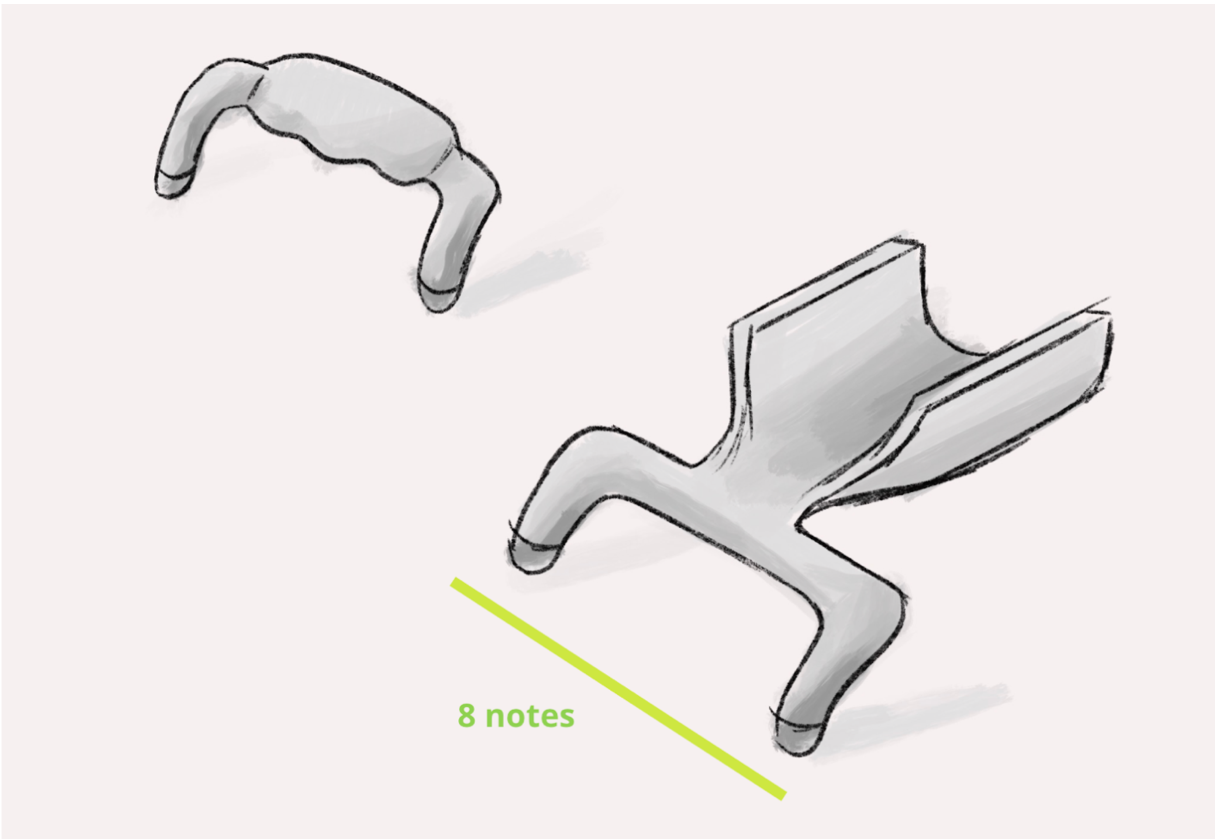


Fig 58. Very rough drawing of test prototype

The first step was to prototype a device to show that a song can be played with only octaves in the left hand and still sound like a full and lush song. The catch: I had to create something to show how to do this without the direct use of my fingers. To show that this would work, I would have to build an apparatus with two "fingers" an octave apart, somewhere to put my hand on or in it, and inhibit using my fingers. To do this, I measured out the width of the white keys on the piano and modelled a device with two "pegs" that were an octave apart. A model of two pegs and a wrist piece was built in Rhino and 3D printed with PLA. I added two rings on each peg where my fingers would rest. These rings kept my fingers stuck in place, so I could not move them out of habit.

The prototype pieces were secured together by electrical tape, and the ends of the pegs were covered in hot glue so that the hard PLA did not hit the keys directly. The hot glue softened the impact. I used an elastic hair tie or a wristband to keep the prototype attached to my wrist. This prototype was extremely rough and arbitrary. Pieces of electrical tape hold it together. Though unruly to the eye, it was a good place to start. There is a saying in design that goes, "Invest a little, learn a lot." I invested little time in this prototype's aesthetics, labour, and material but learned a lot.

Fig 59. PLA print of rough test prototype

Once the prototype was all glued and taped together, I practiced with it on the piano. It was a bizarre sensation of trying to press down keys that my fingers were not feeling and not reaching for. After several hours of practicing, I got used to jumping from key to key and pressing notes without direct physiological feedback. The songs were easy to play after a few days of practicing. I could play most of the songs before, except with all the notes in the left hand modified to bass octaves. The classical ragtime song, Maple Leaf Rag, sounded almost identical to the original, even though the left hand was only octaves.

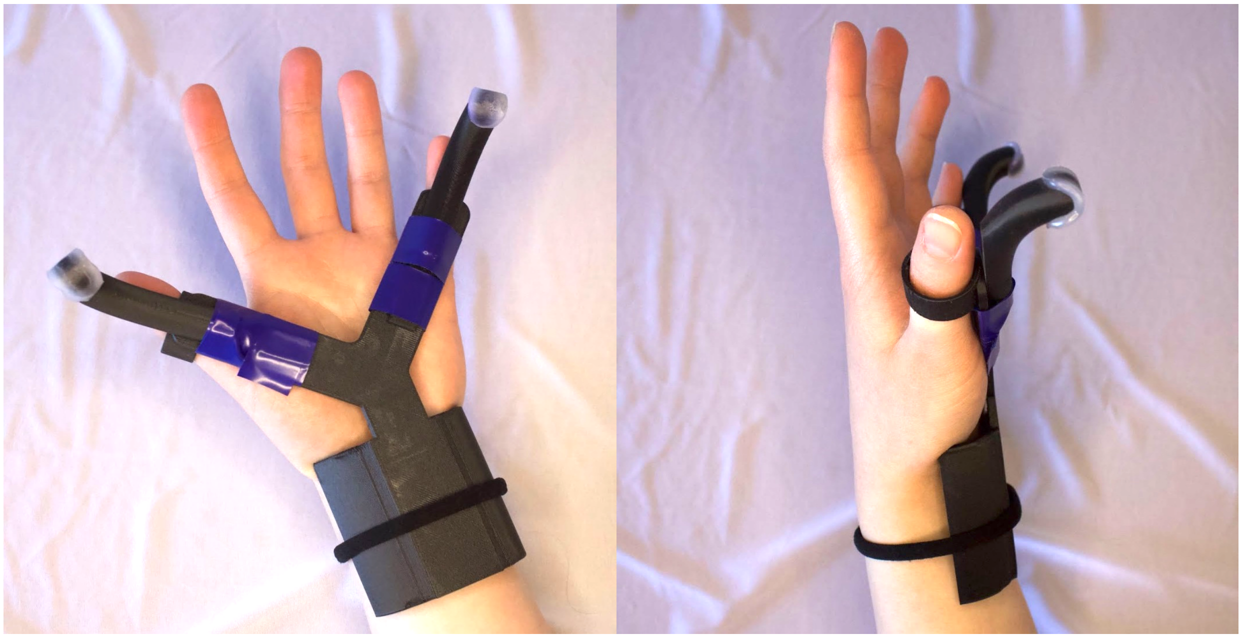


Fig 60. Rough prototype fixed to hand

Fig 61. Rough prototype used on a piano

Fig 62. Different angles showing the rough prototype on the piano

Fig 63. Screenshot from video of me playing Maple Leaf Rag with the rough prototype

After testing out this initial prototype and successfully playing a song, I determined that this model was an adequate starting point. The next step was to refine it, make it more robust, and, of course, more aesthetically pleasing. However, the main concern with this prosthesis is that it works for the intended purpose. The essential physical components are that the two 'fingers,' or pegs, that push down the notes at an octave, that the pieces were connected, and that this device is attached to the wrist of a prosthesis socket. There was also debate about whether the device should mimic realism. Should it look like a realistic hand with fingers outstretched, reaching for the octave? Does it matter that it is a hand at all? If this were the case, the fingers that were not in use would get in the way or block the vision of the other keys. However, if we removed those three middle fingers, would someone want a realistic thumb and pinky device without the other fingers? In this case, considering the uncanny valley would also be beneficial. The uncanny valley is a phenomenon where images or objects that are realistically human in resemblance look aesthetically pleasing up until a certain point where the human likeness evokes uneasiness or creepiness (Vukadinović et al., 365). Human-like, barely-human, but not 'quite' human causes discomfort and attaches feelings of 'strangeness' to the object or image.

Looking at existing products, like Fillauer TRS, we see attachments that look like tools rather than anything close to a realistic hand. The ability to participate in activities or complete tasks correctly and easily trumps any concern with realistic aesthetics. It is not to say that aesthetics are not necessary. In this case, for functionality, it would be appropriate to utilize the design principle of "form follows function," which means that the aesthetics should reflect the function of the design and not be the driving force of the design.

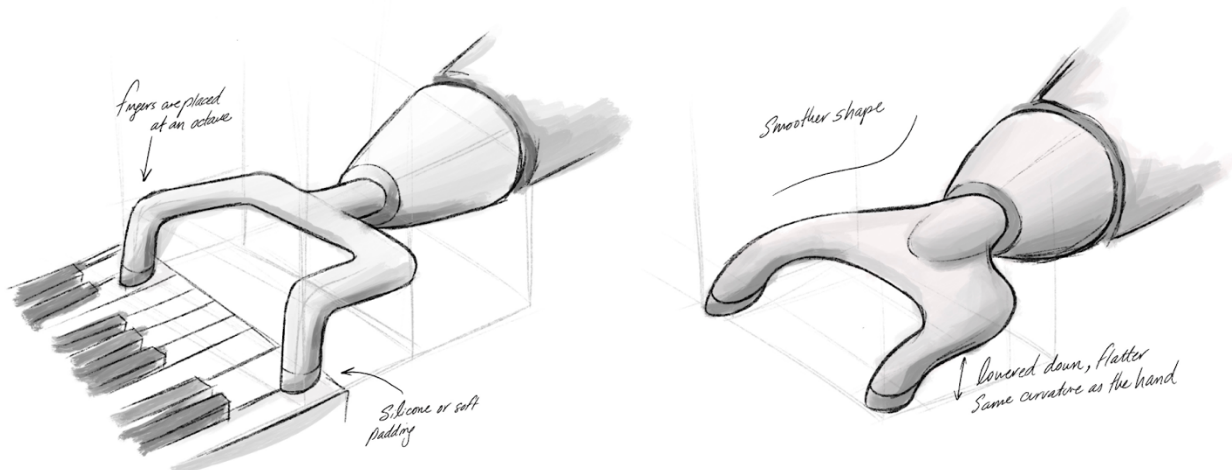


Fig 64. Rough sketches of piano prosthesis

Figure 64 (above) is an example of the aesthetics following the function. For this design, we simply needed two pegs attached in the middle and a clear view of the keys in the middle, and it must be attached to the wrist of the socket. The sketch on the right is refined by adding more soft and curved contours, smoothing harsh edges, and providing a more streamlined look.

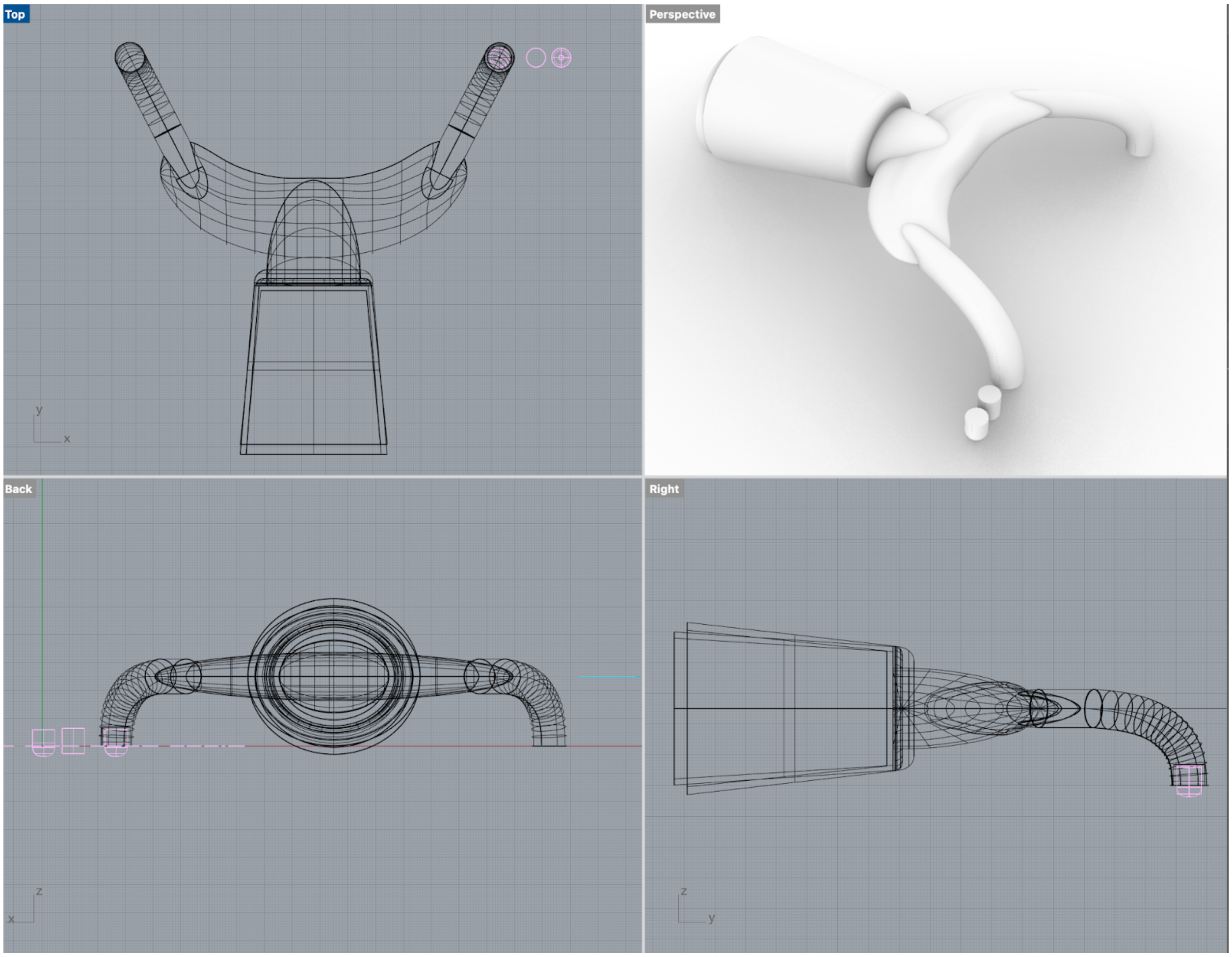


Fig 65. Piano prosthesis model in Rhino 6

The final form of the prototype was a simple wrist piece with a smooth "palm" where the pegs would attach at each end at an angle. Two holes were boolean-differenced at the bottom of each peg. I printed out two small dowels, covered them with a small sheet of silicone, and then inserted them into the holes of the pegs. These silicone pads would create more grip on the keys and have a softer impact to prevent the PLA and keys from coming in contact directly, which produced a disruptive clicking sound.

Fig 66. Close-ups of the piano prosthesis printed from PLA

Fig 67. PLA Piano Prosthesis on piano

Fig 68. Close-up of where the pegs insert into the prosthesis. Shows the thin edges and sharp corners prone to breakage.

The prototype was simple, which allowed function to be the most critical component of the design. The pegs perfectly line up at an octave and allow for full views of the keys underneath it. The only downside of this prototype was that the pieces were printed individually. This meant that the sharp edges of the "palm," where the peg holes are, were fragile and very sharp. It caused the edges to break easily when the pegs were friction-fitted into the holes. However, resin could be a better option as it prints a more robust structure, and fine details are not as fragile as with PLA. The piano prostheses files were submitted to the Elko Engineering Garage to print in standard black resin. This time, the bass clef symbol was modelled and boolean-differenced in Rhino on the wrist of the prosthesis. For piano, the bass clef represents notes lower on the scale, usually played with the left hand.

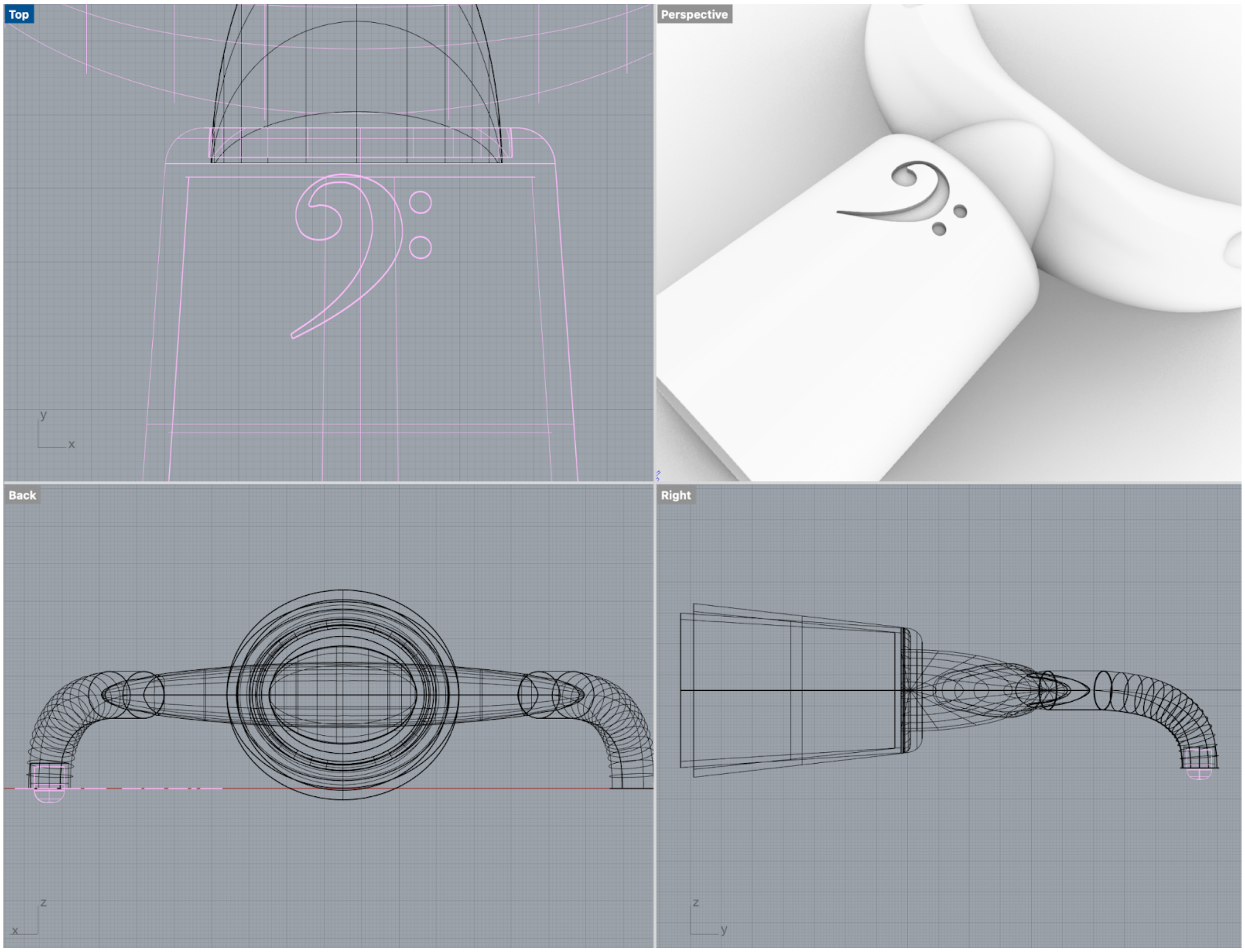


Fig 69. Piano Prosthesis in Rhino with extra details

The resin print turned out refined and very smooth. All of the pieces fit together perfectly, and there was no breakage on the sharp corners of the palm. As for the bottom of the pegs, I modelled small mushroom-shaped pads that would fit into the holes. I wanted these pads to be soft and squishy to emulate natural skin and tissue. The Elko Engineering Garage had a material option of Flexible 80A, a resin with a shore hardness of 80A. The shore hardness scale is a scale that measures rubber materials based on how hard or soft they are. 80A on a shore hardness scale is similar to the hardness of a car tire. I submitted those models in that material to Elko to see if they would be soft enough for the intended use of the prototype.

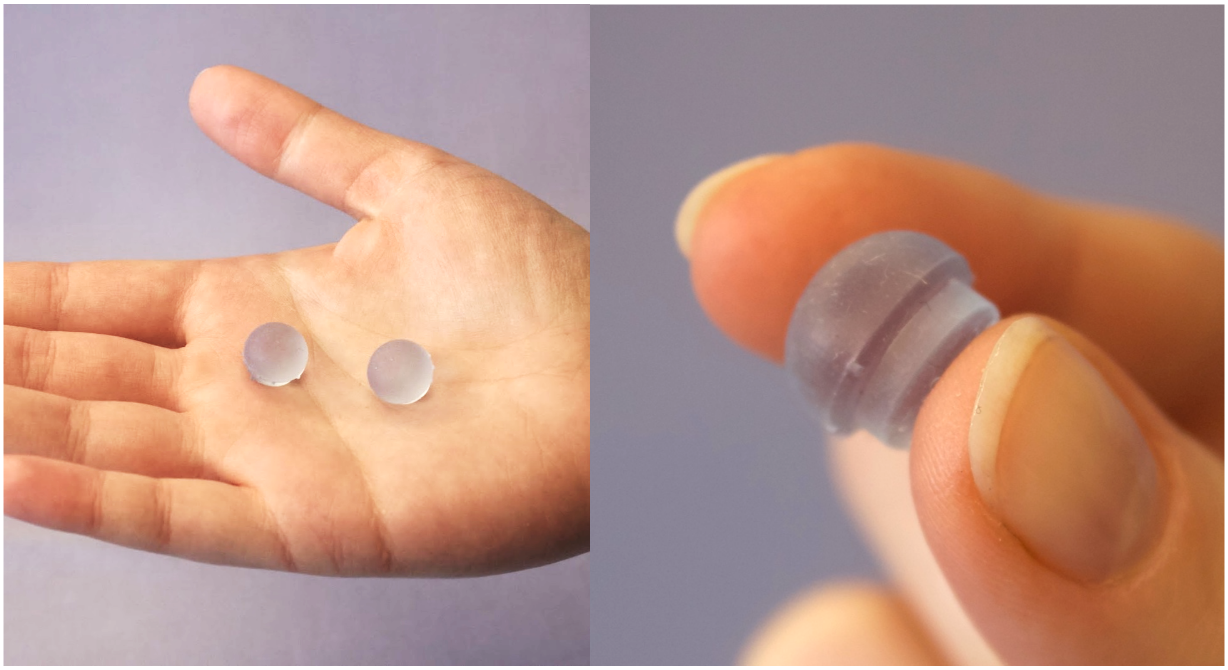


Fig 70. Pads printed out of Flexible 80A

The pads were printed successfully, though the material needed to be much softer. 80A was too hard for the intended use, as it still created a clanking noise when tapped on the surface of the keys. For the next iteration, the shore hardness had to be much softer. I ordered a silicone mould-making kit online, which is said to have a shore hardness of 15A on the product packaging. 15A on the shore hardness scale is softer than rubber bands, which would have a subdued impact on a hard surface compared to 80A. I modelled a mould in Rhino with registration points so that the moulds would fit snugly. The silicone resin was poured at a 1:1 ratio into the moulds and left to cure for 24 hours. When released from the mould, the pads were soft and squishy and did not create noise when tapped on a surface. They were similar to the bounce and 'give' that fingertips have. These silicone pads were glued to the ends of the pegs.

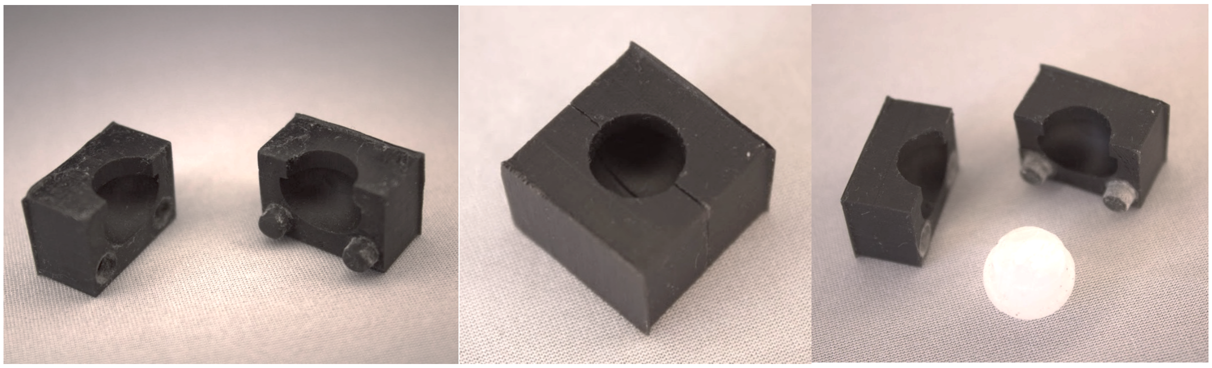


Fig 71. Resin-printed mould for silicone pads

Fig 72. Silicone pads

The piano prosthesis was sanded and sprayed with black Dupli-Color automotive paint for a glossy and refined aesthetic. A protective clear coat was applied on the last layer. This glossy black coating was added to the final prototype to indulge the gloss bias. Gloss bias is a human behavioural preference where we tend to like shiny and glossy things, as we perceive them as more visually appealing than dull ones (Lidwell et al.). Despite the piano prosthesis focusing on function over aesthetics, it can apply this gloss bias to make it visually appealing yet not distracting from its intended purpose. The gloss on this prosthesis device also mimics the glossy finishes on stand-up and grand pianos.

Fig 73. Final Piano Prosthesis Prototype. Printed in resin, sanded, and coated in glossy automotive paint.

Fig 74. Close-ups of Piano Prosthesis prototype

Fig 75. Different angles of Piano Prosthesis prototype

Fig 76. Piano Prosthesis prototype pressing down piano keys

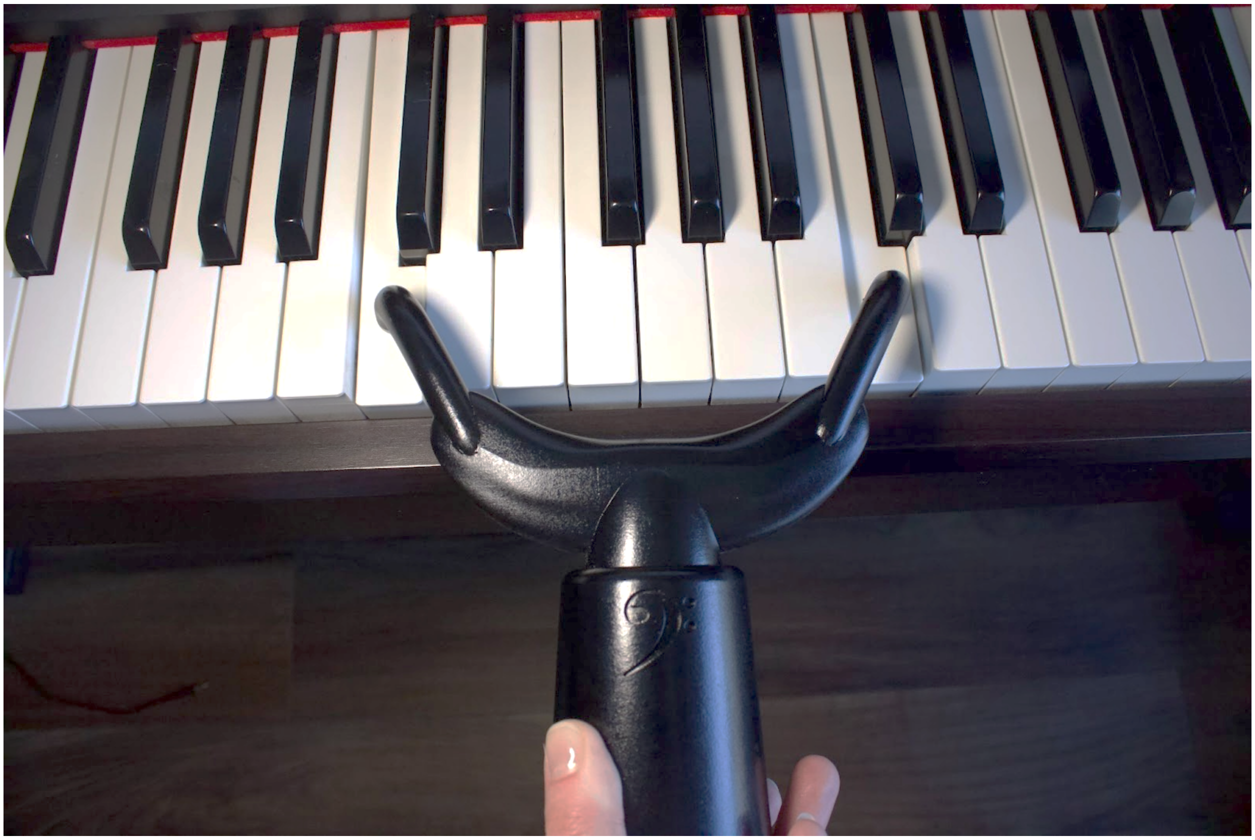


Fig 77. Player's view of the prototype on the piano

This prosthesis demonstrated another simple 'low-hanging-fruit' solution, as the form was only as simple as required for its intended purpose. This prototype had no moving parts, no extra hardware, and required no electrical signal from the muscles. The outcome is a durable prosthesis that can be used with speed and force to achieve the appropriate tempo and dynamics of a piece. Though this prosthesis is situated at an octave, pieces of music can still be played with the bass notes to perform a fully lush and complete song.

Takeaways

Further research and prototyping are needed for this prosthesis model. First off, the attachment base (where it locks onto the socket) is not appropriately modelled. I did not have access to an attachment-compatible prosthesis socket, so I could not take precise measurements to make sure that it actually fits a socket. The model shows the intent but not the precise locking system. A limitation of the model is that I had the luxury of applying downforce from the top of my hand when testing the first arbitrary prototype. Someone with a limb difference could not apply the same downforce as myself. Instead, the downforce would have to come from the residual limb and the weight of the prosthesis. For future research, materials and the overall weight of the prosthesis should be taken into consideration. The prosthesis cannot be too light, as the keys would need more force from the wrist or residual limb. The prosthesis also cannot be too heavy and weigh down the wearer's arm. The force needed to push down the keys would also depend on the type of instrument. Digital keyboards are very touch-sensitive, while real pianos have considerable weight to the keys. Another limitation of the prosthesis is that it is fixed in an octave position. For future research, creating a more sophisticated prosthesis could allow for chords consisting of three or more notes but would require more moving parts or potentially electronic pieces to move additional pegs to different positions. Overall, as a functional prosthesis that requires no electronics or hardware, this could be a solution for someone with a limb difference who wants to play piano.

The importance of this prosthesis is tied to the salutogenic model as a GRR. Even though this prototype was ideated as an artifactual-material SRR since it is a physical product serving a very specific function, it is actually a GRR due to its use for creating music. Antonovsky informs his readers, just as I did in Chapter 3 that there are many things that can help with tension management. As such, he contends that music can be a powerful GRR in combatting stressors (Antonovsky 1979, p. 121). This prosthesis, or access to prostheses that create music, can be more than just a pastime for someone, rather, having access to music as a tool to overcome, manage, and find meaning could increase the SOC and quality of life for an individual. The importance of salutogenesis is the focus on the individual, and what the individual needs in order to cope and overcome stressors. In a pathogenic approach, music may not be of any importance. However, in salutogenic model, if the individual identifies that music is an important part of their life, interests, or dreams, then it is of importance to create solutions to facilitate those needs and goals. Investing resources to create GRRs and SRRs for one's interests, wants, and hobbies could increase mental well-being and the SOC, ultimately moving them towards ease on the ease/*dis*-ease continuum, increasing overall health.

Case Study III: Ring Splints

For the subsequent two case studies, the focus will shift from prosthesis devices of the hand to other disability devices. As discussed in Chapter 5, the reason not to focus solely on prostheses is so that the essential concepts and ideas of design and salutogenesis can be discussed to expand to other areas and not be reduced to just one area. The case studies and research have been limited to the hands to keep the concepts clear. However, a small step in a different direction is to introduce the conversation about how design and salutogenesis can translate into other territories in healthcare.

Empathize

This case study will examine a disability device for the hand, which are conditions that affect the hands but do not include the total or partial loss of a limb. Chapter 5 analyzed products from companies like ImaginAble, the Active Hands Company, and Verily, where all the products were designed to complete a task or function. Moreover, with that, the form and aesthetics followed. What about products that aid aesthetics? As discussed in Case Study II: Piano Prosthesis, the function is critical when performing a particular task. A device designed for kayaking, skiing, or playing the piano must effectively complete or facilitate that precise activity. However, during research, a device that stood out for aesthetic potential was finger splints for joint conditions. Different options range from bulky and visually 'medical' to plastic or silver rings. The plastic rings seem to only come in one pale skin tone. Someone with arthritis, Ehlers-Danlos syndrome, or other joint conditions would need finger splints for functional support, but should aesthetic considerations be given? The piano prosthesis prioritized function, while aesthetics came after. However, it was meant to be worn for sessions of activity and then taken off and switched out with another hand or device. Even still, aesthetic consideration and effort were applied. Finger splints are worn for prolonged periods throughout the day, yet there are few aesthetic options.

Fig 78. Collage of finger splints from amazon.ca, ring splints by Zomile, and walmart.ca

The splints can be easily purchased online, making them very accessible to those who need them. However, some improvements could be made to their appearance that would make a significant difference. The primary demographic for arthritic conditions is those aged 55 and older (75% of people with osteoarthritis) (World Health Organization, “Osteoarthritis”). However, there are still younger demographics with this condition in which the appearance of the available splints may not fit their needs and preferences. Things like social media, body image, social events, and even a dating life are prevalent and may deter someone from wearing these splints or braces when they genuinely need them. Furthermore, it is not safe to assume that the older demographics are also satisfied with the aesthetics available to them. Why should these splints and braces not consider aesthetics when they are worn for extended periods on highly visible hands?

Define

The finger splints that are widely accessible do not reflect personal aesthetics or, I argue, even take into account aesthetics at all. A majority of what is available is bulky and needs aesthetic options. The products that are smaller and more discreet are sold in one pale skin tone, which would not work for those who have lighter or darker complexions, or there are very basic silver ring options. This is a problem concerned with aesthetics just as much as functionality. However, the aesthetics need improvement. Stressors and psychological pathogens someone could experience are:

- Body image
- Lack of choice
- “Standing out”
- Social perceptions

I put “standing out” as a stressor due to the low aesthetic qualities of the splints, some of which are very obtrusive. These splints are naturally visible since they are worn on the fingers. This is not to say that these devices are to be ashamed of, but they can bring unwanted attention to someone who may not prefer them. Someone may want a more discreet and aesthetically pleasing product, and someone else may not care. It is vital to create choices and options for people, as issues on aesthetics can be a huge proponent of how we see ourselves, identify ourselves, and want products to reflect us.

Ideate and Prototype

Looking at the products available for joint issues, I identified that there may already be an adequate starting point. It just needs to be adjusted slightly. The smaller, ring-like splints are not obstructive to the person wearing them, and they fit the contours of the fingers. They are reminiscent of jewelry, but of course, with the pathogenic focus of health, they do not go beyond the basic form. The metal splints already on the market may be an excellent option for someone who wants durable rings that are not overwhelming with decoration. Some people may prefer this simplicity. However, how can aesthetics play a more significant role? What if this is not what someone wants to wear on their hands for extended periods? During my research, I came across an article titled “This jewelry designer is creating beautiful braces for people with this rare joint disorder” (Revelist and Anderson). The article discusses a woman who created rings for her sister-in-law, who has Ehlers-Danlos syndrome. She called it the “warrior-goddess” hand braces. The bronze was shaped and decorated in a way that is personalized to the aesthetic preferences of her sister-in-law.

Fig 79. “Warrior Goddess” hand braces by Amy Pieroni, Business Insider

Unfortunately, the article also states that she does not make the rings for sale, as they were just a gift to her sister-in-law. However, I soon found that others were doing something similar. On the website Etsy, people make handmade rings for arthritis that look like jewelry. These rings are more accessible and aesthetically pleasing than the plastic or regular silver ring splints.

Fig 80. Arthritis rings from Etsy

These are great examples of splints that focus on function and aesthetics to cater to people's aesthetic preferences while serving their initial purpose. Even though there are options on the market, I started thinking about how these rings can become even more accessible and customizable. If someone wanted to make their own ring, they would potentially have to take jewelry and metalworking classes and invest in materials. 3D printing came into mind as a form of increased accessibility and customizability. There are open-source sites such as Thingiverse, which is the website of the Jointed Hand in the first case study. The sites are accessible, free, and not limited to people with a 3D printer. There are many online 3D printing services where one would submit 3dm or STL file, select the type of material and colour, and the company will print it and send the model in the mail. It is also becoming more popular for public and school libraries to have 3D printing labs. For example, just at the University of Alberta there are three places that offer 3D printing services.

This is where I go back and redefine the design problem. For this case study, it would be best to explore customizability and accessibility as a way to give even more control to the wearer. The 'how might we' question is now narrowed down and quite specific: "How might we create ring splints that are accessible through open-source websites and 3D printing services to increase accessibility and customizability control of the wearer?" To start, I sketched some rough ideas for the rings following the forms from other companies and makers, which are two rings attached by a bar in the middle.

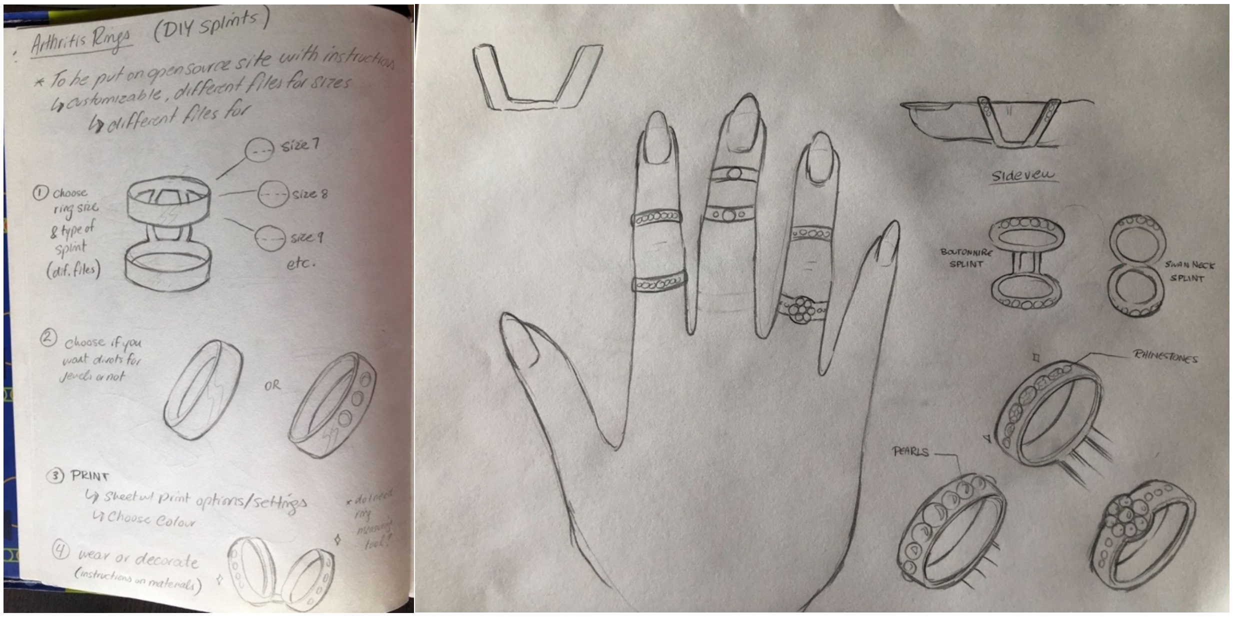


Fig 81. Sketches of ring splints

The rings were modelled in Rhino in various sizes. The design included a larger ring on one end and a smaller ring on the other. This is because our knuckles get smaller as they get closer to the fingertips. The rings were exported and printed on an Ender 3 Pro with PLA. The rings required some sanding but were sturdy and fit comfortably on the fingers.

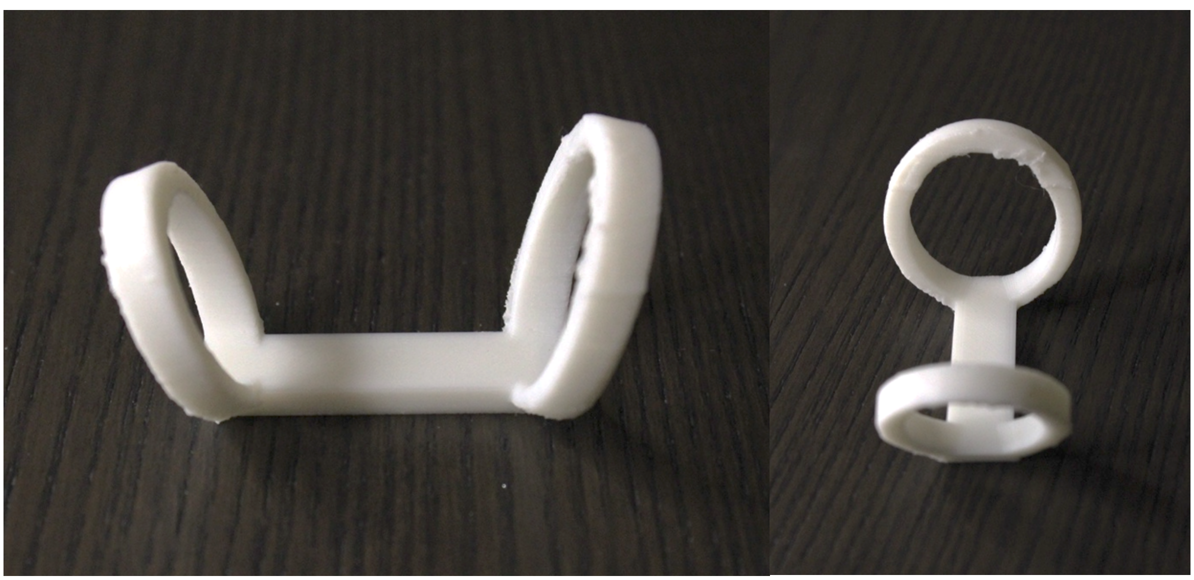


Fig 82. PLA print of ring splint

Fig 83. Ring splint on finger

The rings could be left just as is or decorated to someone's preferences with just a few gems. These pearls and gems can be readily purchased online and require some clear glue to adhere them to the print, allowing for full customization.

Fig 84. Decorating the ring splint with half pearls

Fig 85. Decoration continued

Fig 86. Fully decorated PLA ring splint

These rings worked well, considering they are PLA. I was curious how they would turn out in other materials, so I sent a handful of ring sizes to Elko Engineering Garage to be printed in clear standard resin. This material was the better choice, as it had no layer lines, and minimal sanding was required. Once again, I decorated the rings with variations of pearls and gems.

Fig 87. Fully decorated ring splints. Printed in clear resin.

Fig 88. Decorated ring splints. Close-up and on hand

These rings were a good start, but the model had to be fixed because the rings were too far apart. Instead, the rings should be closer to the knuckle to stabilize it. I sketched out a second variation with the bar shorter and the rings closer together. The PLA prototype was once again successful and only required some sanding.

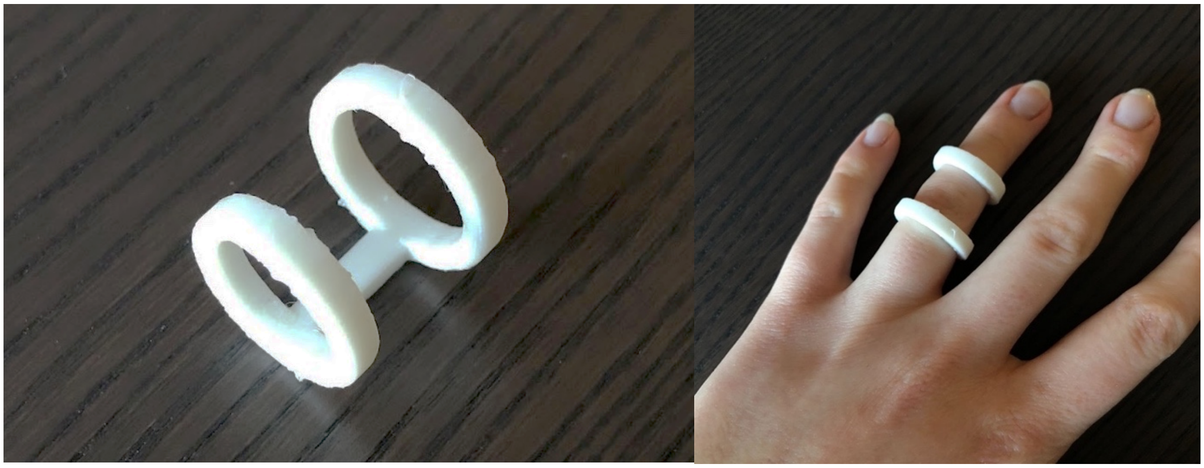


Fig 89. New iteration of ring splint

The next step was to create multiple ring sizes with variations of combinations. For example, two people could have the same ring size for the first finger joint but two different sizes for the third finger joint. Finger sizes are unique to each individual, so I needed to create different combinations of sizes for each ring size. For example, a size 8 ring would need a corresponding small ring of 7.5, 7, 6.5, 6, etc. This process would be repeated from sizes 13.5 to 3.5. The result was 186 different combinations of sizes.

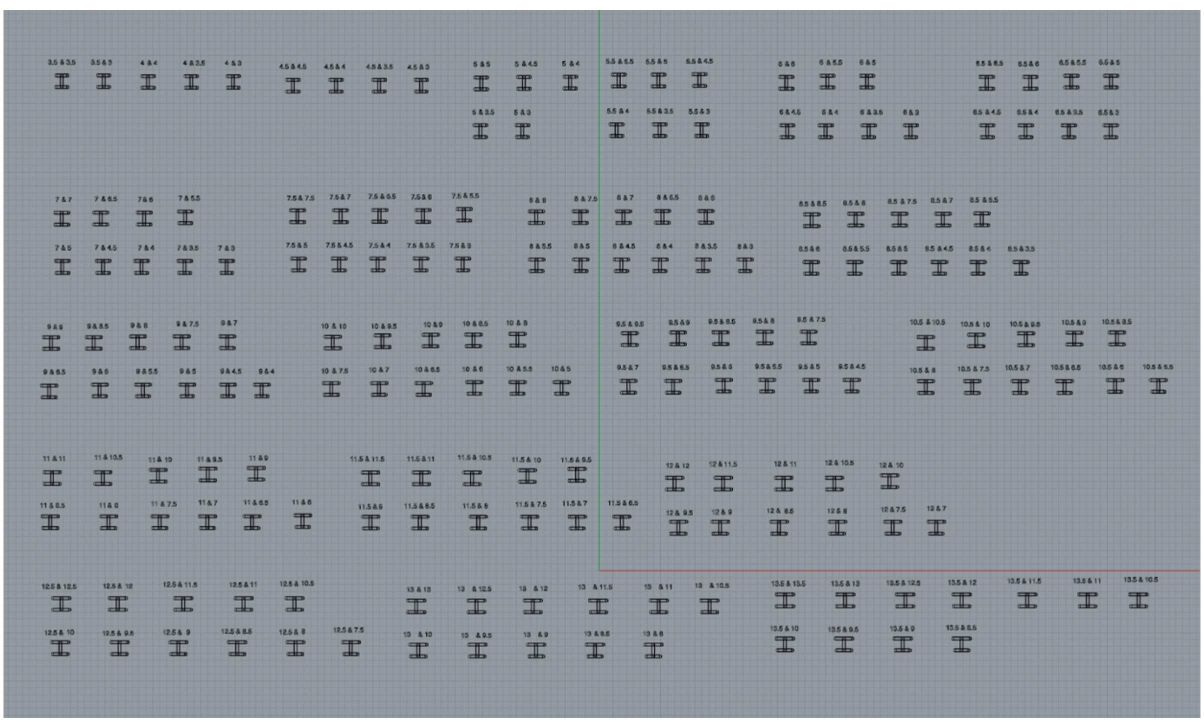


Fig 90. All the combinations of ring sizes in Rhino

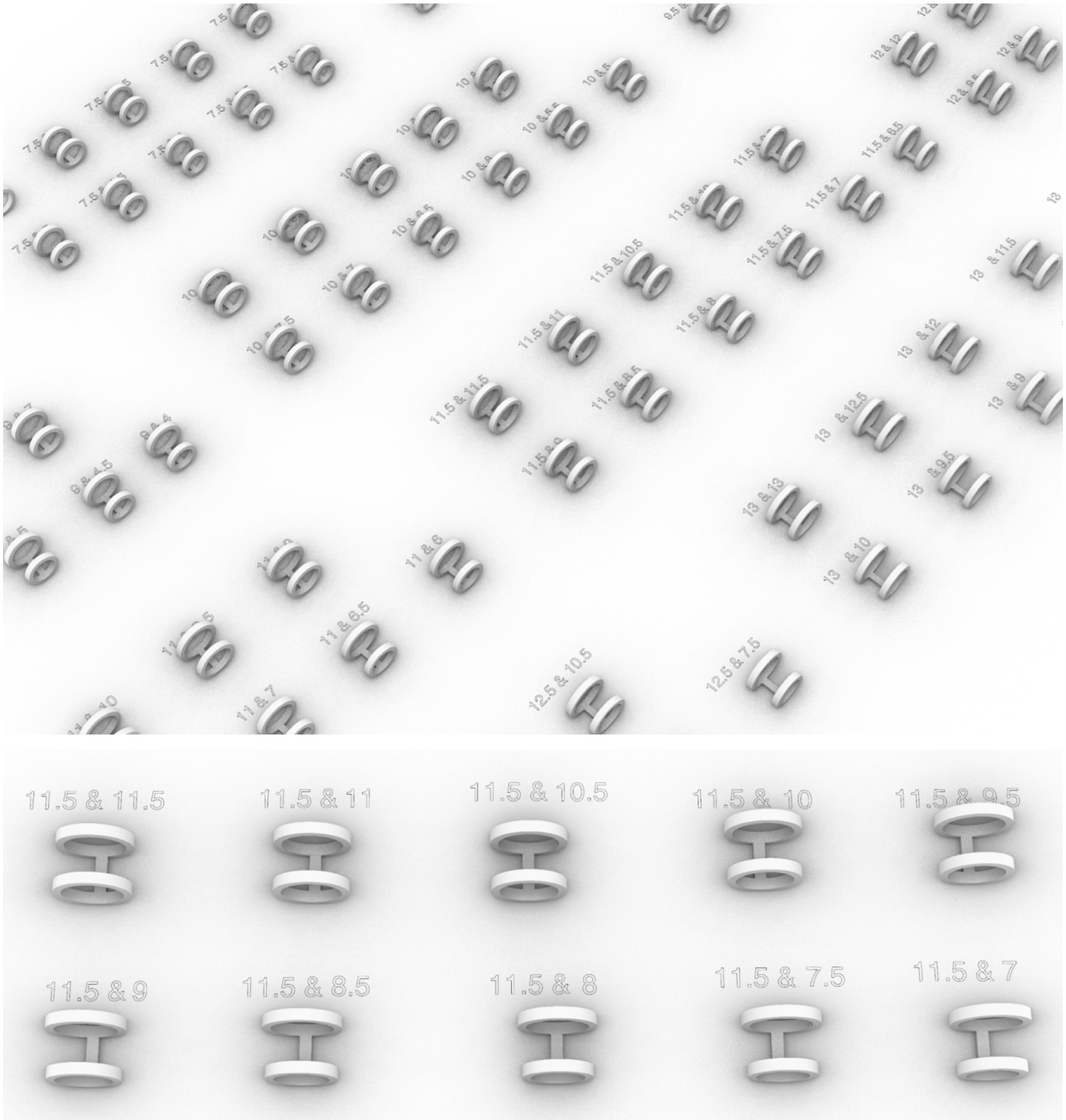


Fig 91. Close-up of the ring splints in Rhino showing combinations of sizes

A handful of models were sent to Elko to test out different materials. They were submitted to be printed in Vero on a Stratasys J750. Vero is a polymer material similar to acrylic that provides excellent detail and smoothness. This material can be printed in colour or a combination of colours in transparent/clear and opaque. I submitted a batch to be printed in regular transparent, clear magenta, and clear cyan colours to see how they would turn out. Printing in colours could be an excellent way for someone to personalize their ring further.

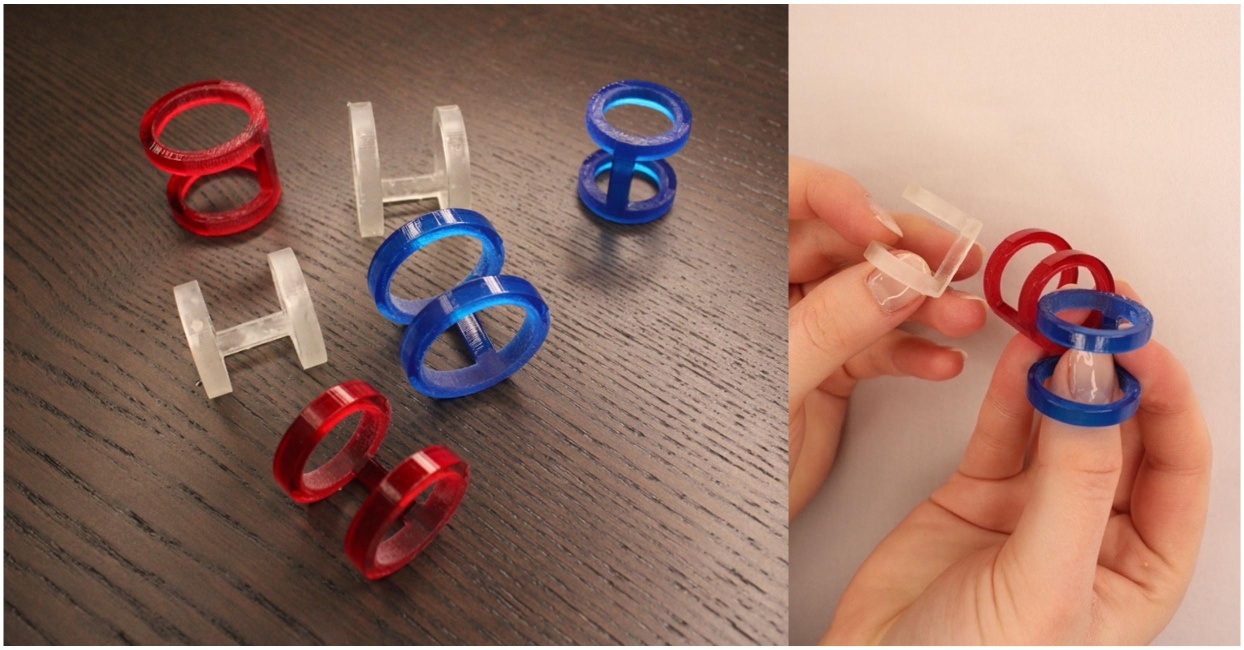


Fig 92. Ring splints printed in clear, cyan, and magenta Vero

The rings were smooth and detailed and even more robust than the PLA and standard resin. They required very minimal sanding. The only drawback of printing in Vero is that it can be expensive for large prints or batches of prints with many pieces. For example, a batch of 11 rings (various sizes) was about $44. However, this is only an average of $4 per ring, significantly cheaper than arthritis rings on Etsy, which can cost anywhere from $15-$130 each.

Fig 93. Decorating the Vero ring splints with different gems

Fig 94. Close-ups of the Vero ring splints with rings shown on the fingers

Some of these rings were decorated with gems, and some were left plain. The rings were comfortable on the finger and worked better than the first batch since they were closer together on the knuckle. All that was left to do was upload each ring onto Thingiverse so others could access and print it. The project name was titled “Arthritis Rings”, as the splints are most commonly found online with “arthritis” in the name, so to be found easier they were named as such. The files were organized in a way that was easy to find ring sizes. Each folder was named the size of the largest ring in the folder. For example, the folder “11.5” had the rings with the largest size of 11.5 and all the corresponding variations. The files were uploaded to Thingiverse under a Creative Commons license. Instructions are written in the summary on how to find the appropriate ring in the folder. I included a ring size chart in the images section. I also checked a box when uploading indicating that this model is a “work in progress” and may be subject to change. In the future, I will keep updating the files when necessary, whether to add more files or fix and update the models. The user can even adjust these models themselves if they upload them to a 3D modelling software.

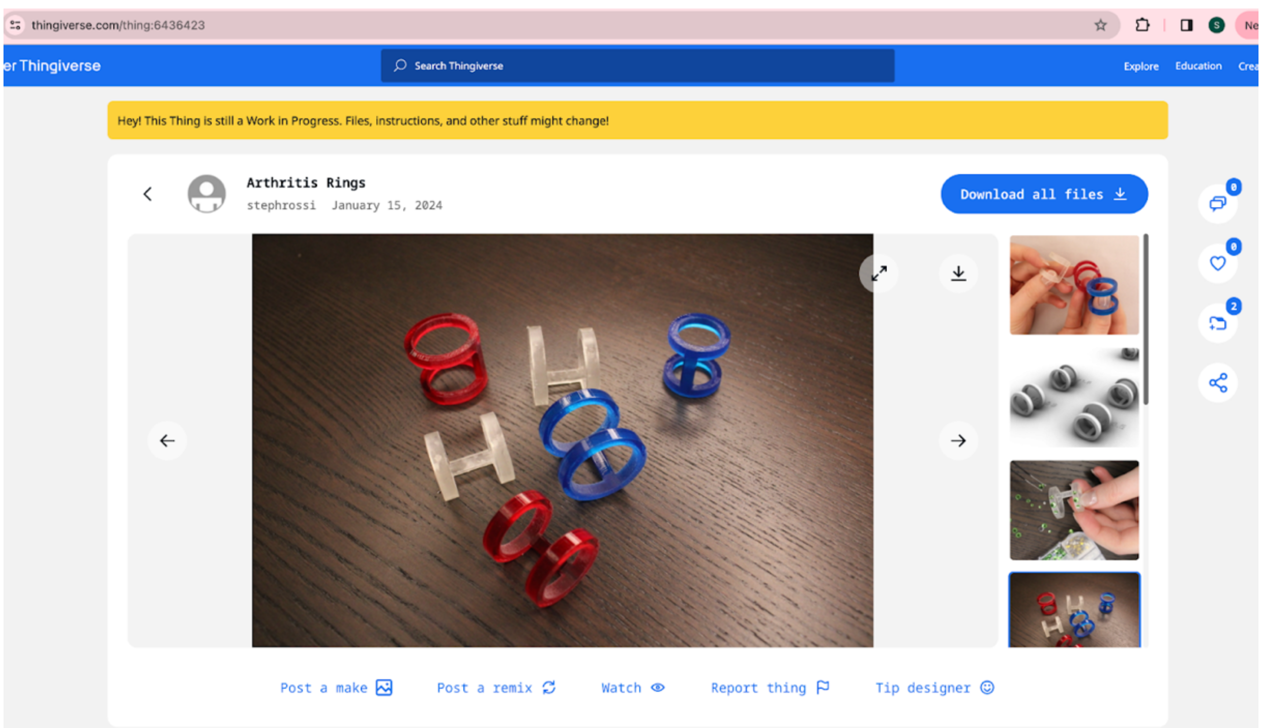


Fig 95. “Arthritis Rings” files uploaded into Ultimaker Thingiverse

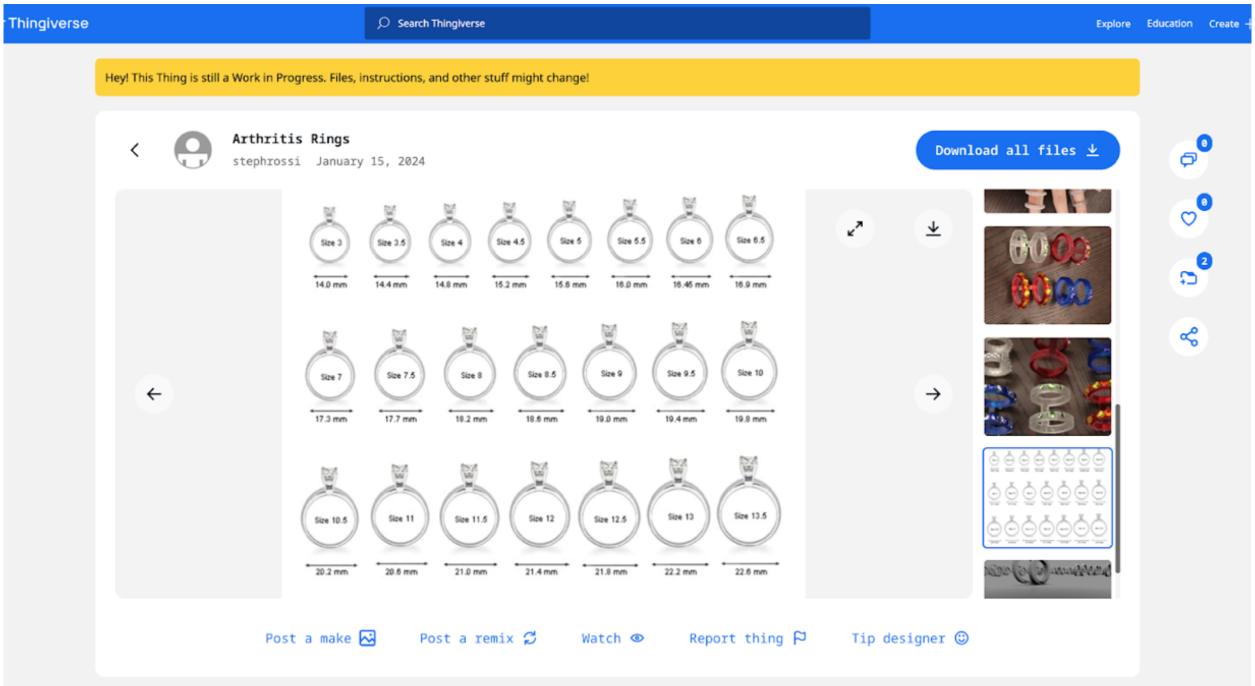


Fig 96. A ring size chart was included as a guide to select the appropriate file

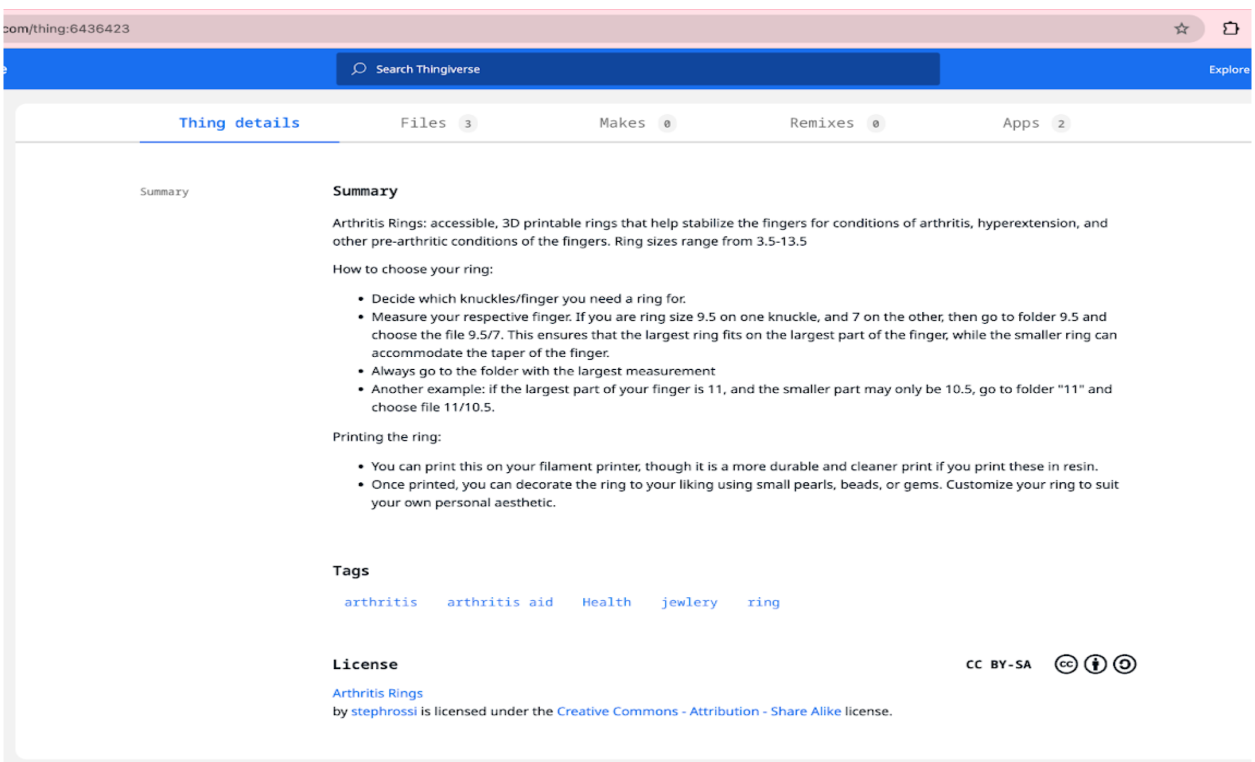


Fig 97. Instructions and recommendations were written in the summary of the project

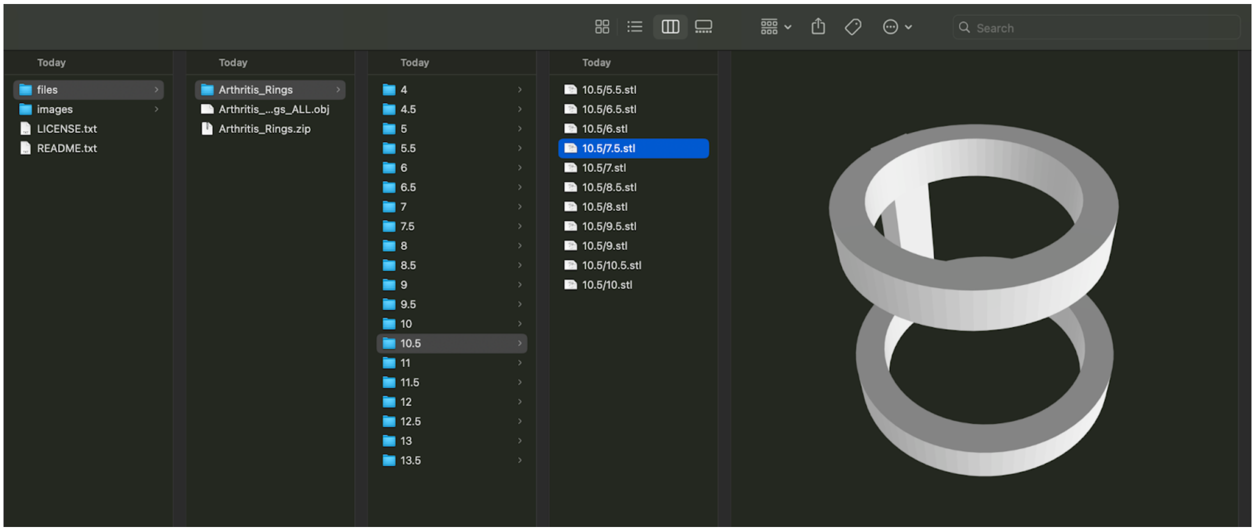


Fig 98. Example of how someone would navigate the files to select the appropriate ring

These ring splints are an ongoing project and will be updated in Thingiverse when new designs are developed. In fact, some areas of improvement have already been identified. For example, these rings may work for some conditions of the finger, like hyperextension and lateral instability, but may not work for everyone with these conditions or other conditions. Just as much as uniqueness comes from personality, interests, and values, there are also physical traits unique to each individual. Therefore, the ring splints may need a shorter bar and rings at a steeper angle to work for different conditions for different people. Health should not be one-size-fits-all, so these splints should not be either. More models will be developed and uploaded onto Thingiverse to increase the accessibility and variety of choices available. Design is an ongoing process, and this case study reflects that.

Takeaways

This case study, though not initially intended, was a great opportunity to explore ways to increase accessibility and customizability for someone needing a device. 3D printing technology is becoming increasingly popular and accessible, so open-source file sharing can be a vessel for creating and disseminating devices and pieces that are affordable and personalized. An essential aspect of this case study is the concept of choice. Someone may be okay with the regular, purely functional splints available to purchase online. However, this may not be the case for everyone. Perhaps someone wants to keep their disability more discreet and would opt for something that was disguised as jewelry or aesthetic decoration. As mentioned at the beginning of the case study, there should be no shame in disability and the use of devices or prostheses. However, with the issue of stigma that people with disabilities face, there could be some who would desire to have something more aesthetic and personalized to their preferences. The emergence of aesthetic and personalized disability devices can shift the stigma and conversation to "That's cool, what are you wearing?" rather than "What happened to you?" Being inquisitive of the device rather than patronizing the human would open a more inclusive and compassionate dialogue. Further research will be done to update different models of rings to accommodate a wider range of conditions. These small rings, which are artifactual-material SRRs, can help with issues of body image, stigma, and self-esteem, just by a small change in aesthetics. As discussed in Case Study I, having self-esteem can greatly impact and improve one's SOC. A salutogenic orientation to small areas of intervention can alleviate stressors and "psychological pathogens" that would otherwise be overlooked in a pathogenic focus. While pathogenesis focuses on basic function, curing, and healing, it is also important to look at the person inside the body and ask what would truly help someone beyond "curing" the physical pathogens of the disease or condition. A salutogenic model looks at how to combat psychological pathogens, which are of important in increasing the SOC and ease in which someone perceives and navigates their overall health.

Case Study IV: Rowing Device

Case studies I and III explored improving aesthetics and personalization in prostheses and splints for disabilities and conditions of the hand. Case study II explored the functionality for which a piano prosthesis was prototyped. Case study IV will focus on functionality for disability devices; however, it strays into a different realm than the first three case studies. Case studies I, II, and III all had in common that they catered toward the individual's creative side. The first three studies explored the creation of SRRs for combating mental and social well-being issues, such as body image, self-expression, self-care, social perception, lifestyle, hobbies, and aesthetics. One recalls from Chapter 2 that mental and social well-being are essential, however physical health is also important.

Empathize

As discussed, the National Institute of Health outlines that the best way to achieve good physical health is to engage in physical activity, eat well, maintain a healthy weight, and maintain and build muscle mass (Physical Wellness Toolkit). Although healthy eating is outside this thesis's scope, physical activity building muscle mass and weight maintenance may be opportunities for intervention. The WHO has recommended 150 minutes of activity per week, though, as mentioned, people with disabilities may face barriers to activity due to inaccessible spaces, inadequate devices or aids, and mobility limitations. Chapter 1 discussed the higher rates of obesity, disease, and mental health problems among those with disabilities. Increased activity can drastically improve physical health by reducing disease, obesity, and all-cause mortality. It is clear that physical health is essential, and it would be necessary to explore further to improve mental, physical, and social health. What areas of opportunities are there for other disability devices to increase physical health and ability?

Define

Increasing physical activity for those with hand disabilities may not be as simple as going for a walk or a run. After all, a disability or condition of the hands may also affect the function of the legs, as many conditions affect numerous areas of the body. It is also unfair and wrong to reduce a demographic to one kind of physical activity or assume that they do not want more choices in their activities. The Association for Applied Sport Psychology states that up to 80% of people starting a new exercise program do not stick to it ("Exercise adherence tips"). Their suggestion for greater adherence is to pick an enjoyable activity, as a dislike for an activity, no matter the benefits, will result in a loss of motivation. Increasing choices in activity for those with disabilities would increase the chances of someone finding the exercise routine and activity they enjoy, resulting in greater adherence.

There could be many reasons for someone to have a hand disability or conditions leading to reduced hand function, such as arthritis, cerebral palsy, nerve damage, stroke, neuropathy, carpal tunnel, and even simply atrophy in the aging population. These conditions can affect full or partial use of the hands and weaken grip strength. Though some may find that they enjoy activities that do not involve using their hands, there may be a portion that would like to participate in other activities but cannot. Of course, creating devices that facilitate all activities would take time and effort and exceed the span of a thesis. However, what kind of exercise would be worthwhile for a demographic who has a condition or disability of the hands? There must be a few requirements when picking an appropriate exercise. First, the exercise must be low-impact so as not to put pressure on the joints. Second, it must be attainable at a leisurely pace or low effort. Finally, it must be worthwhile. It is worthwhile, meaning the exercise has physical health benefits such as increasing muscle mass, endurance, or cardio. The exercise must be worth the effort put into it. One exercise that comes to mind that covers all these aspects is machine rowing.

Why machine rowing? Rowing is an excellent exercise because it is low impact, as no hard pressure is applied to the joints. It is also a seated exercise, which can benefit those who have trouble standing for long periods. Although seated, the exercise requires the whole body's movement by using the legs, core, and arms. Rowing is both a cardiovascular exercise and a muscle-strengthening exercise. The exercise can be performed at a low or high intensity, and typically, the machines have a resistance setting on them, making the exercise easier or harder. It is a low-impact, cardiovascular conditioning and muscle-strengthening all-in-one exercise that works the entire body.

The diagram below shows a great example of the muscles worked during machine rowing. Red areas are the primary muscles worked, and yellow is the secondary muscles.

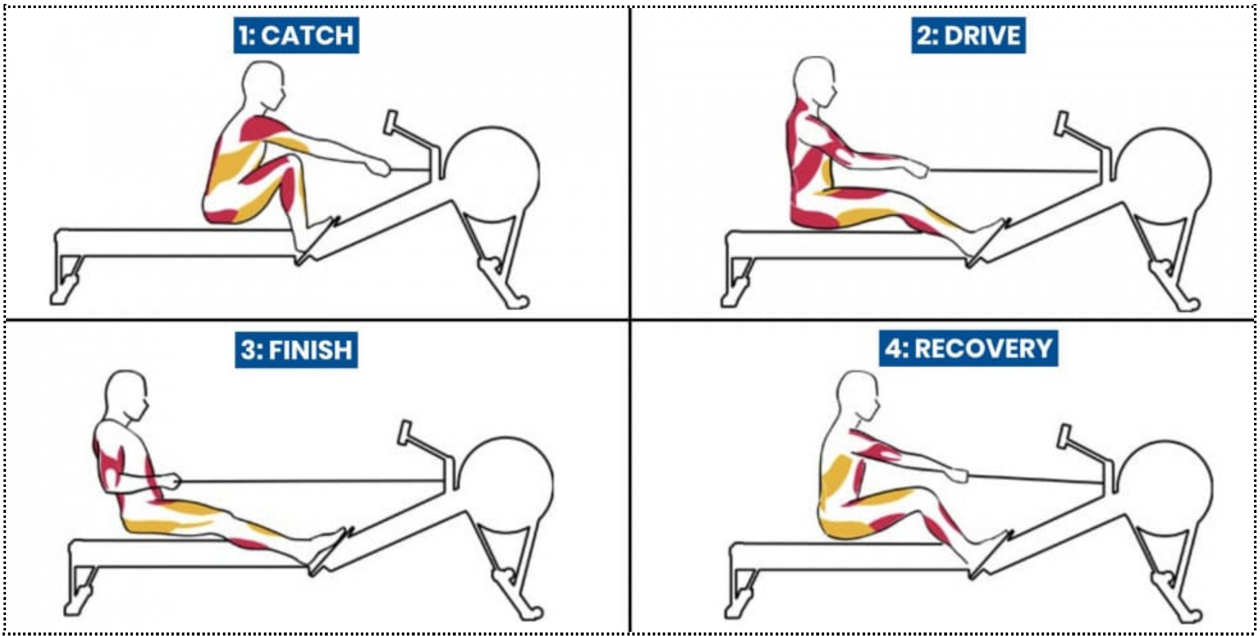


Fig 99. Muscles worked from machine rowing. (Diagram from boxlifemagazine.com)

It is clear that machine rowing benefits the entire body: muscles, joints, and heart. It is perfect. Almost. The only drawback is that it requires grip strength of the hands to hold and pull the handle towards the body. Even though the resistance can be lowered, people may still not have the required strength in their hands to hold and pull the handle. It is quite a predicament that this highly effective, low-impact, seated, cardiovascular and muscle-strengthening exercise is not accessible to those with hand disabilities. This exposes an area of opportunity, though it would be essential to consider why this design opportunity is important. As mentioned above, everyone deserves a choice in the activities they do. It is important to break down accessibility barriers to empower people to take control of their health and even break stigmas of disability by enabling more ability. The ability to exercise increases physical health and in turn, helps mental health. Social well-being can also be increased, as those with disabilities can feel more involved with the gym community, which could decrease the high rates of loneliness in those with disabilities.

The stressors that someone without access to devices for physical activity could face are:

- Poor physical health
- Poor mental health (as a result of physical health)
- Lack of choice
- Stigma
- Isolation
- Body image

An analysis of the products available for sport and physical activity shows no machine rowing devices specifically designed for individuals with grip strength issues. The Canadian Paralympic Committee shows that Para rowing requirements are disabilities of the core and legs, and no mention of disabilities of the hands ("Para Rowing"). Olympic Para rowing does not include any member with hand disabilities. Why is this? The images of the team members also show no devices or aids. If devices are not used in Para rowing, the highest level of the sport, then an adequate device may not exist. How might we create a device that can facilitate activity on the rowing machine for those with grip strength issues?

Ideate and Prototype

The requirements for a rowing machine device are that it withstands the pull force of the rowing handle and it must take the stress off of the fingers. As always, I wanted to see if something was already available as a starting point since there is nothing specific on the market for rowing. When looking online for devices, I came upon lifting hooks for the gym. These hooks are a common product that avid weightlifters use in the gym to help ease the stress on the fingers while lifting heavy weights. This might be something that can also be used on the rowing machine rather than kettlebells and barbells. I bought the lifting hooks for both hands and tested them on the rowing machine. Some weight was relieved from the fingers, but there were apparent issues. The hooks were not designed for the rowing handles circumference, making it difficult for the hook to stay on the handle. The hook also needed better left and right rotation. When pulling the paddle to the 'finish' position, the wrists are naturally angled as they are tucked into the body. The hooks could not accommodate this angel, making the ends lift off the paddle. The hooks would also come off the paddle due to the lack of pull-force on returning to the catch position. The force of the paddle coming into the catch position was not enough to keep the paddle in the hook. Using this product was a good place to start since it outlined some critical details to remember when designing the first prototype.

Fig 100. Using lifting hooks from amazon.ca. to test out the rowing machine

For Version 1 (V1), I naturally thought about the lowest-hanging fruit. I sketched out a wrist brace with a simple fabric or nylon strap that would be velcroed into the brace to form a loop around the rowing handle. I started with a fabric loop due to the angle required at the finish position. The fabric is softer and more flexible than the rigid lifting hooks. I purchased a simple wrist brace and cut up a fabric shopping bag for the fabric piece. I had sewn one end to the brace and the other end to pieces of Velcro. The Velcro would then attach to the Velcro inside the brace to secure the handle.

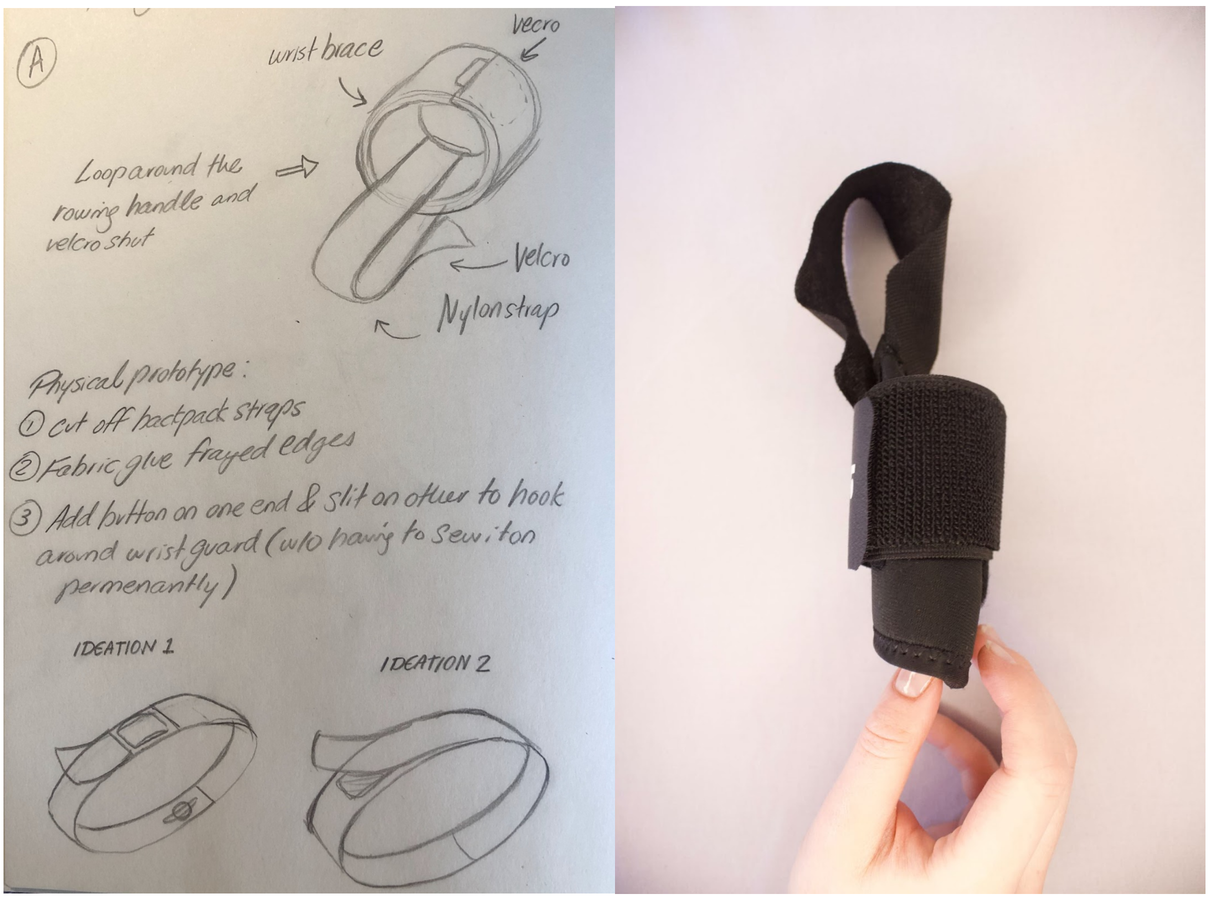


Fig 101. Rough sketch of Version 1, and physical prototype of Version 1

However, a simple test proved that the fabric and Velcro were not strong enough. Tugging on the fabric loop caused the Velcro to rip out of the brace. Surely, it would not withstand the pull force of the rowing machine.

Fig 102. V1 prototype

Version 2 was more sophisticated than V1. Instead of sticking with the fabric loop, a more robust hook would be more effective at alleviating the stress off the fingers. I 3D-modelled a hook in Rhino to fit the circumference of the handle better than the lifting hook. The pieces include a Velcro strap looped inside the brace twice, rather than outside of the brace once like V1, and a 3D printed PLA piece to hold the hook. The hook would slide into a keyhole on the plastic piece, and the pull-force of the paddle would keep the hook from coming off of the plastic piece. If someone wanted different sizes, I wanted the pieces to be separate to make the hook interchangeable.

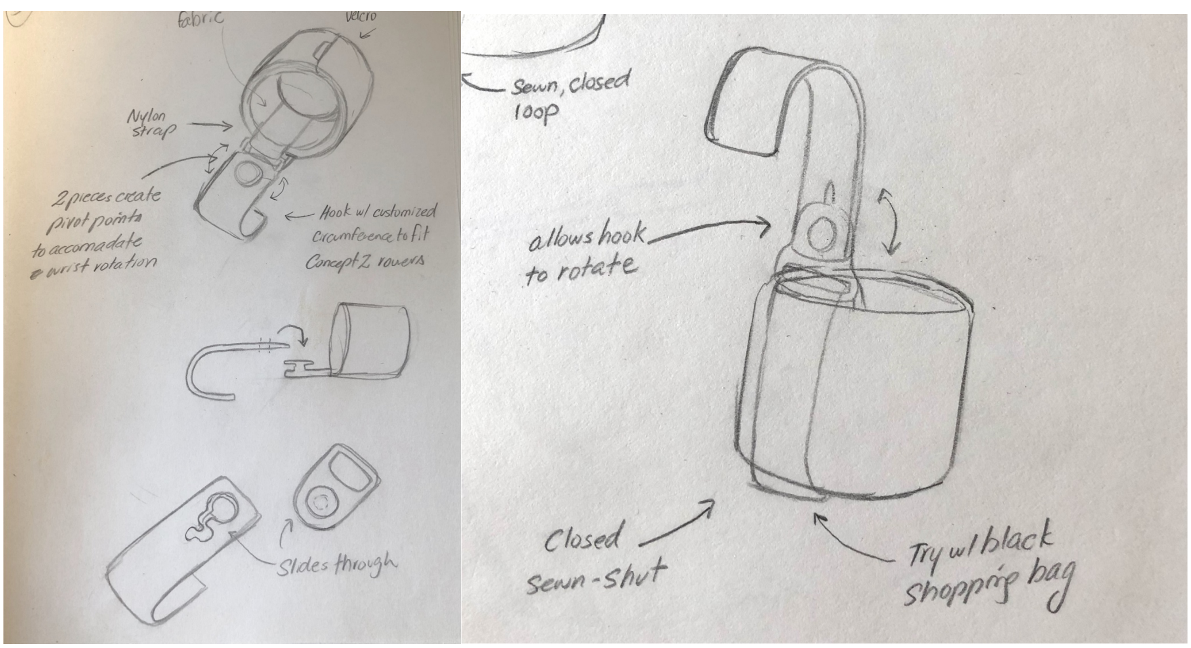


Fig 103. Version 2 rough sketch

I tested V2 on a rowing machine in the university gym. I tried it with my grip on the hook and then tried to row without using my fingers to see if it would hold up in the scenario where someone has very little or even no strength in the fingers. It was apparent that the Velcro was still not strong enough. Fifteen seconds into rowing, the Velcro ripped off of the brace once again, and all of the pieces went flying as the rowing handle flung them at high speed into the wall across the machine. For the next iteration, it was evident that Velcro would not be used due to strength requirements of the device. The plastic hook needed a tighter circumference, as the lack of pull-force going back into the 'catch' position caused the hook to leave contact with the handle. V2 was also challenging to put on. The Velcro and plastic pieces were not intuitive to put on because they were not sewn into position in the brace.

Fig 104. V2 hook on the rowing machine handle

Fig 105. V2 pieces and demonstration of how to put it on

Version 3 was updated to have a smaller circumference, though not completely closed onto the handle. For this version, a clip would be better than Velcro at securing the hook from the brace. The clip was sewn onto the bottom of the brace with nylon, allowing room for the clip and hook to align with the hand.

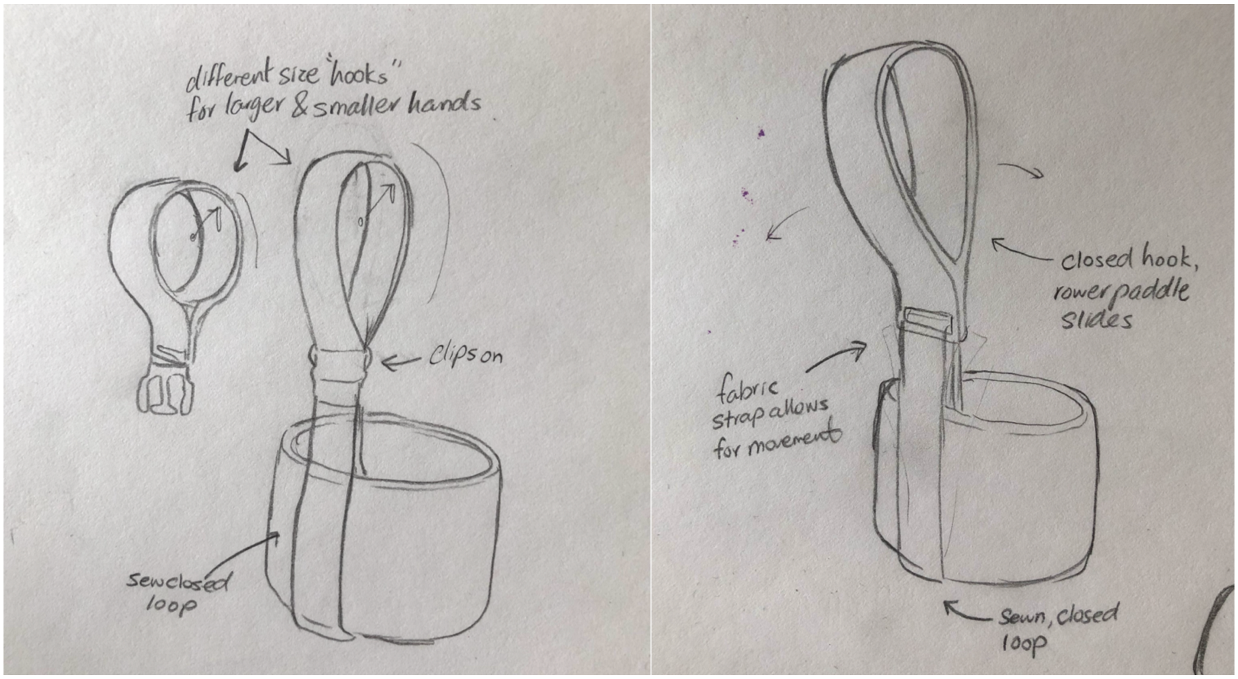


Fig 106. Rough sketch of V3

The device was much easier to put on. It only required the brace to be wrapped around and velcro with no added steps. The brace held up reasonably well when rowing, and it was again tested with and without my use of fingers. It did not fly off like V2 when I lifted my fingers, but after a few minutes of rowing, the nylon at the bottom was pulling the wristband up due to the force of the hook pulling forward. This caused the bottom of the brace to lift and almost fold up. The circumference of the hook also needed to be corrected. For the next iteration, I had to accept that the hook had to completely encompass the handle so as not to come off during the catch position. The attachment of the hook also had to change from the bottom to the top so that the brace would not start lifting at the bottom.

Fig 107. Demonstration of how to put V3 on

Fig 108. Strap pulls the brace from the bottom causing it to slide upwards

Version 4 was greatly simplified. A saying within design goes, "The best design is as little design as possible." The hook was once again updated for a smaller circumference so that it would always stay in contact with the handle. This meant the hook would slide onto the handles at the ends rather than be hooked anywhere on the handle. In V4, the hook was attached to the brace at the top with nylon and sewn shut on both ends. The hook was fixed in place, which scrapped the idea of interchangeable hooks. In this version, I asked why the hooks needed to be interchangeable. What was the purpose of that? In V2 and V3, I was thinking about different sizes but realized that people purchase appropriate sizes they need for everything. There is no need for this wearable product to have multiple sizes, as someone would only use one size. Instead, the device should be offered in different sizes as separate devices.

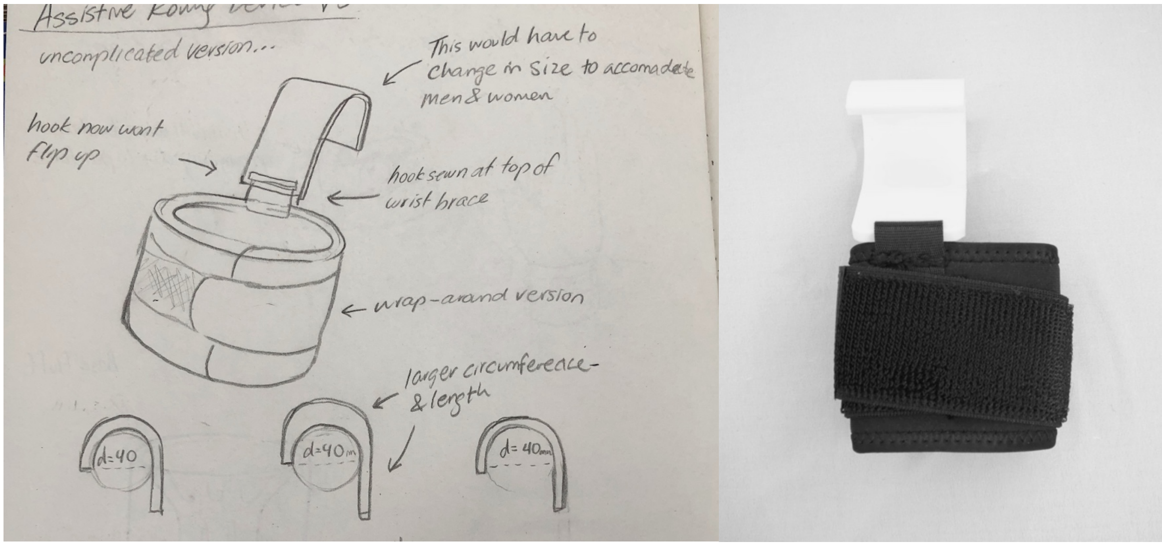


Fig 109. Version 4 sketch and prototype

V4 was tested on a rowing machine, with and without using my fingers. The device was working better than V3, as the change in nylon placement prevented any lifting, and the hook had no opportunity to come off of the handle. However, after a few minutes of rowing (with and without gripping), the brace would slide up from the pull-force of the handle, causing some discomfort as all the pressure congregated at the base of my hand instead of spreading evenly across the wrist. For the next iteration, I would have to find a brace that covered more surface area to distribute the force and secure the brace.

Fig 110. Demonstration of how to put V4 on

Fig 111. Rowing hook on the handle of the machine

Fig 112. Brace is not strong enough to withstand pull-force of the machine. It pulls the brace upwards and puts pressure on the base of the wrist

For Version 5, I used a brace that was intended for carpal tunnel syndrome. It was much larger than the brace used for V1-V4, as it went all the way to the mid-forearm. The increase in surface area with three velcro straps to tighten would mean that the force could be distributed across a larger area of the arm instead of the wrist. It would also be more secure since all three straps could tighten up the forearm. The hook was sewn with nylon on a "V" pattern. The brace had a metal bar in the middle, so the nylon had to be sewn around it. The nylon still allowed the angled motion as needed for the catch and finish positions.

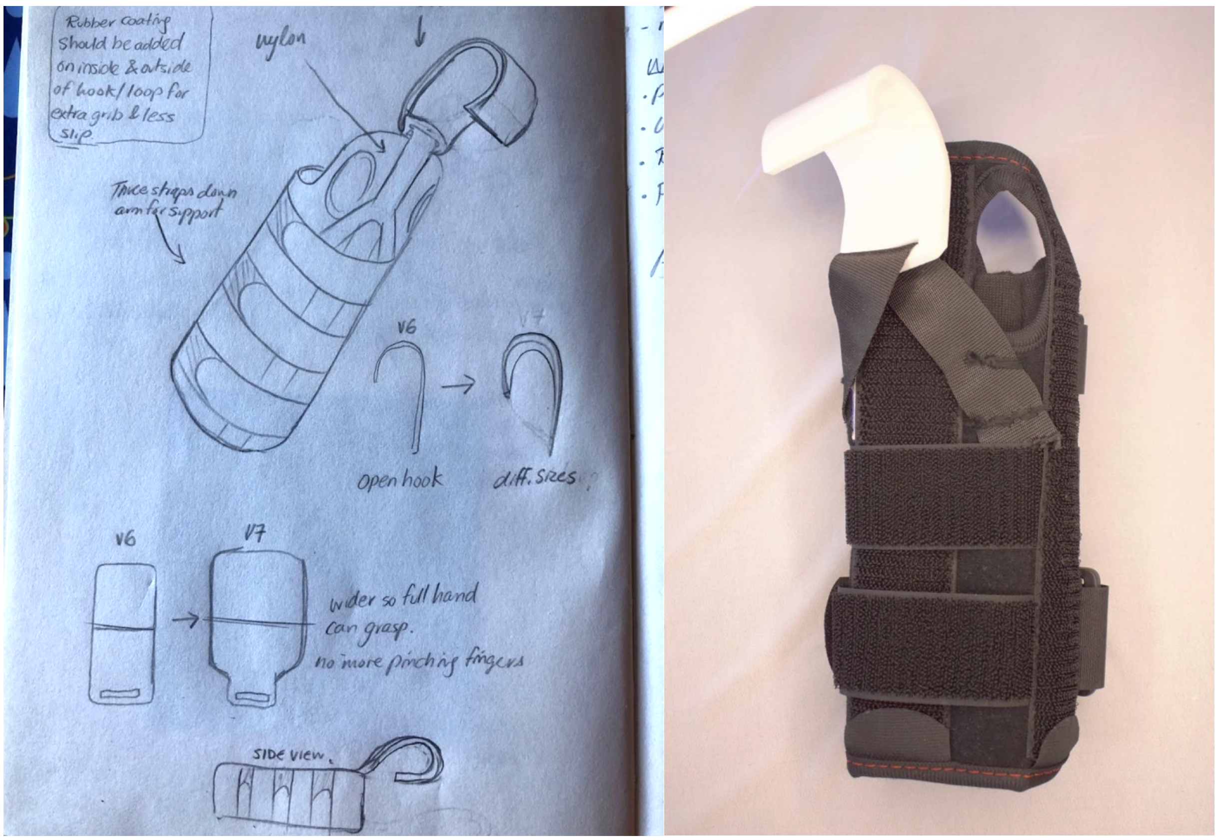


Fig 113. Version 5 sketch and physical prototype

V5 was tested on the rowing machine. It was the most comfortable and reliable iteration so far. A lot of the pressure was taken off the wrist, and the brace fit snug on the forearm. I was able to row for a considerable amount of time and was able to be used without any grip at all. Most of the major issues were fixed for this iteration, which allowed me to look at details to refine. I noticed that during rowing, there were some points where the edge of the rowing hook and the handle would pinch the side of my finger. This was because the hook was smaller in width than my hand. Therefore, some of my fingers were not entirely on the hook. In the catch position, the handle would move slightly toward the back of the hook, and in the finish position, the force would move the handle to the front of the hook, sometimes catching my finger. For the next iteration, increasing the width of the hook would fix this issue.

Fig 114. Testing V5 on the rowing machine

Version 6 included the width adjustment of the hook. It was now wide enough (using anthropomorphic data) for a whole hand to fit. The hook was printed in PLA and sprayed with 5-6 layers of Plasti-Dip rubber coating and sewn onto the brace with nylon. Even though the hook could not come off the handle without sliding off the sides, I added 5-6 layers of Plasti-Dip so that the hook would not move from side to side. The rubber coating would reduce friction and sliding on the handle. This was done out of caution, in case the hook slides so close to the edge that it slides off the handle completely. The rubber was also more manageable for the fingers to grip, as the plastic is a much more slippery material.

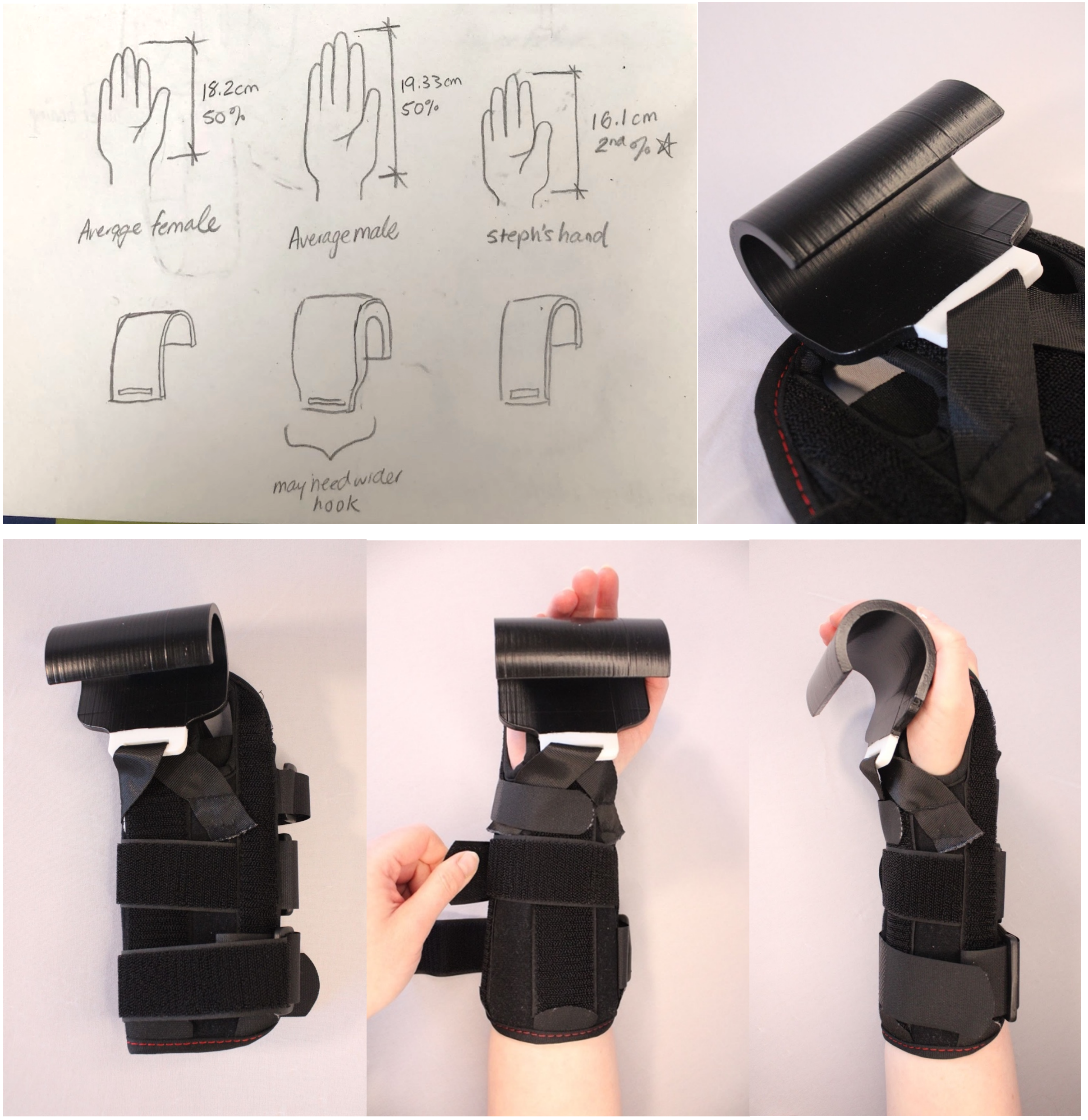


Fig 115. Rough sketch and updated prototype of V6

V6 was tested on a rowing machine and could be used without fingers. When fingers rested on the hook, there was no more pinching or catching on the sides. A small adjustment of the width of the hook completed the model.

Fig 116. Testing V6 on the rowing machine

Version 7 is the final design. It is a minimal refinement from V6, where the sharp corners on the opening of the rowing hook are rounded off for a smoother aesthetic. Different sizes were modelled in Rhino to accommodate larger hands. Larger hands would need a larger circumference around the hook, but the inner circumference would have to stay the same size to hold the rowing handle. For aesthetic appeal, some minor details were added to the middle of the medium and large hooks. These details also allowed less printing material, as the printer did not have to fill those empty spaces with material.

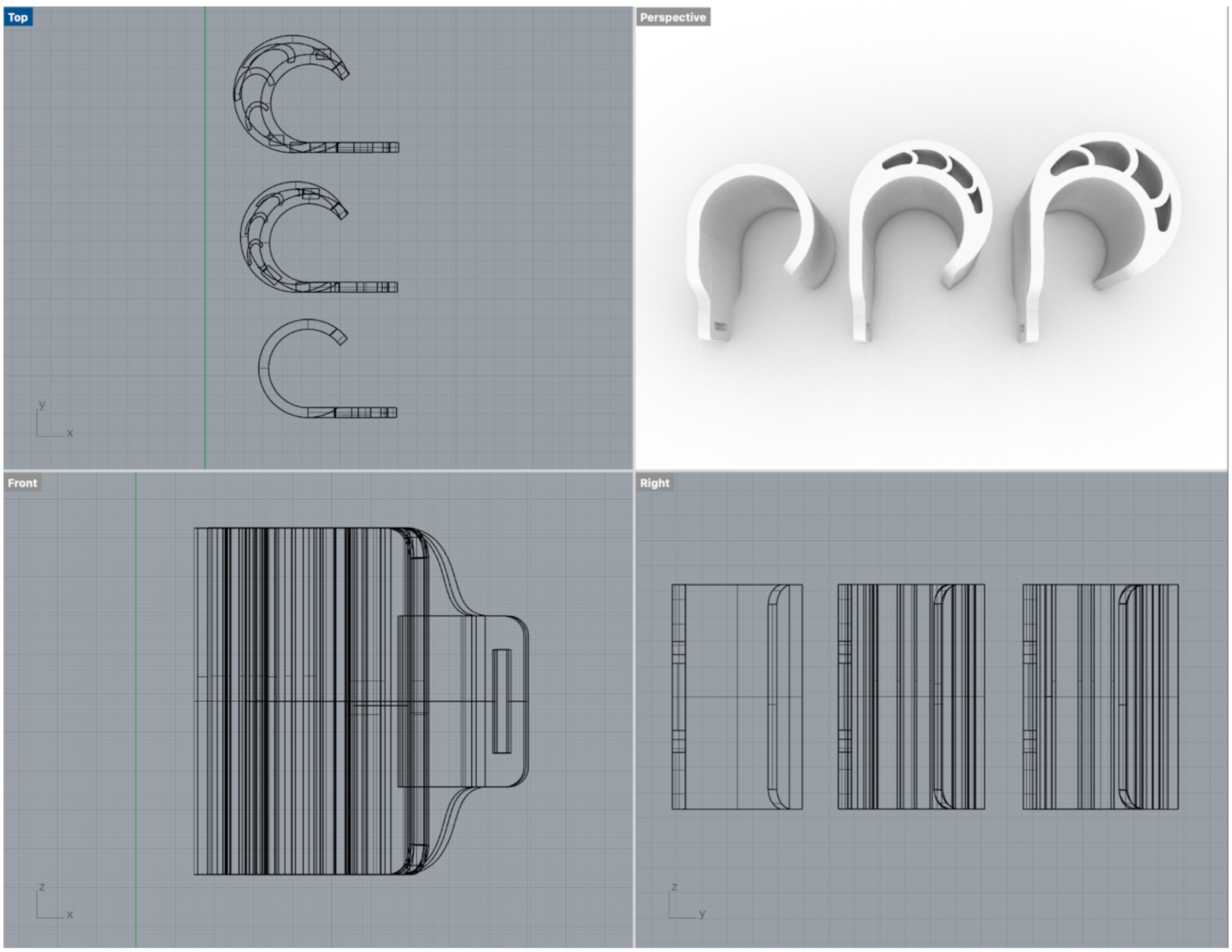


Fig 117. Version 7: small, medium, and large rowing hooks modelled in Rhino

V7 small, medium, and large were printed in PLA, sprayed with rubber coating, and sewn onto the braces. This prototype required minimal parts and effectively alleviated pressure from the fingers while rowing. The prototype could be used without any finger grip at all and stayed comfortably on the arm and wrist.

Fig 118. Small, medium, and large rowing hooks. Close-up of medium hook

Fig 119. Testing out V7 of the small rowing hook on the rowing machine. No grip needed!

Fig 120. Testing the V7 medium rowing hook on the rowing machine

Takeaways

The drawback of this prototype is that the aesthetic considerations needed to be more minimal. This is not because aesthetics are not important, but because there were significant functional considerations. The large brace was necessary in order to distribute force and hold onto the arm without putting pressure solely on the wrist. For future considerations, a more aesthetic brace should be designed as long as the function is not compromised. This case study explored another example of improving disability devices for overall well-being, this time in the physical health realm. Devices that allow for more choice in activity could help people find activities they like, which would contribute to greater adherence to exercise. Focusing on breaking down barriers to health could help obesity rates, improve cardiovascular conditions, and increase muscle mass and bone density while also lowering risks for diseases and atrophy. All-cause mortality rates for those with disabilities could drastically improve if devices were focused on inclusion in activities. Improving ability and mobility through devices could challenge social stigmas, get people in social settings such as the gym or a club, and empower those with disabilities to choose what they want to do in life.

Just as the piano prosthesis was a GRR disguised as an SRR, so is this rowing device. Even though it is a specific activity, if it is someone's main source of exercise, it could be considered a biochemical or valuative-attitudinal GRR. This is because exercise is shown to be beneficial in managing stress (Childs and De Wit; "Exercise and Stress: Get Moving to Manage Stress"; (Pedersen and Saltin, 1). Someone who is feeling stress for a wide variety of reasons would be able to use this rowing device as their go-to GRR. Ultimately, easing stress through exercise while increasing physical health can move someone up the SOC continuum and increase overall ease and health. However, the pathogenic model looks at physical health, it does not go beyond physical health for basic functioning. While practitioners prescribe good diet and exercise as means in improving physical health, it does nothing to provide ways to achieve it that are accessible, fun, or sustainable because prostheses and devices do not allow for such ability. A salutogenic approach paired with the capabilities and methodologies of design, however, can explore the importance of breaking down barriers to exercise and health, and also provide solutions to the problems. Pathogenesis prescribes exercise for good physical health, while salutogenesis explores factors of what someone needs and wants to adhere to exercise to improve health, and design achieves the solution.

These four case studies looked at specific scenarios of function and aesthetics, which led to solutions that may otherwise not be considered without a salutogenic orientation to each problem. However, to understand the complexity of personality, lifestyle, interests, and values of someone with a hand disability, it would be helpful to talk to someone in this demographic to truly understand how they feel about devices and what personalization would actually mean. These four case studies demonstrate customization due to them being products designed specifically with the end user in mind. However, if we truly want to personalize, we must bring in the *person*.

Chapter 7. Participant Study

7.1 Study Outline

Moving forward from the case studies, I wanted to get the perspectives of someone with a hand disability. Qualitative data is needed to explore and understand these topics. Qualitative data is used instead of quantitative data because the data are words rather than numbers (Busetto et al., 1). Words can tell stories, convey emotions, and provide interesting information and interpretations, which is imperative when utilizing a salutogenic orientation and user-centred design. Quantitative data helps identify problems and patterns with statistics, but for this research, it would be invaluable to discover reasons why these statistics may exist (Busetto et al., 1). Qualitative data was collected through a semi-structured interview. Semi-structured interviews allow for flexibility in discussion and progress based on the participant's response (Gill et al., 291). The flexibility in the semi-structured interview allowed for ease of flow of conversation, inviting surprising thoughts and perspectives and uncovering more meaningful responses by diving deeper into the response. In this chapter, I summarize and highlight key findings from the interview with the participant.

A study was created and approved by the Research Ethics Board 2 to gather information about preferences and experience of prostheses for people with hand amputations or congenital limb differences. Exploring both prostheses and disability devices would be too large of a scope to cover in the required time frame, so it was narrowed to just limb differences and prosthesis design. The study was structured to have an initial interview session, an ideation and analysis stage, and then following interviews to discuss the design ideas. This process would repeat until a satisfactory design is achieved. The initial interview would discuss the participants' experiences with prostheses, their thoughts on aesthetics and function, and potentially brainstorm ideas for personalized prostheses. I made it clear that these prostheses were not to be manufactured but instead would be used to discuss the importance of the ideas and concepts from the conversation. After each interview, I analyzed the data by transcribing it and extracting key points for ideation. Ideation would take the form of sketches, which would then be presented to the participant in the next meeting. The second meeting would allow for the participant to discuss the ideations and provide their opinions on the proposed designs. If the designs require additional ideation, another meeting would be necessary.

The interviews aimed to get qualitative data from a participant with a limb difference of the hand by discussing their experiences with prostheses, if they thought commercially available prostheses were satisfactory to their functional and aesthetic requirements, and if they were not, how they could be improved. I hypothesized that utilizing design thinking and a salutogenic orientation to design the function and aesthetics of a prosthesis or assistive device can improve prostheses' use and personal connection for the wearer. Focusing on the design of aesthetics and function could create outcomes that are truly personalized to the wearer. I intended to determine what functions and aesthetics were essential to the participant. Through this small study, I intended to create a conversation on the importance of focusing on an individual with complex thoughts, perspectives, needs, wants, interests and values. Getting a perspective from someone with experience on the matter would highlight the importance of these areas.

One participant was identified for the study. They were identified through word-of-mouth and were contacted through email. They had a congenital limb different in the right hand and had experience using prostheses. There were two rounds of interviews and two rounds of analysis and ideation. Due to time zone and location differences, the interviews were conducted online via Google Meet. Each interview took 40-45 minutes and was audio recorded for ease of transcription and analysis. The participant will be known as Participant A (‘PA’ for abbreviation).

7.2 Interview #1

In the first interview, I discovered that Participant A was born without his right hand (congenital limb difference), which he still refers to as his hand. The first question I asked was if he currently had prostheses. He is someone who also 3D prints, so he said he is actually in the process of making a prosthesis for himself. He showed his 3D-printed prosthesis, the "Raptor Hand," and he was figuring out a non-electric way of opening and closing the hand. He downloaded the model from Thingiverse and modified it.

> PA: "So basically the hand is just an upscale version of Thingiverse. I changed the fingers a little bit because I'm not good with knots. So my solution was to use steel rope and metal stoppers on it."

He continued that he also has a myoelectric prosthesis from a company that can read certain gestures from his residual limb. However,

> PA: "We couldn't really get it to work"

This is concerning since myoelectric arms are more expensive than other prostheses. If they do not work properly or are hard to use, then there might be an issue with adherence to the prosthesis. PA also had other body-powered prostheses that strapped around his back to control the open and close motion of the hand or claw.

> PA: "I never really gotten using these for a couple of reasons. Um, one, I do have a fair amount of arm. So I didn't visit physical therapy when I was younger. So I got pretty good with just my arm. Unless I'm pushing forward to grabbing something, it's just kind of like a heavy thing that's there. And a big design flaw that these have is that essentially how these are fit is, there's like a, like a paper mache. I don't know if you've seen the process. There's like a paper mache for your arm to get a mould. And then they make this plastic thing in here that fits it in. And the thing about these on my hand at least, is that it cooks my hand. So after I wear it for a while my hand is just beat red. It's hot. It hurts. And that's one of the problems I've had with prosthetics. Also, I am missing three and a half inches from the top of my hand to the wrist and then the hand itself. And, uh, something that most people wouldn't notice is that it's kind of heavy. So one of the pros of the 3D printed hand is that it's lighter."

This was an important perspective on prostheses. Even though the sockets are moulded to the wearer, they are still uncomfortable, and someone may find them too heavy to wear. 3D printing was proving to be an effective way of not only personalizing prostheses and devices, as discussed in the case studies but also reducing the material weight, which can be too heavy for long periods. He said that the 3D-printed version "is the best prosthetic I have just because it doesn't weigh much."

PA was provided one when he was in elementary school. He described the prosthesis as an arm with a claw that "didn't look like a hand at all." I was surprised to hear that he also did not have a choice in the prosthesis that he received.

> PA: "They just kind of gave it to me. If there was any choice, I wasn't aware of it."

He described going to physical therapy while in elementary school to get used to using the prosthesis. However, he did not adhere to it because it was heavy and actually hindered his daily activities, as he was already proficient without it. Clearly, the prosthesis was imposed upon him to potentially make others more comfortable than himself. The stigma was present in this scenario as perhaps others felt more comfortable with him wearing a prosthesis rather than him 'exposing' his disability. I was surprised to hear he did not have a choice when he was younger. I asked if the prosthesis hindered him instead of helping him. To which he responded:

> PA: "Yeah, it is. I mean that is one of the problems with prosthetics. Unless I need to like push forward and grab like hold something in that hand, then I'm just pretty good with the hand I have."

He then added that it would be nice to have a hand for some activities, like using VR (virtual reality) controllers and learning to play some instruments. I disclosed that I was working on a prosthesis to help reach octaves for the left hand. We started discussing the functionality and aesthetics of prostheses and his opinions on functional versus aesthetic prostheses.

> PA: "I think that I would like one on either end of the spectrum and like less than the middle, because, like, you know, I can wear this [Raptor Hand]. And when I'm walking around without a prosthetic, if I pay attention, I can catch people double looking, just 'Oh wait, something is different.' And, you know, I might get less of it with this [holds up Raptor Hand] slightly less, though I can hide my regular hand pretty easily.

PA's insight into the 'double-takes' is impactful and provides a commentary about society's perceptions of someone with a limb difference, as he gets looks from people more often when he is not wearing a prosthesis. He continues,

> PA: "But I would argue that, you know, I think one of the pros of making these [holds up 3D printed Raptor Hand] is that it looks cooler. If you're gonna wear a prosthetic that's not completely realistic, you might as well make it look cool."
>
> Me: "So in terms of that, you'd say aesthetics are important to you in a way that maybe it kind of escapes realism? You know, because you mentioned it's kind of hand-like, but it still looks fake. And was it the Raptor hand you called it?
>
> PA "Yeah, it's the Raptor Hand"
>
> Me: "Yeah, where it looks kind of cool and robotic. So would that be your choice instead of this realistic skin-looking thing? You'd prefer to have something more bionic and robotic?"
>
> PA: "Yeah, because I mean, like, then there's just not much different. I mean it's a little something I noticed wearing the prosthetic around, because this is the first time I wore a prosthetic for a prolonged amount of time in over a decade. That people still looked. They've got the double-takes. And, you know, you're probably going to get that. Like, you're still probably going to get that if you're wearing something semi-realistic. So you know, if people are going to look at it, it might as well look cool."

PA mentioned that all the aesthetic prostheses he's seen have been trying to mimic realism. Nevertheless, as discussed in case study II, something trying to mimic realism may end up falling into the uncanny valley. It may bring negative attention to the prosthesis, as it looks real but is not entirely accurate, which may unintentionally evoke an adverse reaction. There is a need for aesthetic prostheses that deviate from realism and instead focus on aesthetics that the wearer prefers, whether it is cyborg, superheroes, or robots. PA also brought up an interesting point about those born without limbs as opposed to those with congenital differences.

> PA: "It seems to all kind of focus around more realistic prosthetics. I'm guessing it's because, if I had to guess, it'd be because it's for people who weren't born with one arm. So they kind of want that realism back."

This was an interesting point. Perhaps more people lose limbs than are born without them, so there may be a higher demand for realism and symmetry for someone who originally had a limb there. Regardless, there should be choices for those with and without congenital differences. If this is the arm that will be part of their body, then ultimately, shouldn't they be the ones who get to choose how the extension of their body looks? We soon discussed prostheses with attachments for the socket for interchangeable hands and tools. PA said he was considering a socket with detachable hands and showed interest in the piano prosthesis prototype.

> PA: "So if I had something like that piano thing where I can just put it on, because I have a keyboard and I can try that out... I have an Oculus Quest that at a certain point kind of becomes useless just because there's an expected second controller there. I like playing instruments, just because I like to try out a bunch of things. I'd probably make something just because it looks cool. Like, I joke about making a hand with Wolverine claws. I'd kind of like another claw just for the nostalgia. Just walking around with a claw. You know, it just depends on the situation.

> Me: "Interesting. Yeah. So it would be like a mix for you between function-specific and also just like aesthetic-specific. You know, you mentioned the claw thing. For you, that interchangeability you would say is important, like both functions and aesthetics?"

> PA: "Yeah. You know, like I said, you know, when you're wearing something like this, it's accessorizing".

The interview concluded with asking PA if we could meet to discuss some design iterations that pertain to our conversation. He agreed that it would be fun. This first interview was very insightful and brought up issues that were not apparent when doing the case studies. Even though he had various prostheses, none were working well enough that he would want to wear them. His favourite hand, which he had first worn for an extended period of time in over a decade, was one that he downloaded and 3D printed from the internet. The issues around stigma, the imposition of the prosthesis when he was younger, and the double takes he gets without it now are unfortunate to hear but a reality for many people who have amputations or congenital limb loss. He has a positive and inspiring outlook when he says people will look anyway, so he might as well be wearing something cool. This actually displays a strong SOC from PA, as he comprehends and makes sense of the situation, finds ways to manage the situation by utilizing 3D printing his own prostheses (artifactual-material GRR) and his confidence (emotional GRR), and finds meaning in the situation by creating a positive perspective and way to move forward. Now it was time to find ways to create SRRs (specific prostheses) to further the SOC and increase the activation of GRRs. The key takeaways from our first conversation were:

- There needs to be more choice for prostheses
- 3D printing is excellent at keeping prostheses lightweight
- 3D prints are becoming more accessible through online sources
- PA likes different tools to serve different purposes
- Stay away from realism
- PA would like aesthetic and functional prostheses on either end of the spectrum

Participant A had grown accustomed to his hand when he was younger and did not need to have something to cover his hand for the sake of covering it. If PA would wear prostheses, it would have to truly serve a purpose: facilitate a function or aesthetics.

7.3 Ideation: Round 1

Fig 121. Mood board. Images from dexerto.com, superherobd.com, nytimes.com, facebook.com, scrolller.com, instagram.com, creator.nightcafe.studio.com, teepublic.com, artstation.com

Participant A mentioned the accessorizing aspect of prostheses, straying from realism to make them more robotic and making them "look cool" for the sake of making them look cool. He had also mentioned that he "joked" about creating Wolverine claws from the DC superhero. With 3D printing technology, customization and personalization could achieve these aesthetics while also keeping them lightweight to not put so much pressure on the residual limb.

The first idea I wanted to ideate was the Wolverine Claws. This is the low-hanging fruit since the design and aesthetics could be explicitly referenced from existing images. This design would be purely for aesthetic purposes, like a passive prosthesis, but with aesthetics that are not meant to look fleshy and skin-like. Instead, they are the preferences of the wearer. In this case, Participant A.

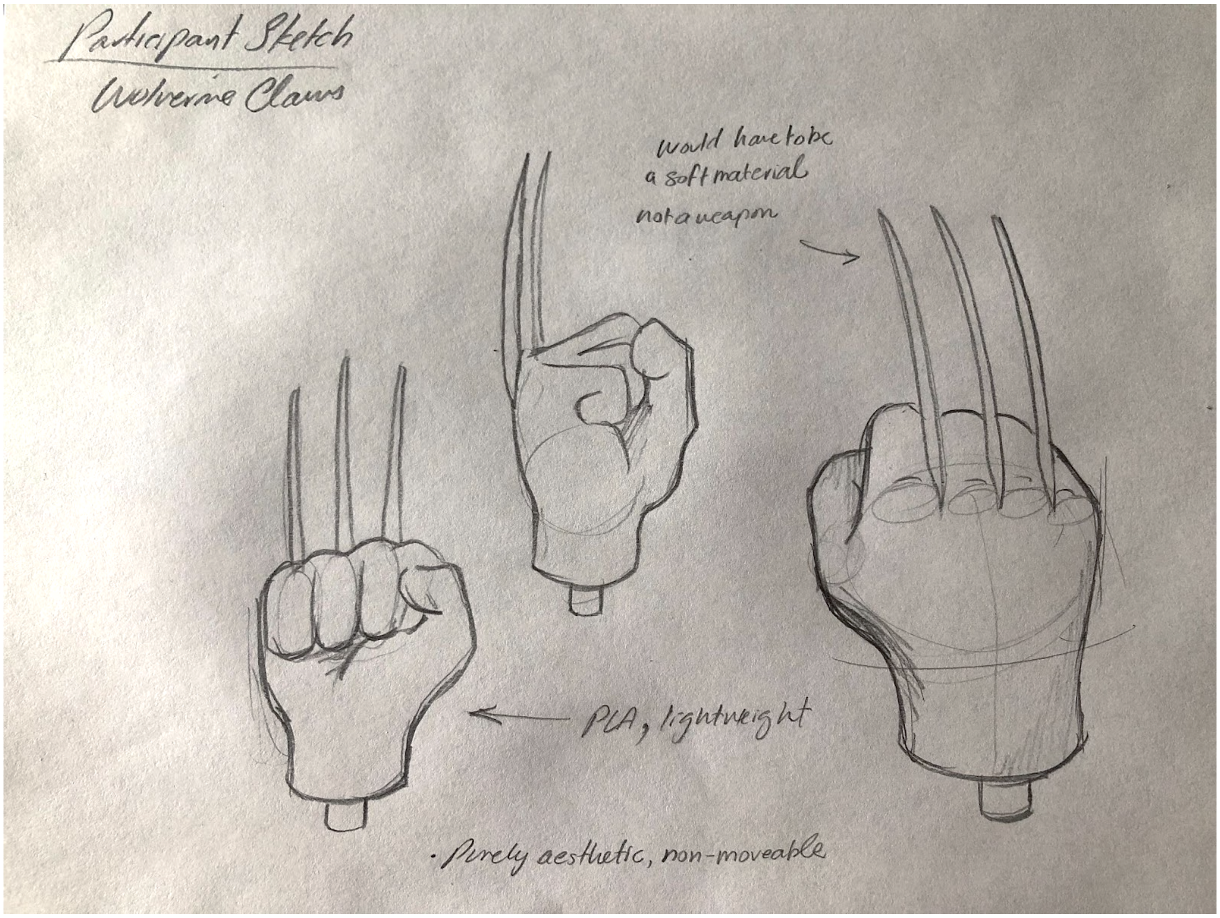


Fig 122. “Wolverine Claws” rough sketch

The first sketch was simply a fist with claws to mimic the aesthetics of the DC superhero Wolverine. This hand would screw on as an attachment to a socket. Since passive prostheses mimic the wearer's other arm, why can’t there be passive prostheses with other designs? Perhaps not for daily use or a trip to the mall, but this hand could be acceptable for events, conventions, and even Halloween.

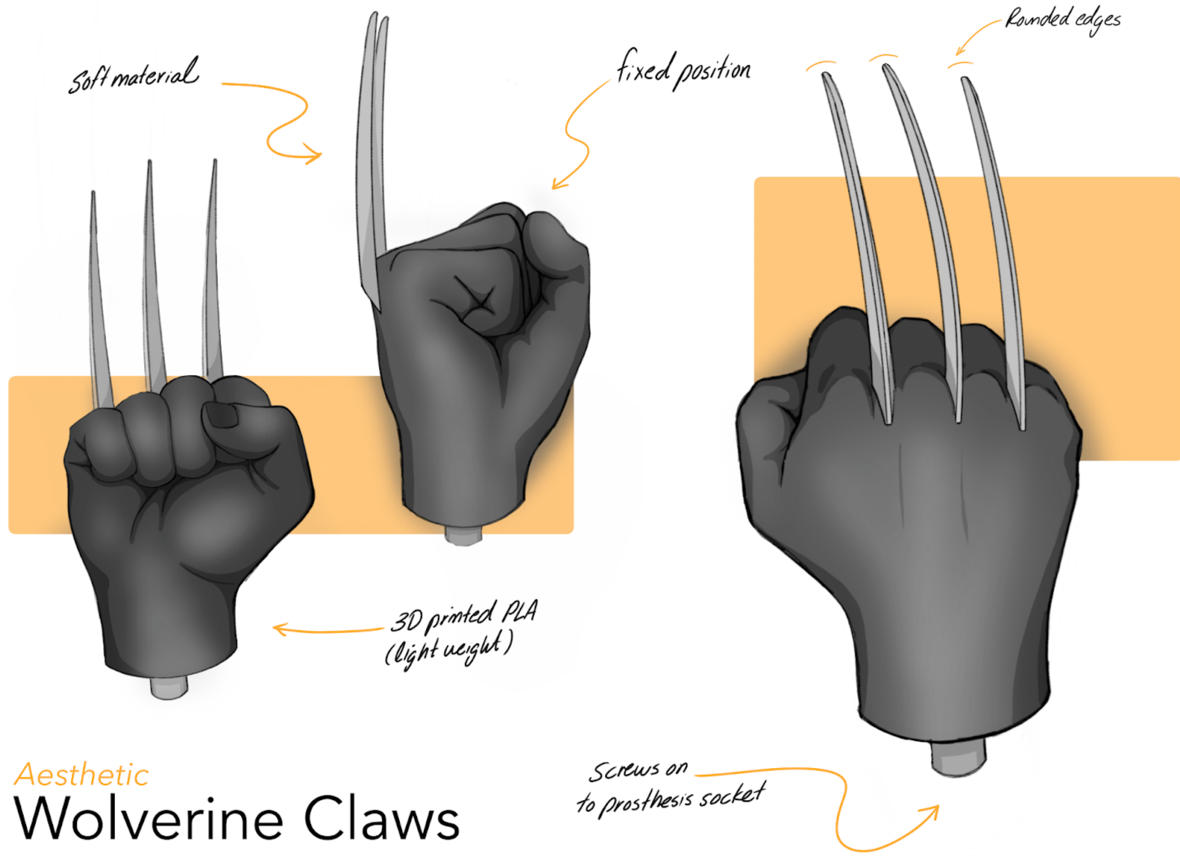


Fig 123. Concept sketch of "Wolverine Claws" passive prosthesis

Of course, the claws would have to be a softer-than-plastic material such as a TPU or resin with a lower shore hardness, and the points and edges would have to be rounded as well. 3D printing would keep the prosthesis lightweight with a material like PLA. A smaller nozzle and a lower layer height would increase the quality and resolution of the print. This prosthesis could be relatively easy to produce, as Thingiverse and other open-source file-sharing sites have models of hands and fists to download. Though the shape of the fist is realistic, keeping the colours grey or black and away from fleshy tones would prevent it from falling into the uncanny valley.

The following ideas from the conversation and the mood board were to make hands that catered to PA's wants of having a hand just because it "looks cool." We had talked about something robotic rather than realistic looking. Again, these ideas would be looking at aesthetics rather than functionality. I did not know precisely what aesthetics, colours, and forms PA gravitated towards, so I sketched out two ideas with different lines, shapes, and forms. They would be called ‘Cyborg Hands’. The first hand had a lot of decoration and details for a maximalist look. This sketch followed robotic images on the mood board that were more complex.

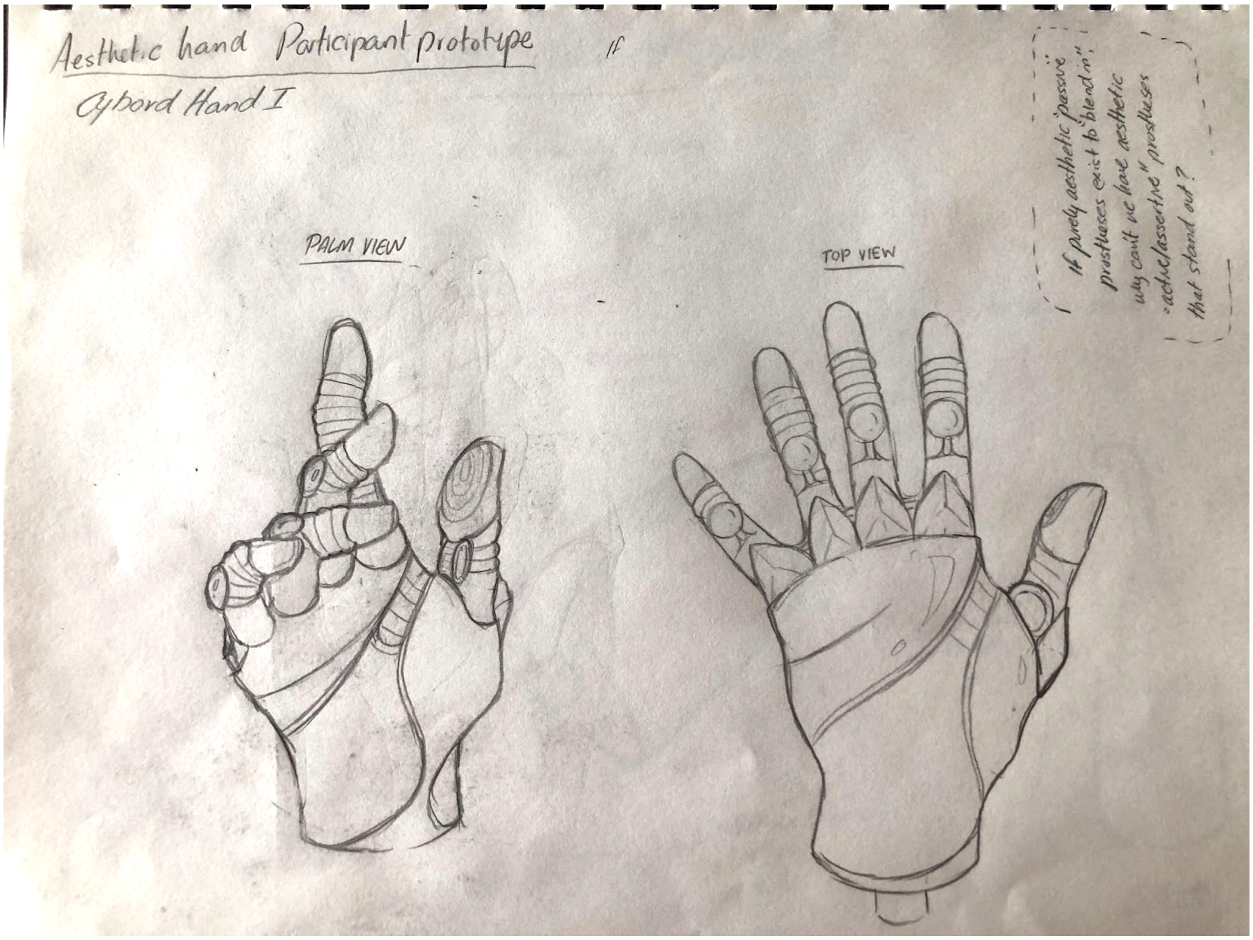


Fig 124. Rough sketch of “Cyborg Hand 1”

I colourized the sketch with two different colour palettes since colour still needed to be discussed with PA. It was also interesting to see how the overall aesthetics of the design changed from the application of different colour combinations.

Fig 125. Concept sketch of “Cyborg Hand 01” in blue

Fig 126. Concept sketch of “Cyborg Hand 01” in maroon

The second hand was more simplistic compared to the first ideation. Adding an LED light on the second hand would also be interesting. Accommodating lights in a passive prosthesis is achievable, since there is no additional hardware inside to wire around.

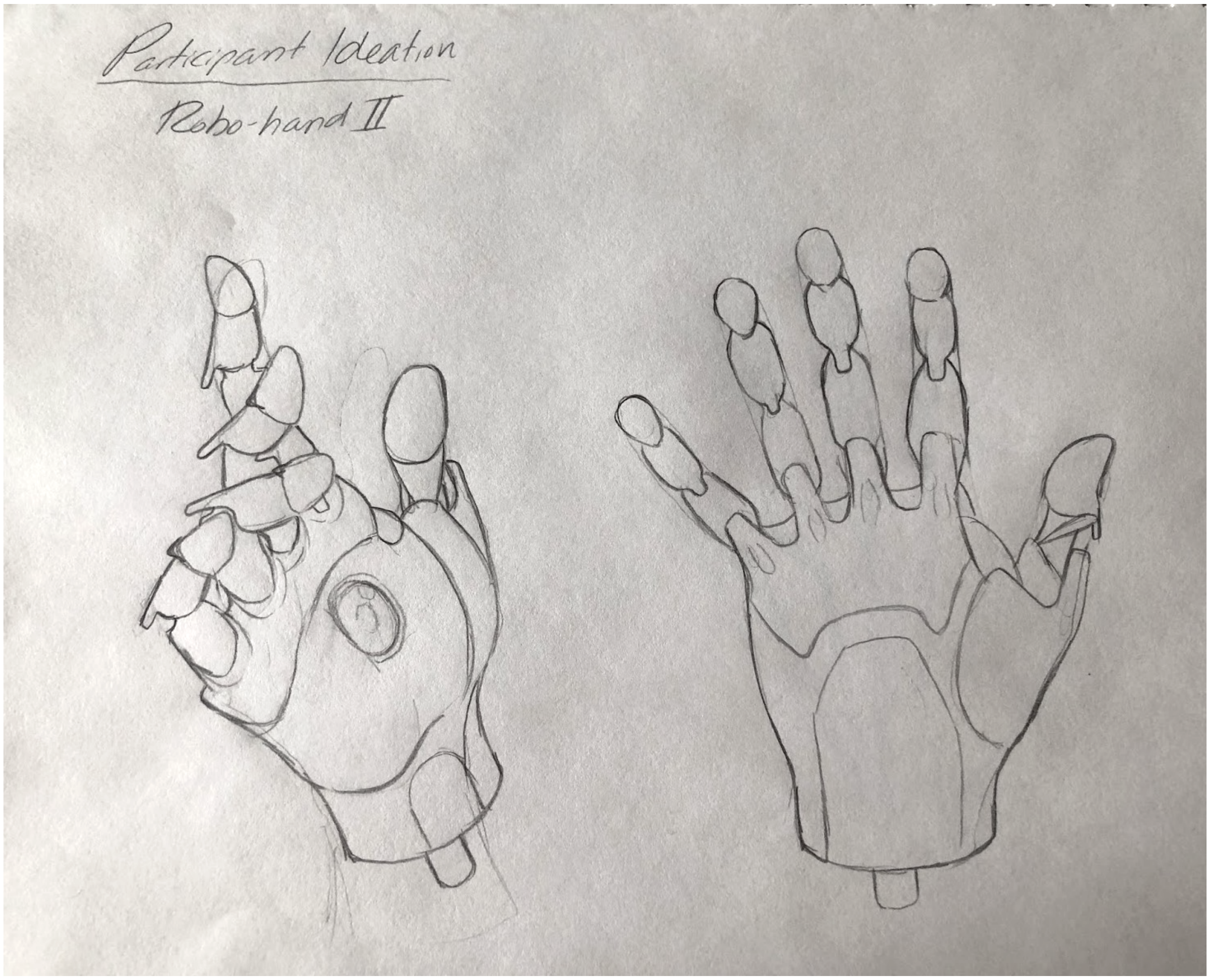


Fig 127. Rough sketch of "Cyborg Hand 02"

Again, two different colour combinations would be beneficial, as it would be helpful for PA to see the possibilities of colour for each hand and how it changes the overall aesthetics. I intended to figure out which colours PA would gravitate towards.

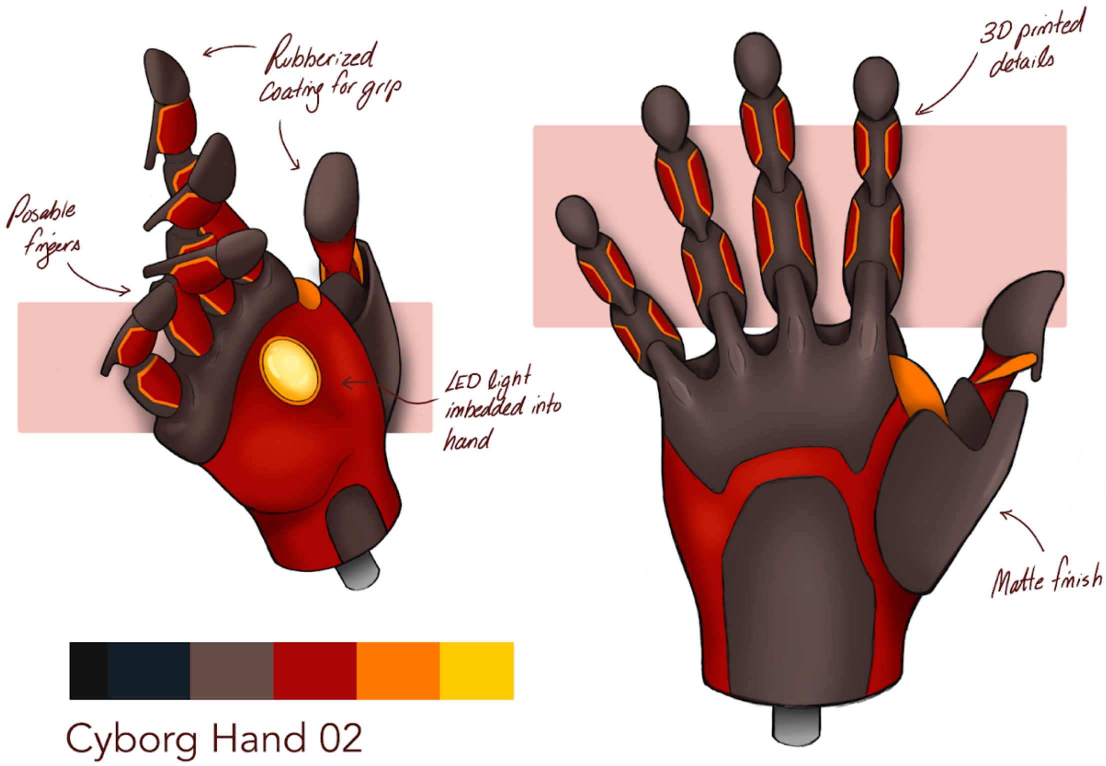


Fig 128. Concept sketch of “Cyborg Hand 02” in red

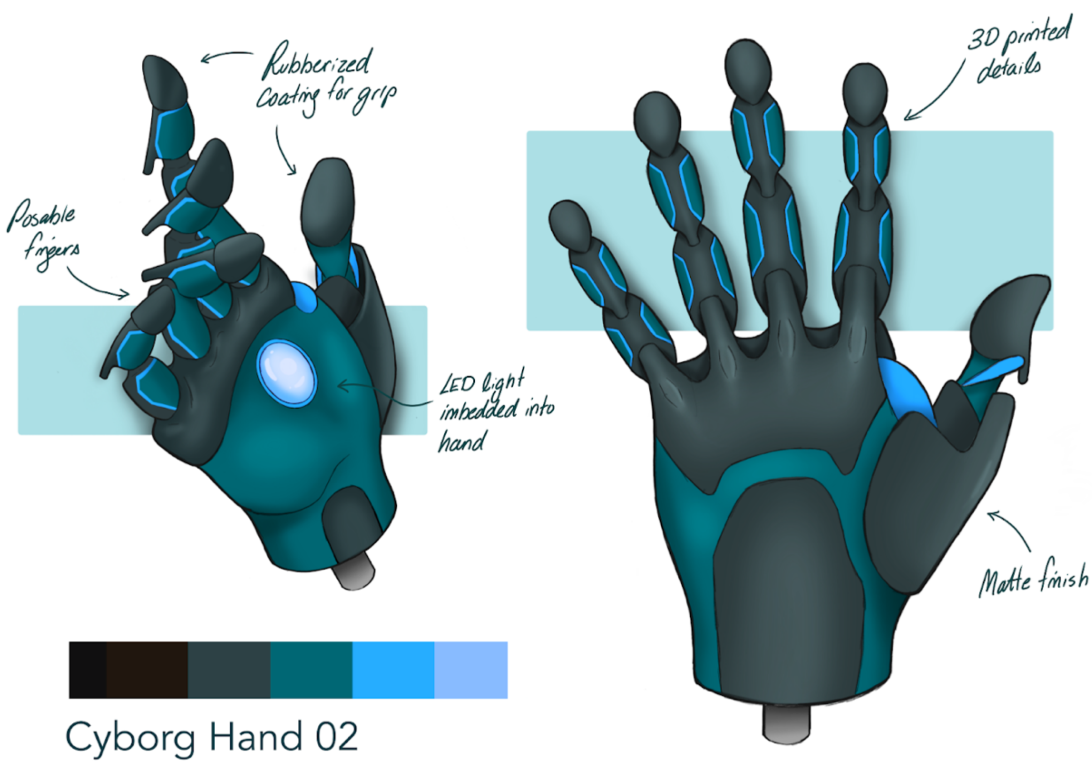


Fig 129. Concept sketch of “Cyborg Hand 02” in blue

I also wanted to tackle one functional prosthesis that came up during the conversation. PA had shown interest in the piano prosthesis since he wants to learn instruments and owns a keyboard. Case Study II: Piano Prosthesis was created with the intention of the left hand. However, it could still be used for the right hand if someone wants to play octaves. Another low-hanging fruit would be to take out one of the pegs so that a single-note melody line can be played, which is common for the right hand.

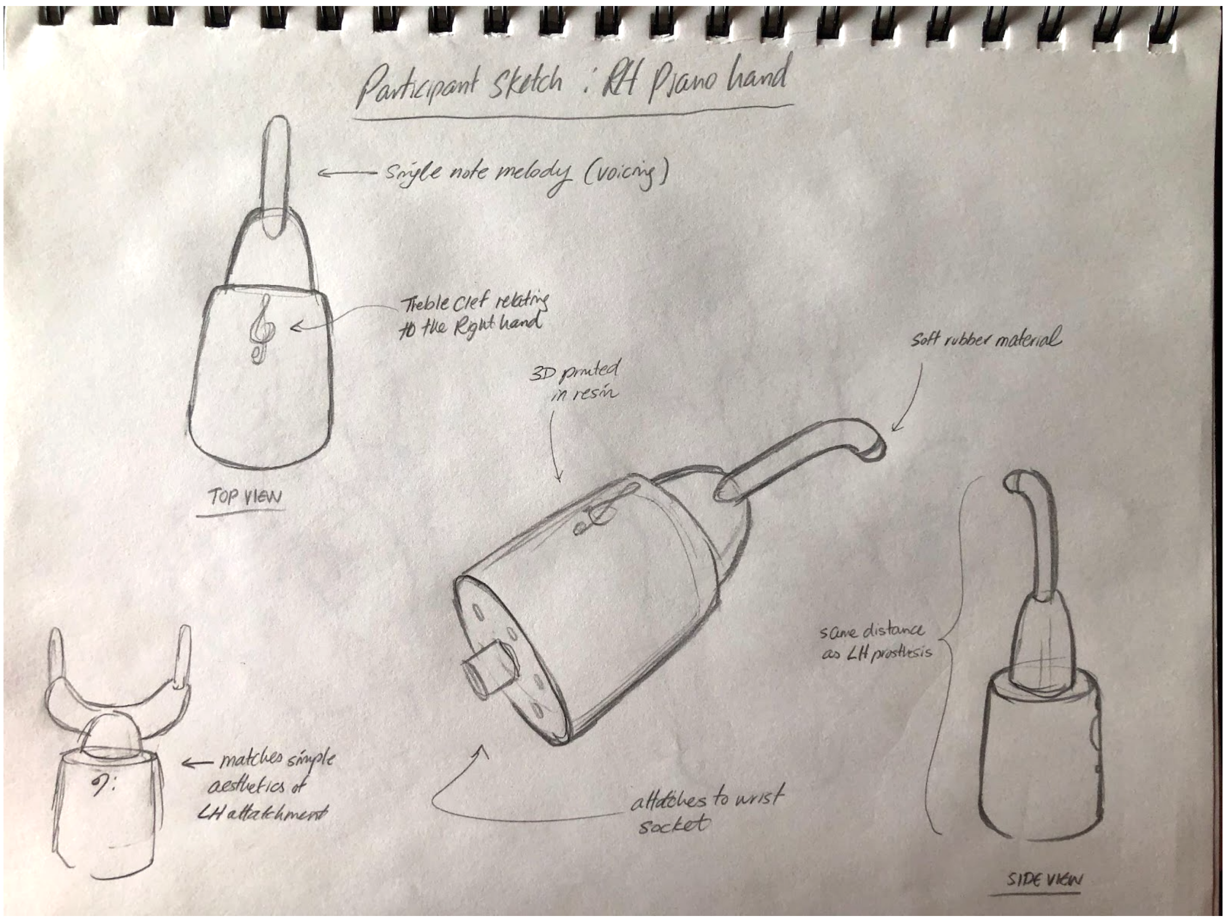


Fig 130. Rough sketch of right hand piano prosthesis (single note)

The Right-Hand Piano Prosthesis would match the form and aesthetics of the Left-Hand Piano Prosthesis. Since the treble clef corresponds to the right hand, the detail would be on this prosthesis.

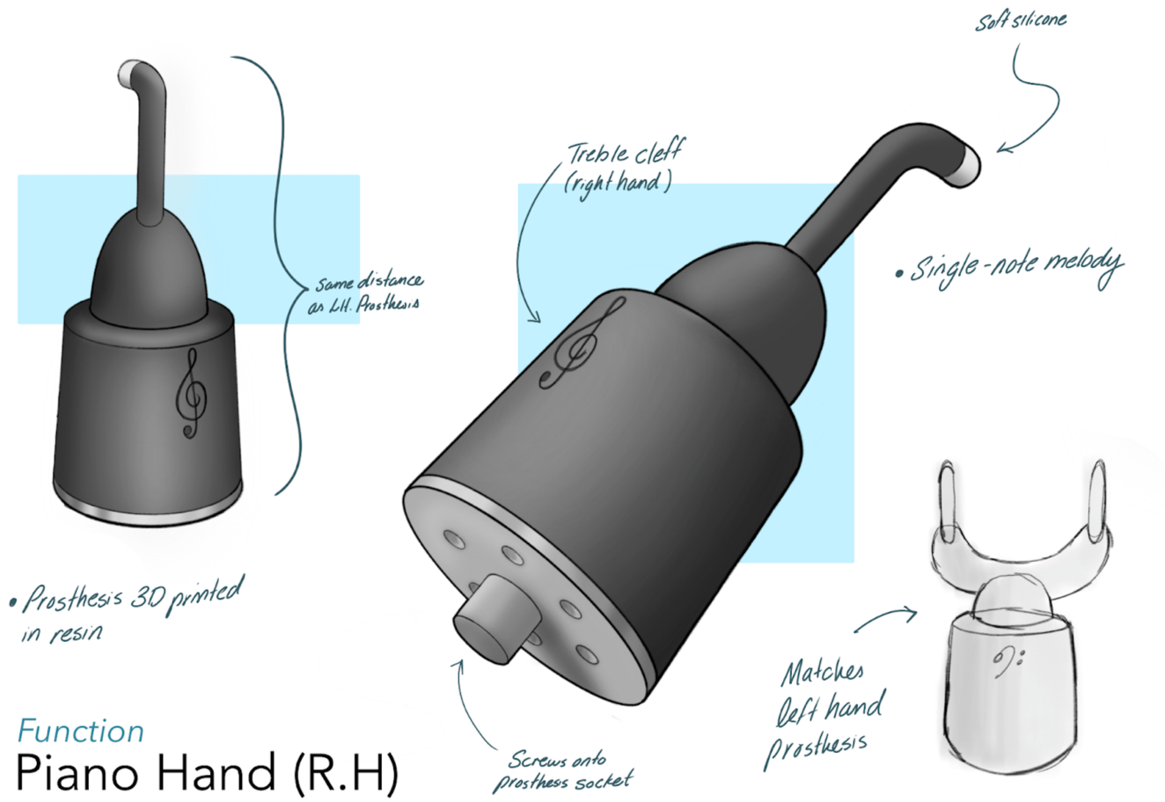


Fig 131. Concept sketch of right-hand Piano Prosthesis

At this point, I wanted to talk to Participant A to discuss his thoughts and ideas on the ideations. With some visual material, it is better to pinpoint what is working for form and colours and what is not.

7.4 Interview #2

The second interview aimed to get feedback from Participant A on the ideations and discuss how prostheses could be improved by talking in more detail about aesthetics and functionality. At the beginning of the meeting, PA mentioned he attended an AI conference, where he wore an updated version of the 3D-printed Raptor Hand. During the conference, he observed that many people were uncomfortable with the prosthesis.

> PA: "Well, some people like thought it was cool when I had some conversations with it. But I also like went to shake people's hands with it because everyone, you know, instinctively puts up the right hand and that's why kind of why I was wearing it. And it kind of threw people off guard".

PA had experienced a wide range of reactions to his 3D printed prosthesis, which echoed his reflections from the last discussion, where he experienced double looks from people whether he was wearing the prosthesis or not. "If people are going to look anyway, might as well look cool." This conversation segwayed into a discussion of the ideations. I shared my screen and reviewed each drawing, discussing my thought process and tying in the points from our previous discussion. While presenting, PA looked excited and was smiling throughout the slideshow. When I was done presenting the ideations, I asked for general feedback, and then we could go into the details of the drawings. When discussing the Wolverine Claws, he said that they might get in the way of many things, and a simple solution would be to have the claws retract into the prosthesis so they are not exposed all the time. We discussed having a lever, button, or springs that would move the claws in and out of the hand, which would be a consideration for the next set of ideations. When we moved on to Cyborg Hands, PA said he gravitated towards Cyborg Hand 02 in the blue palette because his favourite colour is blue. He liked things more 'streamlined' rather than highly detailed, like Cyborg Hand 01.

> Me "I was wondering would these designs be useful to you, hypothetically? Like, would you see yourself using these designs if they were available to you?

> PA: "Yeah, they look cooler than the one I have, so... Yeah I'd wear something like this".

We talked about passive prostheses, which are typically made to mimic someone's other arm or hand. I asked him about his thoughts on them.

> PA: "Well, I've worn, I've been recently just wore a passive prosthesis for about a few days. You know, as long as it's light and not encumbering, it's usually not too bad. The only problem I really had once was when I had to carry a tray and open a door. And that, that kind of, that was kind of difficult because I had to balance

> it on my arm. But, you know, I mean, I was wearing it mostly just for fashion and also to, like, have something there if someone went to shake my hand".

He said that having something on the hand to move the fingers so they could be used to help carry things, create hand gestures, or shake someone's hand would be useful, as long as the fingers were not too easily moved. Having the fingers moveable enough to wrap them around something would be helpful for him. We discussed silicone pads on the fingertips to help grip a prosthesis if the hand was to hold something. This would be an interesting consideration for prostheses. They are moveable enough so that they can be semi-functional. We moved on to talking about the functionality of the Piano Prosthesis.

> PA: "So, you know, as long as the base isn't too wide, I don't think it would get in the way. My wrist, my elbow kind of has a good up and down motion. You can make it go really quickly. So I think that'd be good. I'm curious how the right-hand one would work on the left hand, or the left-hand one would work on the right hand. I wonder how much I'd be able to, if I'd be able to, like, if my turn would be enough".

> Me: "Oh, like in terms of playing one note with the two pegged one?"

> PA: "Yeah."

> Me: "Oh, interesting. That's interesting. Because I haven't thought about someone doing it like that because I had designed it set an octave. But yeah, you're right, like, interesting to kind of switch it over and play a single note".

PA was referring to the wrist movement he would need to angle the left hand version of the Piano Prosthesis in a way that would allow him to switch between playing octaves and single notes. Instead of having two different prostheses, have one prosthesis that can do both functions. We discussed having a peg that could switch around so that an octave could be played and then switched back for single notes. This would be a consideration for the next set of ideations.

Participant A had some questions about the production of these prostheses. We talked about 3D printing and autobody paint to make things look glossy and refined, and PA even brought up electrolysis for metal coating. However, PA questioned:

> PA: "I think the thing that's worth considering is who's going to take the effort to make it look like that? I mean, if you're selling it, but, I mean, if you're just making a hand, like, sanding a 3D print is really time intensive".
>
> Me: It's true. But I think everything's comparative though, because we have to imagine how much time a prosthetist is taking, filling in all these little hairs and details on the hands and stuff.
>
> PA: Oh yeah that's true.
>
> Me: So, it's like the idea of, well, what if that effort was spent into making a cool hand, you know, is it the same amount of effort? Is it more or is it less? Like, it could be actually the same amount of time, if we think about it, you know.
>
> PA: Yeah, that makes sense.

As idyllic as my thinking may be, this is a fair topic to contemplate. If prosthetists take the time to colour-match skin tones, create skin textures, and add nails and hairs to the arms and hands of passive prostheses, then could that effort be put into something not realistic? Like an aesthetic robotic or cyborg hand? If the effort was shifted to what people truly want, we might find that there is actually a lower demand for hyper-realistic prostheses. Again, this would depend on person to person and also factor in whether they were born with or without the limb in the first place. Just before our conversation ended, PA asked if I could send him the 3D modelling and STL files for the piano prostheses. I gladly sent them to him so he could print, customize and test the prototype as he pleased. I was happy that he found the prototype of interest. After our conversation, I returned to the drawing board to refine the ideas with what had been discussed.

7.5 Ideation: Round 2

The ideations were close but needed just a few more refinements with the ideas from Participant A. The Wolverine claws were updated to have a lever that retracts the claws in and out of the hand. Since this ideation is for aesthetic purposes, there is no hardware inside that would inhibit a contraption, even something as simple as a lever.

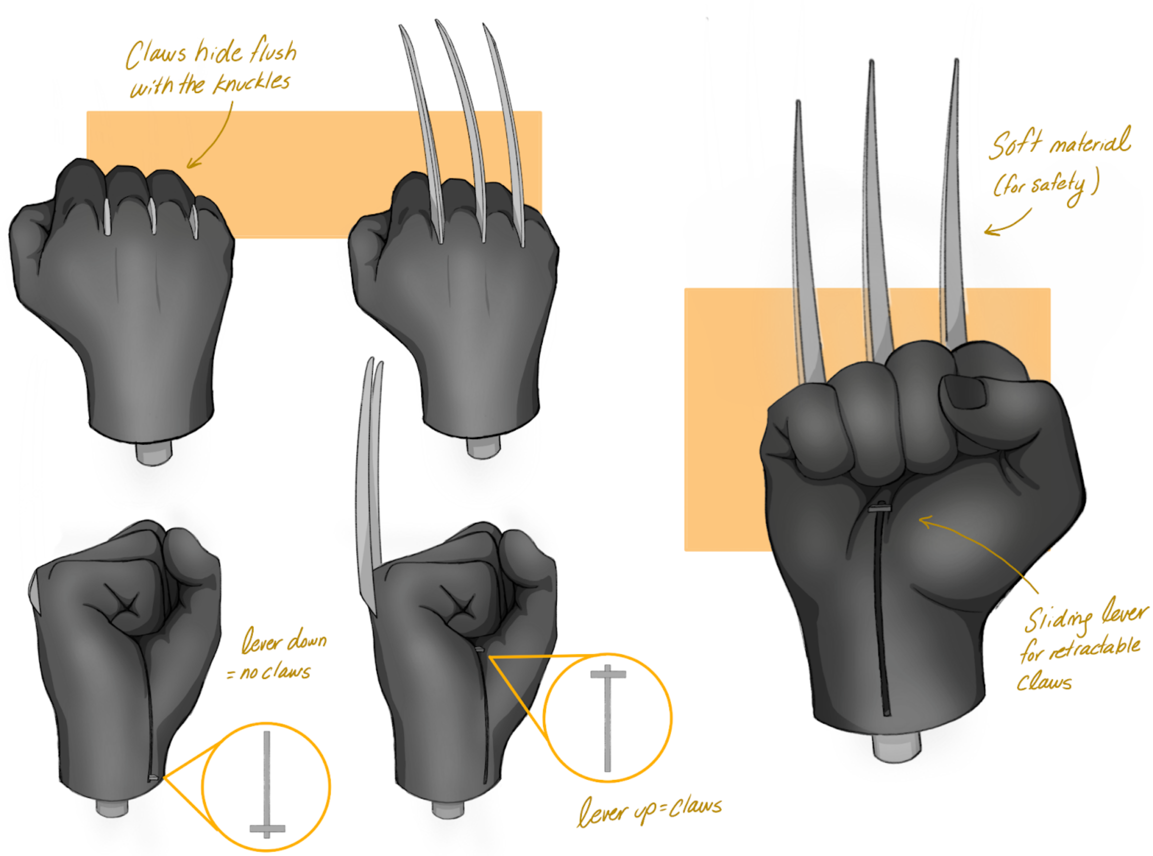


Fig 132. Updated concept sketch of the “Wolverine Claws” prosthesis

I ideated another version of the Cyborg Hand with the aesthetics and colours that PA was drawn to. Two different blue colour palettes were chosen: a true blue and an aqua-marine palette. If these prostheses were hypothetically manufactured, the fingers would have some structure inside that would facilitate movement through the joints so that the wearer could pose them.

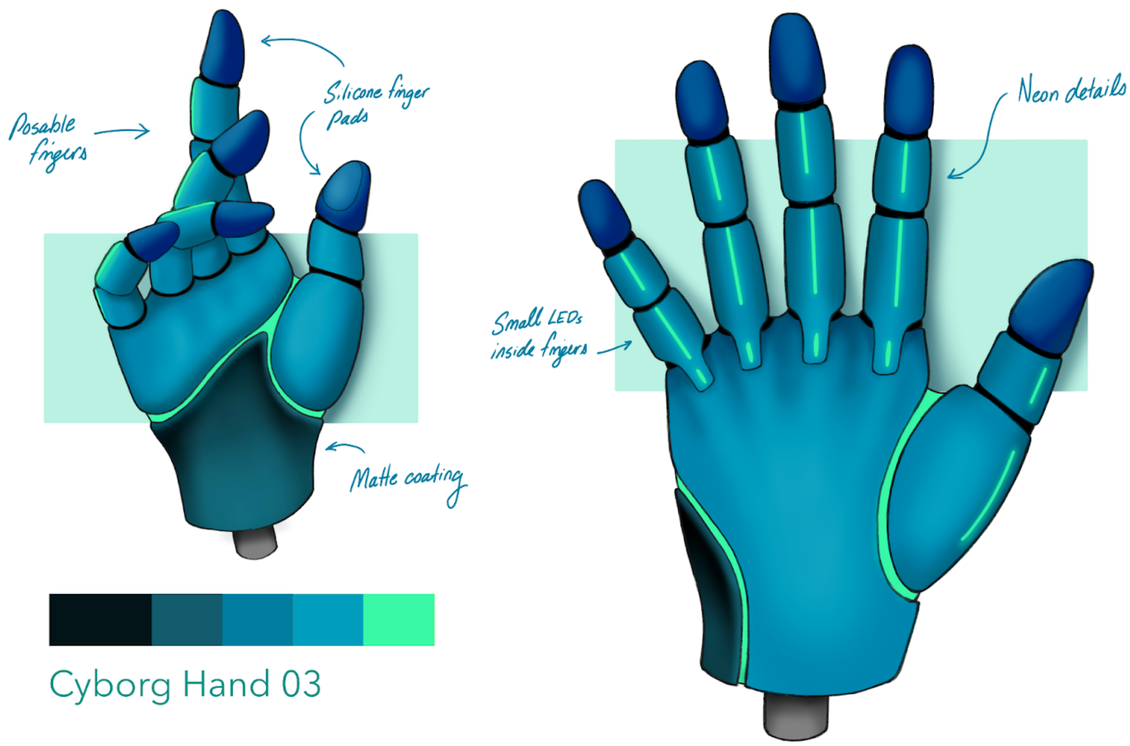


Fig 133. Concept sketch of “Cyborg Hand 03” in aqua-marine

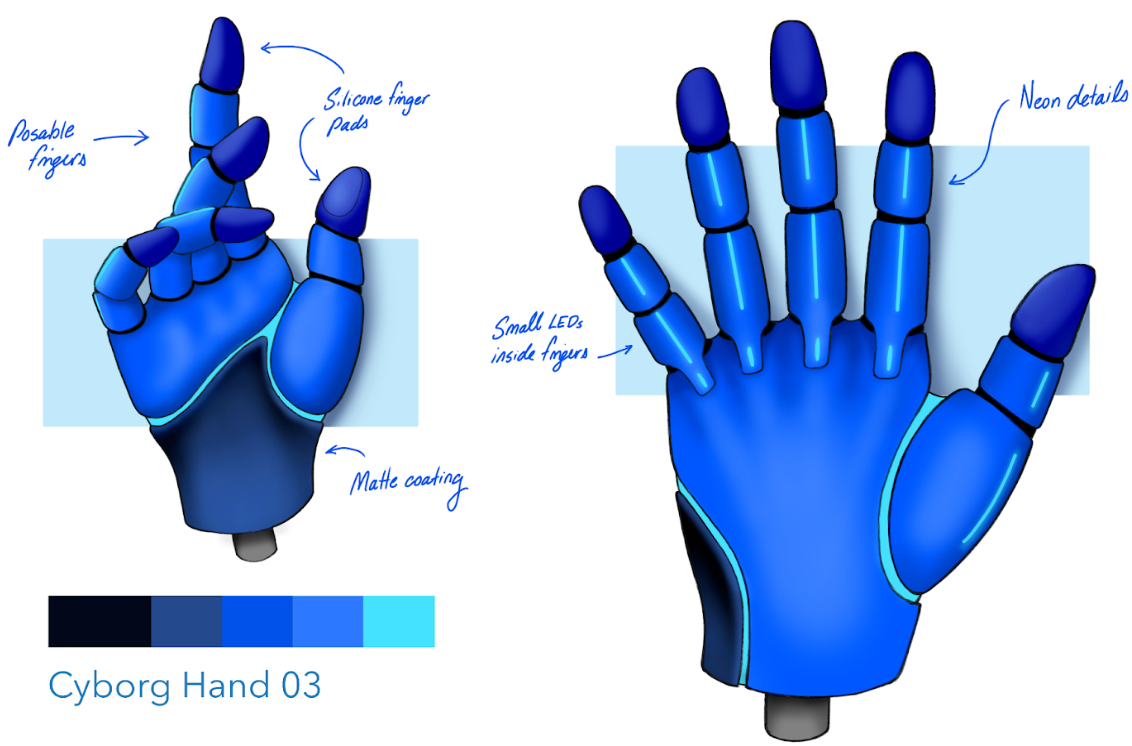


Fig 134. Concept sketch of “Cyborg Hand 03” in true blue

The ideation of the piano prosthesis turned from a single note to an octave prosthesis, this time with the ability to move one of the pegs to play single notes. The peg on the right can twist upwards to give the ability to play single-note melodies without angling the wrist. The peg on the left would be stationary, as it makes sense that this peg would stay down as it reflects the index finger.

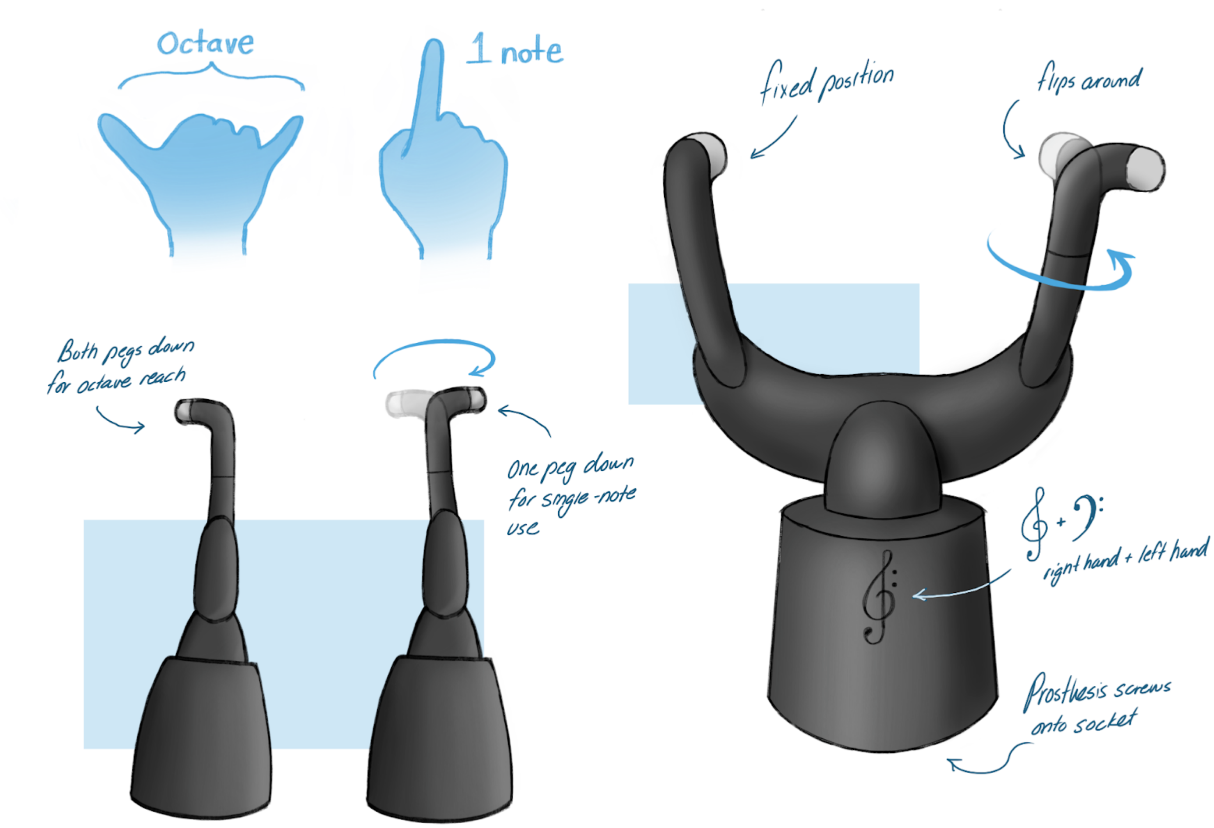


Fig 135. Updated concept sketch of the Piano Prosthesis.

These iterations, though simple, could be effective in facilitating the functions and aesthetics wanted by Participant A. These prostheses could be relatively inexpensive due to 3D printed material like PLA. Shiny, bright colours would be achievable due to the possibilities of post-processing. Like Case Study II: Piano Prosthesis, the prints can be sanded, primed, and sprayed with autobody paint. It allows for an aesthetically pleasing finish, and autobody paints offer various colours, metallics, mattes, and pearls. Silicone moulding could also be an option for softening the fingertips. Rubber coatings, as used in Case Study IV: Rowing Device, would be a great way to achieve a different texture and aesthetic finish.

These ideations focused mainly on the aesthetics of prostheses. Participant A brought up the perspective that prostheses are like accessories and that someone may want different aesthetics to simply "look cool." Besides the piano prosthesis, we discussed other functional requirements. However, they would be too difficult to achieve in the scope of this thesis. For example, we talked about VR controllers because he liked to play games on his Oculus Quest. However, this was outside of the scope since operating the controllers requires the complex dexterity of multiple fingers. To design a prosthetic hand with full finger functionality to operate a VR controller would be to dive deep into the engineering and hardware required to make it work, which is outside of my expertise. To draw a device that theoretically works in that manner would also be surface-level and dismissive. Of course, drawing up something that *hypothetically* works would be easy. That is why the ideations stayed very simple for functionality and focused more on the breadth of aesthetics, which are achievable through technology like 3D printing.

This small study with one participant showed interesting perspectives and validated the need for different aesthetic and functional devices. PA had ideas and opinions on devices that could differ from another prosthesis wearer. Wolverine Claws, blue, streamlined robot hands, and a modular piano prosthesis were exclusive to PA's interests and desires. Of course, these ideations are not significant to PA's survival, but they highlight the complexities of his personality and his values. This is the importance of a salutogenic orientation. While pathogenesis has given him prosthetics that are uncomfortable, heavy, and unaesthetic, a salutogenic approach would emphasize what exactly PA needs and wants. From a pathogenic viewpoint, PA could be seen as perfectly healthy, yet salutogenesis asks deeper questions about well-being to find ways to promote further health. Pathogenesis asks if PA is healthy or ill and if the prosthesis “works” for daily tasks. Salutogenesis would ask PA: Can these devices help enrich his life by facilitating new hobbies? Could they help him express his sense of identity and interests? Could they change how people shake his hand, interact, and look at him? These questions are worth exploring and a reason to consider a salutogenic orientation rather than a solely pathogenic paradigm. Salutogenesis promotes health and advocates for the person inside the body rather than reducing them to the physical body. The four case studies and this participant study evoke the question of what other prototypes and solutions are possible with a salutogenic and design perspective and what lies dormant due to the pathogenic orientation.

Chapter 8. Conclusion

8.1 Discussion

Case studies I, II, III, IV, and the Participant Study explore the aesthetic and functional potential of prostheses and disability devices of the hand. They explore the question, "What could these solutions look like if concerns with body image, interests, stigma, ability, and other salutogenic concepts are addressed? What kind of SRRs can combat these stressors to increase one's sense of coherence? The case studies conveyed how the designer could be a general resistance resource (design expertise applied to many areas) to create specific resistance resources (function and aesthetic-specific devices) that apply to specific situations to ease stressors for an individual, increase the sense of coherence, and help move towards ease and health. 3D printing was a great tool to achieve customization for personalized devices, and as accessibility to the technology expands, the application of 3D printing in healthcare solutions could increase accessibility to a wider range of solutions while lowering costs for customized devices. Though the case studies show small areas of intervention, the solutions can have a meaningful impact on the person. Alleviating these small stressors can stop them from further manifesting as tension in the body (poor mental health, physical health, and psychological and physiological stress). The proposed functional and aesthetic solutions display that even the simplest solutions may be effective in combating psychological pathogens like body image, mental health, physical health, and stigma. Though these are only prototypes, they show a salutogenic orientation and design intervention that can improve someone's capacity to comprehend, manage, and find meaningfulness in their lives. Ultimately, focusing on the 'person' inside the body unveils the genuine problems that must be addressed. The salutogenic model nurtures all aspects of well-being (physical, mental, and social), while pathogenesis is exclusively physical. Salutogenesis, with the help of design, guides the creation of SRRs and GRRs that can increase one's sense of coherence, move up the ease/*dis*-ease continuum, and reach health—a life where people are thriving rather than just surviving. As Antonovsky puts it,

> "The more the patient is perceived as a total person, the better. The more the focus is on the needs of the patient, the better. The more decision-making power rests in the hands of the patient, the better" (Antonovsky 1979, p. 208).

The case study outcomes of the lowest-hanging fruit beg the question of what could be possible if research and resources were invested in this problem. First off, there would be more sophisticated and innovative solutions for SRRs. Secondly, the grim statistics on disability and health presented in Chapters 1 and 2 could be improved by increasing solutions that promote overall health and well-being. However, the outcome of a salutogenic model cannot be measured in numbers, as it is naturally situated to be qualitative. Diabetes, obesity, and blood pressure can be measured and translated into numbers and statistics. How can one measure the meaningfulness of the ability to play piano? How can one measure the relief that their device sparks curiosity from their peers rather than judgment? This may be the drawback of the salutogenic model within healthcare, as the proof is not within the numbers and biological data but rather within the emotions and perspectives of the people who tell their stories.

8.2 Limitations

There are a few limitations that were discovered throughout the case studies. Primarily, the solutions of the case studies do not look into the engineering or logistics of how these solutions would be made and manufactured. As a designer, I have limitations in my expertise that prevent me from fully understanding the technical and logistical aspects of producing prostheses. The proposed solutions are low-hanging fruit due to the need for more understanding of the engineering behind the prostheses. For interventions such as disability devices and prostheses, designers could only work with an interdisciplinary team with different areas of expertise. Besides the Splint Rings, which are meant to be used at someone's discretion, the devices would also have to be tested for safety and durability if they were ever manufactured and sold in the real world. The case studies are discussion points for what is possible with design and a salutogenic framework, but it is vital to communicate that these will not be manufactured. Another limitation was that experience-based co-design was not utilized due to the time constraints of the thesis and location differences with the participant. Though user-centered design was at the forefront of the design process and motivations, a co-design approach would have been much more effective in incorporating the salutogenic concepts important to understanding the unique individual.

Finally, there are limitations to the salutogenic model itself. Changing healthcare to a salutogenic approach, or at least incorporating it, would mean overhauling the entire model of Western medicine. As discussed in Chapter 3, lots of clinical research would have to be done in order to prove that it is of enough significance to adopt into healthcare, but as mentioned above in 8.1, without directly measurable and quantifiable data, the importance may be overlooked. The healthcare system is rigid in its structure, making it challenging to incorporate salutogenesis into the hospital or clinic room. Furthermore, it should also not be the burden of the practitioners to incorporate the model into their practice when there are already short appointment windows and burnout in healthcare staff. Healthcare policy would have to change, as would healthcare education and curriculum for medical students. There would have to be a monumental ground-up change for a salutogenic orientation to ever be adopted directly into the healthcare system. Even though designers can help take the weight off of the healthcare system by facilitating a user-centred salutogenic approach to patient solutions, incorporating designers and design methodology would also take time and would have to be researched to understand how it can be implemented.

8.3 Future Research

The research throughout the thesis has shown the need for further exploration into the marriage of salutogenesis, design, and health. Firstly, research conducted into experience-based co-design would be beneficial, as both concepts of salutogenesis and experience-based co-design have overlapping motives of directly involving the end user/patient in increasing their quality of life. In an experience-based co-design setting, it would be essential to have an interdisciplinary team of a designer, patient/end-user, engineers, technicians, and health experts and practitioners, as all parties bring a particular set of expertise, experiences, and skills to the table. Due to the limitations of this thesis, co-design could not be implemented, so further research should be conducted to include this process, as it could yield better personalized solutions. Another consideration into the design process would be to further consider aesthetics when designing for function. As Case Study II and IV were function-focused, the aesthetics followed the 'form follows the function' principle. Due to the time limitations of the thesis, the function was to be the primary focus for those case studies, resulting in sacrificing time for aesthetic considerations. For future research, looking deeper into the aesthetics of functional devices and prostheses would be beneficial instead of leaving to the 'form follows function' principle.

In Chapter 5, the case studies narrowed down to a tiny sliver of intervention: hand disability devices. However, as discussed, salutogenesis could be implemented in other areas of device design. For instance, leg prostheses, reconstructive prosthetics, and even devices outside the body like wheelchairs, canes, braces, etc. could benefit from design with a salutogenic orientation. Research into salutogenesis in other areas of healthcare devices could provide more personalized solutions beyond hand devices. Furthermore, future research should explore how salutogenesis and design could be valuable beyond physical products. Chapter 6 created Artifactual-material SRRs (physical products that help combat the stressors of a particular scenario). It would be beneficial to look beyond physical products, as design also creates systems, services, and experiences. What would a system design with a salutogenic orientation look like? What about a service or experience developed with salutogenesis and user-centred design at the forefront of the design process?

At the very beginning of my thesis research, I was introduced to the concept of salutogenesis when I came across "salutogenic architecture," presented in Chapter 26 of the Handbook of Salutogenesis (Mittelmark et al.). Salutogenic architecture is used in hospital spaces to increase a sense of well-being through biophilia, colours, and interests of specific demographics using that space. It is a step in the right direction since there are barriers to incorporating salutogenesis directly into care. However, so far, salutogenic architecture is the only explicit form of unification between design and salutogenesis. If one were to look up "salutogenic design" on the internet, one would only see architecture-related articles (at the time of this thesis). I propose that true "salutogenic design" should not be the application of the design (such as architecture or physical prototypes) but rather the framework, concepts, and way of thinking that is applied to the design. As this title suggests, bringing the 'person' into personalization through salutogenic concepts utilizing design should be the focus and the framework. For further research, I would like to explore and develop "salutogenic design" as a new design process. Creating a framework from salutogenic concepts like GRRs, SRRs, stressors and tension, ease/*dis*-ease continuum, the sense of coherence, and even the Orientation to Life Questionnaire could offer a methodology that can apply to different areas of design for solutions and applications even outside of healthcare.

8.4 Summary

This study provided a background on topics surrounding disabilities, such as stigma, health, and poverty. With a pathogenic focus in healthcare, issues beyond curing illness and basic function are not addressed. However, being free from disease or cured of illness does not mean that someone is fully healthy. The research has discussed that physical, mental, and social well-being contribute to someone's health, yet the pathogenic paradigm does not support all these aspects. For prostheses and disability devices, the scope must go beyond basic functioning for someone to live a full (meaning all-encompassing) and meaningful life. For people with disabilities of the hand, life is more than being free of illness and the ability to hold and grab objects. Concepts of Antonovsky's salutogenic model can help someone move from dis-ease to ease by exploring topics beyond the physical body. The case studies within the thesis explored the creation of SRRs and GRRs with a salutogenic orientation facilitated by user-centred design. By focusing on non-pathogenic concerns like hobbies, interests, lifestyle, and personality, the solutions present a commentary of what people may truly need to overcome and prevent psychological and physiological ill-health, known as stressors and tension. As this research explored, adopting a salutogenic orientation with the fusion of design can create personalized solutions to help someone increase their sense of coherence, move up the ease/dis-ease continuum, and reach a healthy and meaningful life.

8.5 Food for Thought

As I wrap up this thesis, I would like to leave the reader with a quote from Antonovsky's 1979 book, where the term salutogenesis was first introduced. As surprising as it may be, Antonovsky's simple reflection on his childhood sparked the inception of the robust, complex, and profound concept of salutogenesis.

> "Sources of my ideas are mysterious. Possibly my interest in generalized factors relevant to *dis*-ease stems from my own childhood experience that chicken soup was the appropriate preventative, curative, and rehabilitative solution to all problems. Perhaps this intuitive knowledge was reinforced much later by my becoming persuaded that tender loving care is a more sophisticated kind of chicken soup"
>
> \- Aaron Antonovsky 1979, p. 56

This simple anecdote highlights the importance of empathy and care, which is the root of salutogenesis and the driving force of this thesis. I want people to live well, live healthy, and live fully. I hope this thesis provides a stepping-stone to a new design framework that gives others a more sophisticated kind of chicken soup: empathy and care that helps us understand and comprehend our lives, manage and overcome our stressors, and find meaningfulness where we can thrive.

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Appendices

1.0 Approved Ethics Application

Pro00126589 2023-01-31, 8:53 AM

UNIVERSITY OF ALBERTA

Date: January 31, 2023 8:52:04 AM

Print Close

ID: Pro00126589 **Pro00126589** 1.1 Study Identification

Status: Pre Submission

1.1 Study Identification

*All questions marked by a red asterisk * are required fields. However, because the mandatory fields have been kept to a minimum, answering only the required fields may not be sufficient for the REB to review your application.*

Please answer all relevant questions that will reasonably help to describe your study or proposed research.

1.0 * **Short Study Title** *(restricted to 250 characters)*:
Designing Personalized Arm and Hand Prostheses

2.0 * **Complete Study Title** *(can be exactly the same as short title)*:
Designing Personalized Arm and Hand Prostheses

3.0 * **Select the appropriate Research Ethics Board (***Detailed descriptions are available at here***):**
Research Ethics Board 1

4.0 * **Is the proposed research:**
Unfunded

5.0 * **Name of local Principal Investigator:**
Stephanie Rossi

6.0 * **Type of research/study:**
Graduate Student

7.0 **Investigator's Supervisor***(required for applications from undergraduate students, graduate students, post-doctoral fellows and medical residents to REBs 1 & 2. HREB does not accept applications from student PIs)*:
Timothy Antoniuk

8.0 **Study Coordinators or Research Assistants:** People listed here can edit this application and will receive all email notifications for the study:

Name	Employer
There are no items to display	

Co-Investigators: People listed here can edit this application and will

Page 1 of 20

9.0 receive email notifications *(Co-investigators who do not wish to receive email, should be added to the study team below instead of here).*
If your searched name does not come up when you type it in the box, the user does not have the Principal Investigator role in the online system. Click the following link for instructions on how to *Request an Additional Role.*

Name	Employer

There are no items to display

10.0 **Primary Admin Contact** *(a member of study team)*:

11.0 **Study Team:** *(co-investigators, supervising team, and other study team members) - People listed here cannot view or edit this application and do not receive email notifications.*

Last Name	First Name	Organization	Role/Area of Responsibility	Phone	Email

There are no items to display

ID: Pro00126589 **Pro00126589** 1.4 Conflict of Interest
Status: Pre Submission

1.4 Conflict of Interest

1.0 * **Are any of the investigators or their immediate family receiving any personal remuneration (including investigator payments and recruitment incentives but excluding trainee remuneration or graduate student stipends) from the funding of this study that is not accounted for in the study budget?**

○ Yes ● **No**

2.0 * **Do any of investigators or their immediate family have any proprietary interests in the product under study or the outcome of the research including patents, trademarks, copyrights, and licensing agreements?**

○ Yes ● **No**

3.0 * **Is there any compensation for this study that is affected by the study outcome?**

◯ Yes ● **No**

4.0 * **Do any of the investigators or their immediate family have equity interest in the sponsoring company? (This does not include Mutual Funds)**

◯ Yes ● **No**

5.0 * **Do any of the investigators or their immediate family receive payments of other sorts, from this sponsor (i.e. grants, compensation in the form of equipment or supplies, retainers for ongoing consultation and honoraria)?**

◯ Yes ● **No**

6.0 * **Are any of the investigators or their immediate family, members of the sponsor's Board of Directors, Scientific Advisory Panel or comparable body?**

◯ Yes ● **No**

7.0 * **Do you have any other relationship, financial or non-financial, that, if not disclosed, could be construed as a conflict of interest?**

◯ Yes ● **No**

Please explain if the answer to any of the above questions is Yes:

Important

If you answered YES to any of the questions above, you may be asked for more information.

ID: Pro00126589 **Pro00126589**

Status: Pre Submission 1.5 Research Locations and Other Approvals

1.5 Research Locations and Other Approvals

1.0 * **List the locations of the proposed research, including recruitment activities. Provide name of institution, facility or organization, town, or province as applicable**

- Blinc Lab, University of Alberta, 2E1, 114 St NW, Edmonton, AB (recruitment activities)
- University of Alberta, Edmonton, AB

2.0 * **Indicate if the study will use or access facilities, programmes, resources, staff, students, specimens, patients or their records, at any of the sites affiliated with the following** *(select all that apply)*:

Not applicable

List all health care research sites/locations:

3.0 **Multi-Institution Review**

*3.1 Has this study already received approval from another REB?

○ Yes ● No

4.0 **If this application is closely linked to research previously approved by one of the University of Alberta REBs or has already received ethics approval from an external ethics review board(*s*), provide the study number, REB name or other identifying information. Attach any external REB application and approval letter in the Documentation Section – Other Documents.**

2.1 Study Objectives and Design

1.0 *** Provide a lay summary of your proposed research which would be understandable to general public**

This study aims to find how persons with amputation or limb differences of the arm or hand think of prosthetic limbs that are available to them now, and how they could be improved upon through the design of aesthetics and/or function. Finding what each individual values within a prosthetic, whether is serves a specific function or personal aesthetics, could reveal how different each person's needs, wants, and values are, and create a conversation about if the design of the prosthetics that are currently available to them are satisfactory for different individuals, or if they need to be improved upon.

2.0 *** Provide a full description of your research proposal outlining the following:**

- **Purpose**
- **Hypothesis**
- **Justification**
- **Objectives**
- **Research Method/Procedures**
- **Plan for Data Analysis**

Purpose: The purpose of the research is to get qualitative data on what people with limb differences think about prosthetics they have experienced, if it was satisfactory to their functional and aesthetic needs, and if it was not, in what way could it be improved. The PI intends to find out how different people may value function and/or aesthetics for their prosthesis, and what those functions and aesthetics are. The PI intends to create a conversation on why or why not focusing on these are important to the individual.

Hypothesis: The result of this study will show the area of opportunity where design methodology, design thinking can be applied to the function and aesthetics of arm and hand prostheses. It could show how design could be beneficial in this area to create personalized interventions.

Justification: Prosthetics that are available to people today have limited function and aesthetics. Exploration into what is deemed important in people's lives, whether it is playing sports, styling clothes, or ability to do a hobby, could reveal how important it is to focus the design of the prosthesis to accomplish the desired activity or personal aesthetic. This could result in prosthesis options for the future that support the functional and personal life of the individual.

Objectives: The main objectives are to 1) Find how commercial prosthetics may be lacking. 2) if they are lacking, in what ways. 3) how using design thinking can achieve better outcomes of the overall design of a prosthesis that supports functional and aesthetic requirements of the user. 4) Explore the benefits and potential drawbacks of the new proposed designs.

Research Methods/Procedures: 1) Literary review of peer reviewed sources/articles, 2) interview people with amputation or congenital limb difference of the arm and/or hand, 3) Design iterations of proposed prosthetics using information gathered from interviews, 4) Receive feedback on the new prosthesis designs from those in original interview, 5) Finalize the designs and computer render or 3D print prototypes of the prosthesis.

Initial stages of study will require background information through secondary research. This will be through literary review of peer reviewed articles. People with limb differences of the arm and/or hand will be contacted by email correspondence through help from BlincLab. There will only be one interview per person needed, with a follow-up interview if required and consent is given. Individual participant feedback (2-3 participants) will be done through a series of meetings: initial interview followed by 1-3 extra meetings to talk about outcome of designs and participant feedback and input. All meetings will be 1 hour maximum.

Plan for Data Analysis: Thematic analysis will be used to identify main themes and areas of opportunity from qualitative data (interviews). Cluster analysis will be used in quantitative data (pre-existing surveys) to sort the data into groups to find areas of opportunity within certain demographics and groups of people.

3.0 Describe procedures, treatment, or activities that are above or in addition to standard practices in this study area *(eg. extra medical or health-related procedures, curriculum enhancements, extra follow-up, etc)***:**
Extra follow up might be needed at the conclusion of the study.

4.0 If the proposed research is above minimal risk and is not funded via a competitive peer review grant or industry-sponsored clinical trial, the REB will require evidence of scientific review. Provide information about the review process and its results if appropriate.

5.0 **For clinical trials, describe any sub-studies associated with this Protocol.**

ID: Pro00126589 **Pro00126589**
Status: Pre Submission 2.2 Research Methods and Procedures

2.2 Research Methods and Procedures

Some research methods prompt specific ethical issues. The methods listed below have additional questions associated with them in this application. If your research does not involve any of the methods listed below, ensure that your proposed research is adequately described in Section 2.1: Study Objectives and Design or attach documents in the Documentation Section if necessary.

1.0 * **This study will involve the following** *(select all that apply)*
Interviews and/or Focus Groups
Secondary Use of Information (analyzing data previously collected for another purpose)

NOTE 1: Select this ONLY if your application SOLELY involves a review of paper charts/electronic health records/administrative health data to answer the research question. If you are enrolling people into a study and need to collect data from their health records in addition to other interventions, then you SHOULD NOT select this box.

NOTE 2: Select this option if this research ONLY involves analysis of blood/tissue/specimens originally collected for another purpose but now being used to answer your research question. If you are enrolling people into the study to prospectively collect specimens to analyze you SHOULD NOT select this box.

ID: Pro00126589 **Pro00126589** 2.5 Interview and/or Focus Groups
Status: Pre Submission

2.5 Interview and/or Focus Groups

1.0 **Will you conduct interviews, focus groups, or both? Provide detail.**
- PI will conduct interviews with medical professionals such as a prosthetist, and prosthesis engineers.
- PI will conduct interviews and workshops with people with arm prostheses.

2.0 **How will participation take place (e.g. in-person, via phone, email, Skype)?**

- Participation in interviews and workshops will take place in-person or online through Google Meet or Zoom (depending on the preference and consent of the participant).

3.0 How will the data be collected (e.g. audio recording, video recording, field notes)?
Data will be collected via audio and video recording with permission from the participant. If the participant declines to be recorded, then data will be collected with written notes.

2.10 Secondary Analysis

1.0 Outline what data you are analyzing for this research
- PI will analyze data from previous studies/surveys.
- PI will analyze data from secondary sources.
- PI will analyze qualitative data from interviews and follow up interviews.

2.0 How was the original data collected?
Original qualitative data will be collected through field notes, audio recording, or video recording (interviews and workshops).

3.0 Estimate how many records you will analyze, if applicable (i.e. approximately 300 surveys collected from 2012, 5000 student records from 1999-2009 at University of Alberta).

4.0 How will you receive the data for analysis?
Anonymized by the data holder/custodian (study team never has access to identifying data)

5.0 Will you be obtaining consent from participants for the secondary use of identifiable information?
● **Yes** ○ No

Please remember to upload the following to the Documentation Section:

1) Original data collection instrument(s), or an outline of the information you are analyzing.

2) Original consent/info (if applicable - if individuals have previously agreed for their data to be used in future research/for research purposes).

Status: Pre Submission

3.1 Risk Assessment

1.0 * **Provide your assessment of the risks that may be associated with this research:**
Minimal Risk - research in which the probability and magnitude of possible harms implied by participation is no greater than those encountered by participants in those aspects of their everyday life that relate to the research (TCPS2)

2.0 * **Select all that might apply:**

Description of Possible Physical Risks and Discomforts	
No	Participants might feel physical fatigue, e.g. sleep deprivation
No	Participants might feel physical stress, e.g. cardiovascular stress tests
No	Participants might sustain injury, infection, and intervention side-effects or complications
No	The physical risks will be greater than those encountered by the participants in everyday life

Possible Psychological, Emotional, Social and Other Risks and Discomforts	
Possibly	Participants might feel psychologically or emotionally stressed, demeaned, embarrassed, worried, anxious, scared or distressed, e.g. description of painful or traumatic events
No	Participants might feel psychological or mental fatigue, e.g intense concentration required
No	Participants might experience cultural or social risk, e.g. loss of privacy or status or damage to reputation
No	Participants might be exposed to economic or legal risk, for instance non-anonymized workplace surveys
No	The risks will be greater than those encountered by the participants in everyday life

3.0 * **Provide details of all the risks and discomforts associated with the research for which you indicated YES or POSSIBLY above.**
(Possibly) Participants might feel psychologically or emotionally stressed because study may cause participants to recount emotional or possibly traumatic experiences.

4.0 * **Describe how you will manage and minimize risks and discomforts, as well as mitigate harm:**
- Constant monitoring of participants during workshops.
- Physical and mental check-ins during the workshops, and email correspondence through the duration of the study.
- Make sure consent is up-to-date.
- Make it known participants can withdraw consent and/or leave study at any

time.

5.0 **Is there a possibility that your research procedures will lead to unexpected findings, adverse reactions, or similar results that may require follow-up** *(i.e. individuals disclose that they are upset or distressed during an interview/questionnaire, unanticipated findings on MRI, etc.)***?**

● **Yes** ○ No

Describe the arrangements or referral the researcher will make. Explain if no arrangements have been made.
Participants have to be working with a psychologist in order to participate in this study in the chance that the participant becomes distressed or upset. The psychologist will then be contacted and informed.

6.0 **If you are using any tests in this study diagnostically, indicate the member(s) of the study team who will administer the measures/instruments:**

Test Name	Test Administrator	Organization	Administrator's Qualification

There are no items to display

7.0 **If any research related procedures/tests could be interpreted diagnostically, will these be reported back to the participants and if so, how and by whom?**

3.2 Benefits Analysis

1.0 * **Describe any potential benefits of the proposed research to the participants. If there are no benefits, state this explicitly:**
Primarily, there are no benefits in participating in this research study.

2.0 * **Describe the scientific and/or scholarly benefits of the proposed research:**
This study aims to benefit:
- Current prosthetic (or other device) manufacturing processes in the scientific and medical community.
- PI's academic and professional pursuit in the field of medical design.

3.0 **If this research involves risk to participants explain how the benefits outweigh the risks.**
The study could benefit future prosthetic manufacturing customizable prosthesis options.
As more studies like this emerge, it possibly show the importance of investing research and resources into these areas.

The benefits of the study do not outweigh the risks of the participants.

ID: Pro00126589 **Pro00126589** 4.1 Participant Information
Status: Pre Submission

4.1 Participant Information

1.0 * **Will you be recruiting human participants** *(i.e. enrolling people into the study, sending people online surveys to complete)***?**

● **Yes** ○ No

1.1 Will participants be recruited or their data be collected from Alberta Health Services or Covenant Health or data custodian as defined in the Alberta Health Information Act?

○ Yes ● **No**

ID: Pro00126589 **Pro00126589** 4.2 Additional Participant Information
Status: Pre Submission

4.2 Additional Participant Information

1.0 **Describe the participants that will be included in this study. Outline ALL participants** *(i.e. if you are enrolling healthy controls as well):*

Participants of this study will be:

1) 18-35 years old
2) Have an arm/hand prosthesis (one or both arms)
3) Actively working with/seeing a mental health specialist or psychologist

2.0 * **Describe and justify the inclusion criteria for participants** *(e.g. age range, health status, gender, etc.):*

1) Participants have to be above 18 years of age to provide consent for the study. 18-35 year olds will be the demographic of this study to explore the aesthetic and functional considerations for this age group.
2) Arm prosthesis are chosen for the study due to its exposure (not always covered by clothing) therefore exploring more opportunities for function and aesthetic exploration.
3) Participants must be working with a mental health professional in case the participant becomes upset or distressed during the study.

3.0 **Describe and justify the exclusion criteria for participants:**

1) Participants under 18 will not be allowed to participate in this study because they cannot give consent. Participants may be subject to emotional

distress during the study, so consenting adults are likely more psychologically equipped to handle these potential scenarios. Exclusions from a higher age group (36 and above) are for the purposes of aesthetics choices, physical ability, and lifestyle considerations.

2) Facial prostheses and will be excluded from the study because they are already used for aesthetic functions and may involve more specialized procedures such as MRI or CT scans. Leg prostheses will be excluded because of its weight-baring function, therefore a higher chance of injury may occur during user testing.

3) People who are not working with a mental health professional may not be equipped to handle mental strain if they traumatic experiences or challenging themes come up during interviews.

Defining the constraints of participants also allows for ease of data analysis.

4.0 Participants

4.1 How many participants do you hope to recruit *(including controls, if applicable?)*
3
4.2 Of these, how many are controls, if applicable?
0
4.3 If this is a multi-site study, how many participants do you anticipate will be enrolled in the entire study?

5.0 Justification for sample size:
- Smaller sample size will fit within the time constraints of the study.
- Smaller sample size will allow more time for in-depth analysis, and interviews with each individual participant.
- Smaller sample size will allow time for high quality design iterations

ID: Pro00126589 **Pro00126589**
Status: Pre Submission 4.4 Recruitment of Participants (non-Health)

4.4 Recruitment of Participants (non-Health)

1.0 Recruitment

1.1 How will you identify potential participants? Outline all of the means you will use to identify who may be eligible to be in the study*(i.e. response to advertising such as flyers, posters, ads in newspapers, websites, email, list serves, community organization referrals, etc.)*
Advertising through:
- University of Alberta Student Union website
- University of Alberta Student Digest emails
- "Snowballing" (Information passes through word-of-mouth)

- Contacting Blinc Lab, Edmonton, AB

1.2 Once you have identified a list of potentially eligible participants, indicate how the potential participants' names will be passed on to the researchers AND how will the potential participants be approached about the research.
- Participants will see that there is contact information of the PI on the advertising material (email, website, posters etc.) and reach out themselves.
- Participants identified through "snowballing" will be notified of study and contact information.
- Participants who are approached by the research team or will be asked to participate and given a summary of the research study.
- Participants approached through connections in BlincLab will be given the PI's contact information

2.0 Pre-Existing Relationships

2.1 Will potential participants be recruited through pre-existing relationships with researchers *(e.g. Will an instructor recruit students from his classes, or a physician recruit patients from her practice? Other examples may be employees, acquaintances, own children or family members, etc.)?*

○ Yes ● **No**

3.0 Will your study involve any of the following? *(select all that apply)*
None of the above

ID: Pro00126589 **Pro00126589** 4.5 Informed Consent Determination
Status: Pre Submission

4.5 Informed Consent Determination

1.0 Describe who will provide informed consent for this study *(i.e. the participant, parent of child participant, substitute decision maker, no one will give consent – requesting a waiver)*
The participant themselves will provide informed consent.

1.1 Waiver of Consent Requested
If you are asking for a waiver of participant consent, please justify the waiver or alteration and explain how the study meets all of the criteria for the waiver. Refer to Article 3.7 of TCPS2 **and provide justification for requesting a Waiver of Consent for ALL criteria (a-e)**

1.2 Waiver of Consent in Individual Medical Emergency
If you are asking for a waiver or alteration of participant consent in individual medical emergencies, please justify the waiver or alteration and explain how the study meets ALL of the criteria outlined in Article 3.8 of TCPS2 (a-f).

2.0 **How will consent be obtained/documented? Select all that apply**
Signed consent form
Verbal consent
Implied by overt action (i.e. completion of questionnaire)

If you are not using a signed consent form, explain how the study information will be provided to the participant and how consent will be obtained/documented. Provide details for EACH of the options selected above:

3.0 **Will every participant have the capacity to give fully informed consent on his/her own behalf?**
● **Yes** ○ No

4.0 **What assistance will be provided to participants or those consenting on their behalf, who may require additional assistance?** *(e.g. non-English speakers, visually impaired, etc.)*
Participants with language barriers or non-mobile disabilities (mental disability, hearing impairment etc.) may bring in support once discussed agreed upon by all parties involved that participant is fit for the study.

5.0 *** If at any time a PARTICIPANT wishes to withdraw from the study or from certain parts of the study, describe when and how this can be done.**
- Participant can notify the PI at any time verbally or in writing if they would like to withdraw from the study, or any section of the study.
- Participant will be notified that they can revoke previous data/information from the study.
- A revocation form will be signed by the participant.
- PI will document this decision and revocation form in the research record.
- PI will cease collecting data/information on the participant.

6.0 **Describe the circumstances and limitations of DATA withdrawal from the study, including the last point at which participant DATA can be withdrawn** *(i.e. 2 weeks after transcription of interview notes)*
Participants can withdraw data from study if they feel:
- Their emotional and/or physical safety is at risk.
- Their personal information is being compromised.
- They do not wish to continue the study under other circumstances.

Data will be withdrawn when a participant gives verbal or written statement that they would like their data to be withdrawn.

Data withdrawal may compromise the study, as sample size for participants are small. Data withdrawal may also compromise the integrity of collected data.

7.0 **Will this study involve any group(s) where non-participants are present? For example, classroom research might involve groups which include participants and non-participants.**
◯ Yes ● **No**

ID: Pro00126589 **Pro00126589** 5.1 Data Collection
Status: Pre Submission

5.1 Data Collection

1.0 * **Will the researcher or study team be able to identify any of the participants at <u>any stage</u> of the study?**
● **Yes** ◯ No

2.0 **Primary/raw data collected will be** *(check all that apply)*:
Directly identifying information - the information identifies a specific individual through direct identifiers (e.g. name, social insurance number, personal health number, etc.)
Indirectly identifying information - the information can reasonably be expected to identify an individual through a combination of indirect identifers (eg date of birth, place of residence, photo or unique personal characteristics, etc)

3.0 **If this study involves secondary use of data, list all original sources:**

4.0 **In research where total anonymity and confidentiality is sought but cannot be guaranteed** *(eg. where participants talk in a group)* **how will confidentiality be achieved?**
- PI will ensure that any information collected (images, personal information, recordings etc.) will be kept within the research team and anonymized in the chance that data will be used for publication or distribution.

ID: Pro00126589 **Pro00126589** 5.2 Data Identifiers
Status: Pre Submission

5.2 Data Identifiers

1.0 * **Personal Identifiers:** will you be collecting - at any time during the study, including recruitment - any of the following *(check all that apply)*:
Surname and First Name

Telephone Number
Email Address
Age at time of data collection
Other

If OTHER, please describe:
Picture or recording of the participants extremities (arm prosthesis or residual limb), with consent.

2.0 **Will you be collecting - at any time of the study, including recruitment of participants - any of the following** *(check all that apply)***:**
There are no items to display

3.0 * **If you are collecting any of the above, provide a comprehensive rationale to explain why it is necessary to collect this information:**
- Names will be collected for identifying participants in data and addressing participants during interviews. Names will be kept anonymous otherwise, and will be changed to "participant A, B, C, etc." for publication or distribution of study information.
- Telephone number and email address will be collected as point of contact/correspondence and will not be used for any purposes outside of the study or by anyone outside of the research team.
- Age will be collected for the purpose of data analysis of certain demographics, as well as checking that the participant fits the participant criteria.
- Picture and/or video recording of prostheses and extremities/ or lack of extremities will be taken for use of reference during design iteration and demonstration of final design outcomes.

4.0 **If identifying information will be removed at some point, when and how will this be done?**
- Information and identifying data will be overwritten and deleted (digital) or destroyed (physical) at the conclusion of the study if data is deemed unnecessary to keep.
- 5 years after the study, data will be overwritten, deleted and/or destroyed.

5.0 * **Specify what <u>identifiable</u> information will be RETAINED once data collection is complete, and explain why retention is necessary. Include the retention of master lists that link participant identifiers with de-identified data:**
Identifiable information that will be retained is picture recording of prosthesis and/or extremities (not facial), age, and contact information.

- Retention of picture recording may be necessary for reference of design process and outcome,
- Age will be retained for the purpose of showing aesthetic and functional choices, wants, and needs of a certain demographic. Retaining this information could show future correlation of age and certain aesthetics and functions and present an important window of opportunity or data analysis for future studies.
- Contact information will be retained to allow for follow up with participants.

6.0 **If applicable, describe your plans to link the data in this study with**

data associated with other studies (e.g within a data repository) or with data belonging to another organization:

ID: Pro00126589 **Pro00126589** 5.3 Data Confidentiality and Privacy
Status: Pre Submission

5.3 Data Confidentiality and Privacy

1.0 * **How will confidentiality of the data be maintained? Describe how the identity of participants will be protected both during and after research.**
- Participant information and identity confidentiality will be maintained through secure data storage on the PI's computer (encrypted).
- PI will store physical data in locked filing cabinet.
- PI will not disclose any participant information to anyone outside of the study or other participants.

2.0 **How will the principal investigator ensure that all study personnel are aware of their responsibilities concerning participants' privacy and the confidentiality of their information?**

3.0 **External Data Access**

* **3.1 Will <u>identifiable</u> data be transferred or made available to persons or agencies outside the research team?**
○ Yes ● No

ID: Pro00126589 **Pro00126589** 5.4 Data Storage, Retention, and Disposal
Status: Pre Submission

5.4 Data Storage, Retention, and Disposal

1.0 * **Describe how research data will be stored, e.g. digital files, hard copies, audio recordings, other. Specify the physical location and how it will be secured to protect confidentiality and privacy.** *(For example, study documents must be kept in a locked filing cabinet and computer files are encrypted, etc. Write N/A if not applicable to your research)*
Physical written forms or pictures will be secured in locked filing cabinet. Digital forms, pictures, videos, documents etc. will be stored within computer files and encrypted. Only the PI will have access to these files.

2.0 * **University policy requires that you keep your data for a minimum of 5**

years following completion of the study but there is no limit on data retention. Specify any plans for future use of the data. <u>If the data will become part of a data repository or if this study involves the creation of a research database or registry for future research use, please provide details.</u> *<u>(Write N/A if not applicable to your research)</u>*
Future use of data will be used if research study is needed, or if there is a perceived need to progress further. This could be in the case of:
- Future research project
- Prosthetic/medical advancement
- Program and software advancement
- Increasing need for this type of research (social/economical)

Data repository: N/A

3.0

If you plan to destroy your data, describe when and how this will be done? Indicate your plans for the destruction of the identifiers at the earliest opportunity consistent with the conduct of the research and/or clinical needs:
Destruction of data will be done in the case that:
- Further research advancement is not needed after study is complete (5 years following the study)
- Research study has come across a breach of contract in safety, security, ethics etc.
- Research study has ceased to continue in unforeseen/other circumstances

At the time these circumstances have been identified during the study:
- Participants will be notified their information and data will be destroyed
- PI will destroy any physical documentation
- PI will overwrite and delete digital records

In the circumstance that data has been kept for 5 years and is no longer applicable:
- PI will destroy physical documentation
- PI will overwrite and delete digital records

ID: Pro00126589 **Pro00126589** Documentation
Status: Pre Submission

Documentation

Add documents in this section according to the headers. Use Item 11.0 "Other Documents" for any material not specifically mentioned below.

Sample templates are available by clicking HERE.

1.0 **Recruitment Materials:**

Document Name	Version	Date	Description
There are no items to display			

2.0 Letter of Initial Contact:

Document Name	Version	Date	Description
There are no items to display			

3.0 Informed Consent / Information Document(s):

3.1 What is the reading level of the Informed Consent Form(s):

3.2 Informed Consent Form(s)/Information Document(s):

Document Name	Version	Date	Description
There are no items to display			

4.0 Assent Forms:

Document Name	Version	Date	Description
There are no items to display			

5.0 Questionnaires, Cover Letters, Surveys, Tests, Interview Scripts, etc.:

Document Name	Version	Date	Description
There are no items to display			

6.0 Protocol/Research Proposal:

Document Name	Version	Date	Description
There are no items to display			

7.0 Investigator Brochures/Product Monographs:

Document Name	Version	Date	Description
There are no items to display			

8.0 Health Canada No Objection Letter *(NOL)*:

Document Name	Version	Date	Description
There are no items to display			

9.0 Confidentiality Agreement:

Document Name	Version	Date	Description
There are no items to display			

10.0 Conflict of Interest:

Document Name	Version	Date	Description
There are no items to display			

11.0 Other Documents:

For example, Study Budget, Course Outline, or other documents not mentioned above

Document Name	Version	Date	Description
There are no items to display			

ID: Pro00126589 **Pro00126589** Final Page
Status: Pre Submission

Final Page

You have reached the end of the ethics application.
Click 'Continue' or 'Exit' below.

To submit for ethics review, click "SUBMIT for REVIEW" on the left side of the screen.

NOTE: Only the Principal Investigator can submit an application in Pre-submission (ie: the first time it is submitted).

Pro00126589

Reviewer Notes

No Reviewer notes to display.

2.0 Recruitment Data

2.1 Research Proposal

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Study Title: Designing Personalized Arm and Hand Prostheses by Exploring Function and Aesthetic Preferences of the Wearer

Stephanie Rossi
Ethics ID: Pro00126589

Research Proposal
The objective of this research is to understand how to achieve personalized interventions for people who have lost an arm/hand or were born with an arm/hand limb difference. This research aims to demonstrate ways that focusing on the personhood of the prosthesis user can improve prosthesis designs, and ultimately, improve physical and mental health of the user. In healthcare, the heavy focus is on physical health (Bhattacharya et al. 16), which is curing diseases and fixing physical ailments. This means that commercially available limb prosthetics are mainly focused on functionality rather than how that person feels about the prosthesis, how they feel about themselves, and how others perceive them. I am exploring the question: If someone could fully personalize their prosthesis to fit their complex lifestyle requirements or personal aesthetics, how could this positively impact their mental health and their overall quality of life?

For my thesis, I intend to research mental health concepts in-depth and how to integrate it into a methodology for designing arm prosthetics. The mental health model I am researching is called Salutogenesis: the concept of mental wellbeing and the origins of an individual's health (Mittelmark et al.), in which the way a person comprehends, manages, and finds meaningfulness in life depending on who they are. Salutogenesis also spans into concepts of personhood, such as things like emotions, body image, aesthetics, personal values, and lifestyle. Exploration into these concepts when designing the function and aesthetics of a personalized prostheses could potentially help the user live a fuller life, as the prosthesis is now made exactly for them.

The design methodology that is being utilized to achieve this personalization is called Experience-Based Co-Design (Castro et al. 1302), where the patient is the expert of their own experience, lifestyle, needs, and wants and is involved in the design process. Ultimately, the user guides the design of functionality and aesthetics of their prosthesis. Research into personhood and salutogenesis, paired with design methodologies in this area could span into other healthcare disciplines to achieve more personalized solutions. If prosthetic design could prosper from focusing on an individual's emotions, values, lifestyle, and mental complexities, then other areas of healthcare could potentially do the same to achieve truly personalized care. Therefore, increasing the overall quality of care and quality of life for the individual.

This participant study aims to find how persons with amputation or limb differences of the arm or hand think of prosthetic limbs and assistive technology that are available to them now, and how they could be improved upon through the design of aesthetics and/or function. Finding what each individual values within prostheses or assistive

1

devices, whether is serves a specific function or personal aesthetics, could reveal how different each person's needs, wants, and values are and what is meaningful to them.

Purpose:
The purpose of the research is to get qualitative data on what people with limb differences think about the prostheses they have experienced, if they were satisfactory to their functional and aesthetic needs, and if they were not, in what way they could be improved. The researcher intends to find out how different people may value function and/or aesthetics for their prosthesis, and what those functions and aesthetics are. The researcher intends to create a conversation on why or why not focusing on these are important to the individual.

Hypothesis:
I hypothesize that utilizing design thinking and design methodology for the design of function and aesthetics of a prosthesis or assistive device can improve use and personal connection of prostheses for the wearer. Focusing on the design of aesthetics and function could create more personalized outcomes that are truly catered to the wearer.

Justification:
Prostheses that are available to people today have limited function and aesthetics. Exploration into what is deemed important in people's lives, whether it is playing sports, styling clothes, or ability to do a hobby, could reveal how important it is to focus the design of the prosthesis to accomplish the desired activity or personal aesthetic. This could result in prosthesis options for the future that support the functional and personal life of the individual.

Objectives:
The main objectives are to 1) Find how/if commercial prostheses are lacking. 2) if they are lacking, in what ways. 3) Use design thinking to ideate better outcomes of the overall design of a prosthesis that supports functional and aesthetic requirements of the user. 4) Explore the benefits and potential drawbacks of the new proposed designs.

Research Methods/Procedures:
1) Literary review of peer reviewed sources/articles, 2) Interview people with amputation or congenital limb difference of the arm and/or hand, 3) Design iterations of proposed prostheses using information gathered from interviews, 4) Receive feedback on the new prosthesis designs from those in original interview, 5) Finalize the designs in 2D potentially computer render or 3D print prototypes of the prosthesis.

Initial stages of study will require background information through secondary research. This will be through literary review of peer reviewed articles. People with limb differences of the arm and/or hand will be contacted by email correspondence through help from the BLINC Lab or identify themselves in UofA Student Digest email postings and recruitment posters. There will be two or more interview sessions needed that will be done online or in-person. There will be an initial interview followed by extra meetings for feedback and critique from the participant. All meetings will run less than one hour.

Plan for Data Analysis:

Thematic analysis will be used to identify main themes and areas of opportunity from qualitative data (interviews). Cluster analysis will be used in quantitative data (pre-existing surveys) to sort the data into groups to find areas of opportunity within certain demographics and groups of people.

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BIBLIOGRAPHY

Bhattacharya, Sudip, et al. “Salutogenesis: A Bona Fide Guide towards Health Preservation.” Journal of Family Medicine and Primary Care, vol. 9, no. 1, 2020, p. 16.DOI.org (Crossref), https://doi.org/10.4103/jfmpc.jfmpc_260_19.

Castro, Eva Marie, et al. “Co-Design for Implementing Patient Participation in Hospital Services: A Discussion Paper.” Patient Education and Counseling, vol. 101, no. 7, July 2018, pp.1302–05. DOI.org (Crossref),https://doi.org/10.1016/j.pec.2018.03.019.

Mittelmark, Maurice B., et al., editors. The Handbook of Salutogenesis. Springer International Publishing, 2017. DOI.org (Crossref), https://doi.org/10.1007/978-3-319-04600-6.

4

2.2 Signed Consent Form

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April 4, 2023

Title of Study: Designing Personalized Arm and Hand Prostheses by Exploring Function and Aesthetic Preferences of the Wearer

Ethics ID: Pro00126589

Contact Information
Principal Investigator: Stephanie Rossi, MDes Student, Industrial Design
Mailing Address: 11135 83 Ave NW, Edmonton, AB, T6G 2C6
Email: bilson@ualberta.ca

Supervisor: Tim Antoniuk
Email: tna@ualberta.ca

You are invited to take part in a research study. Before you participate, a study team member is available to explain the project, and you are free to ask any questions about anything you do not understand. You will be given a copy of this form for your records.

Why am I being asked to take part in this research study?
You are being asked to be in this study because you have an arm or hand amputation or limb difference. The research aims to investigate what ways arm/hand prostheses are lacking in areas of functionality and aesthetics for the individual wearer's lifestyle or aesthetic preferences. This study aims to prove how each individual is different from one another, and therefore may require a prosthesis to function differently or look differently from someone else's depending on what the individual would like to achieve functionally and aesthetically.
Inclusion criteria for participating:

1. 18-40 years old
2. Have an arm/hand limb difference
3. Have used an arm/hand prosthesis

What is the reason for doing the study?
The reason for doing this study is to understand how personalized prostheses can help people achieve functional and aesthetics preferences that are important to them, rather than limiting themselves to basic functions or aesthetics that don't reflect their lifestyle or who they are. This research intends to show the importance of personalization in the design of prostheses instead of a one-size-fits-all approach. By designing prostheses that

are truly personalized to the wearer's lifestyle, the wearer may potentially be able to do activities or express themselves in ways that were not possible before.

What will I be asked to do?
You will take part in two or more one-on-one interviews/discussion sessions. These sessions will be in-person (we can discuss location) or online via Google Meet depending on your preference. With your permission, audio recording will take place for ease of data collection and will be transcribed by the researcher after the interview and stored on a secure hard drive.
For the first interview session:
You will be asked questions about your thoughts on functionality and aesthetics of prostheses that you have experienced. You will be asked about what is important to you in a prosthesis, whether function and/or aesthetics are important to you, what exactly those requirements are, what could be feasible in achieving a certain function or aesthetic preference. We will be brainstorming ways that a feasible prosthesis could look like if it had your personal functional and/or aesthetic requirements. You may be asked for picture recording of your extremity or prosthesis, if you are comfortable with that.
For the second session:
You will give feedback on the design ideas that the researcher has come up with. You will be asked if the ideas are satisfactory to your functional and/or aesthetic requirements and discuss if this prosthesis could be useful to you or others if it was brought into the real world. If the design is not satisfactory, we will brainstorm ways together to improve the design. With your permission, there may need to be more sessions to reach a satisfactory design. Designs will not be physically manufactured due to technological limitations. This is just to create ideas on paper or digital platform to showcase the potential for prosthesis designs.

How long will the interviews take?
Each interview session will be 30-60 minutes long, but no longer out of respect for your time.

What are the risks and discomforts?
It is very unlikely to experience risks or discomforts. The only risks and discomforts you may experience is psychological or emotional discomfort if the interview or study causes you to recount emotional or possibly traumatic experiences. You can stop the interview or study at any time if you feel upset or uncomfortable. The researcher will only ask questions about your design preferences and your lifestyle and aesthetic requirements. You are more than welcome to share any information or stories you would like with the researcher, but know that it is not expected of you to share anything that makes you emotional or uncomfortable. It is not possible to know all of the risks that may happen in a study, but the researchers have taken all reasonable safeguards to minimize any known risks to a study participant.

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What are the benefits to me?
There may be no direct benefit to you for participating in this research, although results from this study could help us learn about how prosthetics could be improved upon to benefit further research and others in the future.

Do I have to take part in the study?
Being in this study is your choice. If you decide to be in the study, you can change your mind and stop being in the study at any point until Dec 31, 2023. After that point we cannot remove you from the study because the data will have been analyzed in full. To withdraw from the study please contact Stephanie Rossi (bilson@ualberta.ca) or their supervisor Tim Antoniuk (tna@ualberta.ca). In the circumstance you wish to also withdraw your data from the study, you may notify Stephanie Rossi or Tim Antoniuk before Dec 31, 2023 and your data will not be used or published in the research.

Will I be paid to be in the research?
There will not be any payment for the participants. This is totally volunteer participation.

Will my information be kept private?
Yes. The only personal information we will collect is your email address and your name. Audio and picture recordings will be kept private and stored safely on the researcher's hard drive. No information relating to this study that includes your name will be released outside of the researcher's office or published by the researcher unless you give us your express permission. Sometimes, by law, we may have to release your information with your name so we cannot guarantee absolute privacy. However, we will make every legal effort to make sure that your information is kept private. If you would like to use your real name during the interview process, please indicate it on the last page of the document. When your interview is transcribed, we will assign a pseudonym (fake name) or use the one you have chosen to protect your identity. When research is published, we will use your pseudonym or "Participant A, B, etc.". During research studies it is important that the data we get is accurate. For this reason, your data, including your name, may be looked at by people from the Research Ethics Board. All data that is collected will be stored in the researcher's password-protected computer.

What will happen to my information or data that I provide?
The information that you provide will form part of Stephanie Rossi's Master's thesis in Industrial Design. Your answers to the questions will be used for coming up with possible design solutions for arm or hand prostheses/assistive devices. Data will be analyzed and used to inform the design solutions. After the study, we will store your data for a minimum of 5 years on a password secure computer or secured drive. Any researcher who wants to use this data for another study will have to have the new study reviewed by the ethics board. In this case, your data will be de-identifiable, meaning all your personal information will be removed.

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What if I have questions?
If you have any questions about the research now or later, please contact Stephanie Rossi (bilson@ualberta.ca) or their supervisor Tim Antoniuk (tna@ualberta.ca).

If you have any questions regarding your rights as a research participant, you may contact the University of Alberta Research Ethics Office at reoffice@ualberta.ca or 780-492-2615 and quote Ethics ID Pro00126589. This office is independent of the study investigators.

How do I indicate my agreement to be in this study?
By signing below, you understand:

1. You have read the above information and have had anything you need help understanding explained to you to your satisfaction.
2. That you will be taking part in a research study.
3. That you may freely leave the research study at any time.
4. That you do not waive your legal rights by being in the study.
5. The legal and professional obligations of the investigators and involved institutions are still the same by your taking part in this study.

SIGNATURE OF STUDY PARTICIPANT

Name of the participant: [redacted]

I permit my real name to be used (circle or highlight): Yes No

Pseudonym: Participant A or Participant 1

Signature of the participant: [redacted] Date: 09/05/2023

SIGNATURE OF THE PERSON OBTAINING CONSENT

Name of Person Obtaining Consent: ____________

Contact Email/Number: bilson@ualberta.ca

A copy of this information and consent form has been given to you to keep for your records and reference

Ethics ID: Pro00126589

Ethics ID: Pro00126589
Version April 4, 2023

Page **4** of **4**

2.3 Interview Transcripts

Participant Interview: Session 1
Participant A

S: Hello.

PA: Hello.

S: Hi, [redacted]. Thank you for meeting with me today.

PA: Hi. Nice to meet you.

S: Nice to meet you too. Is it okay if I audio-record the meeting?

PA: Go ahead

S: Okay, for sure. Thank you. So I should introduce myself. My name is Stephanie. I'm currently doing my Masters in Industrial Design at the U of A, and I'm focusing my thesis on Design for Health. So for a specific case study that I'm doing, I'm exploring Design for Arm Prostheses. So I appreciate you taking the time to be a participant in this and helping me understand your experience and learn more about them and the user. Also I need to let you know that you're welcome to withdraw participation at any time, for whatever reason. And if there's any question I ask you that makes you feel uncomfortable, you can choose not to answer as well. But I don't think I'll be asking anything too personal, but you don't have to feel like you have to share any information you don't want to. You can also revoke information either during, you know, our meeting now or in a few days when you remember you said something or shared a specific detail, you don't want to be in the study. You can let me know, and I will redact that specific information. Yeah, so I want to respect your time, and so if we have a very long meeting, I won't let it go over an hour. I don't think it'll go that long. We can keep it short and sweet. If it does go very long, I'll cut it off at an hour. So maybe some context about my thesis and what I'm doing.

My thesis is on how design can help implement concepts of mental health and personhood into health design. So I'm interested in people's emotions, lifestyle, things like hobbies, likes, dislikes, needs and wants. Basically their sense of self and sense of personhood. Like healthcare doesn't really look at that stuff. It's very pathogenetically focused. Health interventions typically like it's survival rather than how one can thrive. So I'm looking at these concepts through disabilities or differences of the hands. For this particular section, I'm looking at exploring upper hand differences for prostheses. I would like to talk to you about your experience, create a conversation if prostheses need to be improved on in any way, but also if they fulfill your sense of, you know, self, personal interest, lifestyle, hobbies, aesthetics, stuff like that. If the interview goes in a way that we uncover the fact that prostheses do need to be improved upon, then we can have another meeting to ideate or brainstorm ideas, um, potentially design a prosthesis if you permit another meeting, that is. Um, if you would not like to meet again, that is totally okay too. Or if you think they don't need to be improved upon and we don't need a meeting to discuss designs, then that's fine too. So I would just like to know about you and your experience with prostheses. So like, do you currently have or use a prosthesis?

PA: Um, I'm working on making one. Uh, this is the one I have currently. I haven't really worked on it recently. But I have a little bit of movement in my hand. And my goal is to try to make a non-electronic way of opening and closing this hand. This is the Raptor hand. You can get it free online.

S: Oh, interesting.

PA: And it's 3D printed. The problem is that, uh, it takes a fair amount of strength to close all fingers. So this is the one [redacted] saw when I was walking around with it. I still haven't really been able to work on it much this year, but, uh, yeah, this is the one I currently have.

S: Okay. Yeah, she said “he works on these prostheses and he's 3D printing”, which interested me because I also do 3D printing. So is it on Thingiverse or, like, an open source?

PA: Yeah. It's on Thingiverse.

S: Oh, cool. That's really cool.

PA: Uh, yeah. So basically, the hand is, um, just an upscale version of Thingiverse. I chose the fingers because I'm not good with knots. So my solution was to use steel rope and, like, metal stoppers on it. So I'm using that in order to, like, make the ropes tight.

S: Oh, that's so cool.

PA: Um, another hand that I have printed that I don't have is the flexi hand from another company. This is a myo-arm band. It's a myo-electric arm band. It goes on the arm and then it can read certain gestures.

S: Oh, interesting.

PA: And we couldn't really get it to work, but, uh, it was like one way of being able to control it.

S: Yeah. Okay. So this is one that you actually got from a company, like this, flexi hand?

PA: No, that is also on Thingiverse.

S: Oh, there's also on Thingiverse. Oh, okay. Interesting.

PA: Uh, I was going to say like one that I did get from a company, the old ones are these. I have a couple of my original ones. Yeah. They're basically the same design. Essentially a strap is on the back, and it goes around the back of my arm, then there's just a wire that pulls it. So when I push forward, it closes. And I never really gotten to using these for a couple of reasons. Um, one, I do have a fair amount of arm. So I didn't visit physical therapy when I was younger. So I got pretty good with just my arm. Unless I'm pushing forward to grabbing something, it's just kind of like a heavy thing that's there. And a big design flaw that these have is that, um, essentially how these are fit is, there's like a paper mache. I don't know if you've seen the process. There's like a paper mache, your arm to get a mould. And then they make this plastic thing in here that fits it in. And the thing about these on my hand at least, is that it cooks my hand. So after I wear it for a while, like, my hand is just beat red. It's hot. It hurts. And that's like one of the problems I've had with prosthetics. Um, also, I am missing three and a half inches from the top of my hand to the wrist and then the hand itself. And something that most people wouldn't notice is that it's kind of heavy. So one of the pros of the 3D printed hand is that it's lighter.

S: Mm-hmm. Okay. Interesting. Yeah. So what was like the process of, because you have that, the one that opens and closes, you just said it's very heavy and you never like used it. When did you get it, and I what was the process of getting that?

PA: Uh, the original ones, I went to the [redacted] hospital, and then they made the mould and then they got it for me. And then I got it and tried it and I was in elementary school. So they started out with a hand that was literally just a claw. Like, it didn't look like a hand at all. It was just a claw. But it was the same mechanism. And I was, trying to get used to using it in like fifth grade. So really, just what happened was there was one meeting where I got the mould in my hand and then the next meeting, I think, they tried to make sure it fits before they actually built the thing, and then I got it, and, you know, I was trying it out.

S: Okay. So did you actually have any choice in the prosthesis that you were given? Did you get to pick or, what was the process of that?

PA: Uh, no, they just kind of gave it to me. I mean, if there was any choice, I wasn't aware of it. They're just like "try this". I was just kind of assuming it was fairly box standard. Something that just kind of fit to my arm.

S: Okay. Interesting. You mentioned that it was really heavy and difficult to start using. So did you use it for a while and then kind of stop using it, or did you not take to it at all?

PA: I just, I tried to use any for a while. I was in this, as I remember, I was in physical therapy. I had a physical therapist come into the school to help me out and try things and we tried to get used to it. And I tried wearing it for a while, and eventually, I just kind of phased out because, you know, again, in addition to being heavy, in school, there's like just more there. So I'm writing. I'm just kind of like putting it down on the desk. The whole paper and it's just kind of weird for me. Yeah, because I'm pretty proficient without it. So.

S: So would you say like that maybe the prosthesis hindered instead of helped, or did it help in any way? Because you stopped using it. So like, do you think it was more of a nuisance?

PA: Yeah. Yeah, it is. I mean, that is one of the problems with prosthetics. Unless I need to push forward and grab, hold something in that hand, then I'm, I'm just pretty good with the hand I have. There's kind of a line where there are things that I need a hand there for, which would be nice. Yeah. Like, uh, for a while before video game remapping, like controller remapping. There were just some games I couldn't play. VR is still a problem. If I want to learn to play some instruments, I just need something there.

S: Yeah. It's really interesting you bring up instruments because I'm having meetings with the Blink Lab here at the U of A, and they work on bionic prostheses and rehabilitation and kind of help people use different hands. And so a group of them are interested in instruments and how people with hand differences can make music. And we had a meeting actually yesterday to discuss what are the options. Like, do we create tools that people wear? Or do we, you know, change the way that instruments are made so people can actually make music without having to feel like they have to change themselves to play the instrument? And, because I, uh, design and 3D print too, I was thinking, like, to have basically a tool *Shows left hand piano prosthesis* that's fixed at an octave for a piano. So at least someone can play potentially octaves on a piano. I mean, there are still a lot of limitations to it. But it's interesting that you bring that up because I'm interested in what people are interested in, if it's sport-specific or, you know, learning how to play an instrument or something. That's kind of why I have a case study on prostheses. It's like, what's like important to people, you know? Interest-wise or hobbies-wise, and what's available for prostheses. So, I have some more questions for you about the function of prostheses. From the ones that you've used or maybe ones that you've come across, what are your thoughts on the functionality of the prostheses in general?

PA: I mean, these are kind of weird (referring to body-powered arm) because you have to push forward to grab anything. And I mean, you can lock it like you can lock it. There's a metal ball on here and a socket that locks it, but it's still kind of awkward. That's just why I'm just kind of trying to make one that actually works with the movement I have. I think the problem is that like, there's no real control of finger movement or wrist movement. So there's only so much you can actually do. I wrapped around with this thing for about a week. And I have yet to get it to close. And it's still the best prosthetic I have just because it doesn't weigh much. There was a problem with like leverage if I was like opening a door with it. Yeah. But I mean, even if I get it to work, it's still, it's still kind of open and close as it's not going to be particularly useful. I'm still doing everything with my, I'm still going to do everything with my left hand.

S: Interesting. Okay. So that's interesting that like even, you know, like I, when I did my research on prosthetics, it seemed like there was like a ton of limitations in terms of like function even because it just seemed like at least the really fancy ones, even like the other ones, like just kind of limited to like just grip function.

PA: And even, yeah, that's basically my experience when I made the one with the myo-hand. Like you could just really only send two signals, and then it just, it just opens and closes.

S: Interesting. Yeah. And even as I mentioned, the piano prosthesis that we designed was kind of due to the fact that even this movement (opens and closes fingers) isn't even possible with with prostheses that are out there right now. So, I wanted to ask your opinion on like aesthetics of prostheses in a way that's like, for instance, could be considered tool-looking versus hand-looking. So I'm wondering what your opinions are on that aesthetics-wise, like is it important to you that it looks like a hand or, you know, what are your thoughts on if it looks like a tool or…

PA: So there's a spectrum between like, you know, on the one hand, it doesn't look like a hand at all, or it looks extremely fake. And the other, it looks just like a regular hand. This one (shows another prosthesis) has a glove and a rubber glove on it, which makes it look more like a regular hand, so it's more on the extremely realistic side, but even then it's still, it still looks a little bit fake. And this one doesn't look real at all. I think that, you know, aside if we're ignoring functionality, I think that I would like one on either end of the spectrum and like less than the middle, because like, you know, I can wear this. And, I mean, when I'm walking around without a prosthetic, if I pay attention, I can catch people, like, double looking just, 'oh wait, something is different.' And, you know, I might get less of it with this slightly less, though I can hide my regular hand pretty easily. But I would argue that you know, I think one of the pros of making like these is that. Anyway, it's almost like accessibility. It looks cooler. If you're gonna wear a prosthetic that's not completely realistic, you might as well make it look cool.

S: Yeah, yeah, fair enough. Yeah. So in terms of that, you'd say aesthetics are important to you in a way that maybe it kind of escapes realism in a way. You know, because you mentioned it's kind of hand-like, but it still looks fake. And where's the one? Was it the Raptor hand you called it?

PA: Yeah, this is the Raptor hand.

S: Yeah, where it looks kind of cool and robotic. Yeah, so would that be like your choice kind of to instead of, you know, have this skin-looking thing? You'd prefer to have something more like bionic and robotic?

PA: Yeah, because I mean, like, then there's just not much different. I mean, it's a little something I noticed wearing the prosthetic around because this is the first time I wore a prosthetic for a prolonged amount of time in over a decade that people, people still looked. They've got the double-takes. And, you know, you're probably going to get that. Like, you're still probably going to get that if you're wearing something semi-realistic. So if people are going to look at it, it might as well look cool.

S: Yeah. Okay, fair enough. Yeah. That's a good way of looking at it, actually. Yeah. So, like, in terms of aesthetics that you come across, you know, the commercial ones. What are they typically like? You know, that kind of mimicry of realism or have you come across ones that kind of like look robotic and cool? Is that why you kind of designed yours is like for that aesthetic?

PA: So all the ones that I've seen kind of try to mimic realism. The one that involved in myo was essentially because there was a son of an English teacher who just started into high school and he wanted to take an engineering class. But he was already building robots in middle school, so he could just teach the class.

S: Oh my goodness.

PA: So they, they basically, the school went to deal with them saying, okay, just do a project, and we'll just give you credit for the class. And my hand turned out to be that project.

S: Oh!

PA: So, we did have a little bit of the like traditional prosthetic experience built-in because the teacher, the mother, had some connections, and we got like a special version of the like glove, like this, this plastic thing in here. Like, one of the new tech things was made the same way as from a company in Pittsburgh. It was a paper mache like they did the mache mould, and then they came back with it, and it was basically just the same thing, but it kind of like it was, it was like a rubbery material, and it sucked in. And also, it had screws on the side so we could screw on 3D-printed parts. And the same problem is the traditional ones. As far as I can tell, I haven't really seen many other prosthetics of the ones I had, but I have been through some places where they were building them, and it seems to all kind of focus around more realistic prosthetics. I'm guessing it's because if I had to guess, it'd be because it's for people who weren't born with one arm. Yeah, so they kind of want that realism back.

S: Yeah, I didn't even think about that. Maybe someone who's instead not born with it was lost to them is used to that realism and lost the symmetry back, I guess. In a way, that's interesting.

PA: Yeah, I've encountered people who have broken their arm and are just absolutely astounded, or some may have no appreciation for how I can just kind of go about the day with one hand.

S: Yeah, that's really interesting because that's your normal versus instead function that's now kind of removed if it was an amputation or an injury. So I guess maybe you would say that contributes to the reason you didn't really take up these prostheses that were given to you because you were kind of used to using your regular hand.

PA: Yes, I am. Yeah, that's largely why I'm just used to without it. People who know me and even myself, we tend to forget that I don't have two hands. It just kind of fades into the background.

S: Yeah, interesting. Yeah, so I also want to ask, what are your thoughts on, like I've been seeing prostheses that have a wrist socket, and then you kind of attach either a hand or a tool to it. What are your thoughts on that? Have you ever considered one of those prostheses, or what are your thoughts on the attachments?

PA: Yeah, that's the way I'm planning on going. These hands actually can, I don't really get any tools for them, but these hands are all detectable. You can detach them and replace them pretty easily. And that's the kind of the way I was going with this one once I be able to get close, get a general design. I do plan on making it so I can just switch up hands. So I had kind of like something like that piano thing where I can just put it on because I have a keyboard and I can try that out. If I want only two different things, I can make a hand for VR or if I just want to hook or something.

S: Yeah, that's what I was thinking when I designed this. It was kind of based on that type of prosthesis with interchangeable attachments. So this would be one tool that you could kind of screw on, and then you could have another hand that goes on after you're done playing or whatever. So you're thinking of adapting that raptor hand to fit your socket then, that's really interesting.

PA: Yeah, once I get to be able to close, I can start actually making an arm and then be able to interchange hands.

S: Yeah, it's interesting. So what kind of interchangeable hands or tools that you're aware of that are available for that? Because if it interchanges, do you know if there's a lot of different options to interchange to?

PA: I mean, I know people make things like you made the thing for the piano. I think I've seen one that's made for a violin somewhere. I'm not aware of like many tools, but I think the thing is that I can just design it. And as long as I just have a connector, I can just stick it on to, like, I'm a pretty mediocre engineer. So I don't know so many design things as I do mould them. Like I just like this was made by mostly measurements of my arm. And this thing in the middle is I made a 3D scan of my arm with a connector. So if I want something to fit my arm, I just need to bring that model in like get it at the right spot and then subtract it and then automatically fit.

S: Okay. Yeah, I see what you're saying! Okay. Interesting.

PA: So, yeah, I mean, I'm guessing I'm just going to have to like, make most of the tools I want from scratch and just kind of add the connector onto there.

S: Interesting. So like, I went through your portfolio too because I saw that you were designing things because [redacted] sent me so much information. And so talking about like these tool attachments, like what would you hypothetically want them to accomplish if they're interchangeable? I guess one doesn't have to accomplish like a million tasks, but you know, have separate ones for individual tasks. So like, what would you like that tool or attachment to accomplish?

PA: Um, basically anything that I come into that I need to hand for, like I mentioned VR, I have an Oculus Quest that at a certain point kind of becomes useless just because there's an expected second controller there. Also like, playing instruments, just because I like to try out a bunch of things. I'd probably make something just because it looks cool. Like, I joke about making a hand with Wolverine claws. I'd kind of like another claw just for the nostalgia. Just walking around with a claw. Um, you know, it just depends on the situation. And whenever I run into a problem that I need a hand for, I can just design something for that. Also, I would like to get as much closer to a regular hand as possible. You know, this movement, wrist movement, you know, I'm just kind of into iterating towards that.

S: Interesting. Yeah. Yeah. So it would be like, I guess, a mix for you between like function-specific and also aesthetic-specific. You know, you mentioned the claw thing.
Yeah, for you, like that interchangeability, you would say, is important, like kind of both functions and aesthetics?

PA: Yeah. You know, like I said, you know, when you're wearing something like this, it's accessorizing.

S: Yeah. Yeah, that's true. That's interesting. You say that because, you know, in my, in my thesis. I'm kind of fond of this question of like, if someone gets to pick their clothes or products that they buy that kind of reflects their sense of self and their personal aesthetics, then why can't someone have a hand or an arm that also does the same? You know, some people like shiny Apple products. Some people don't care about that. Some people love the colour pink. Some people hate the colour pink, you know, so yeah, it's interesting you said that because it just goes to show, like, I guess, the value of choice between those two things. Yeah, so I'm wondering if I can take this information, all that we talked about and then fine-tune, maybe even this one (shows LH Piano Prosthesis) because you mentioned you're interested in learning instruments and you have a keyboard and stuff. Like, if we kind of take ideas from today's meeting and then, if we want, we could set up another meeting kind of like discuss ideas and then ideate and stuff. Because you mentioned you're into 3D printing, and you printed this whole Raptor hand for yourself. So, yeah, I'm wondering if you'd be like interested in another meeting, and I can, we can ideate…

PA: Yeah, that sounds fun.

S: Yeah. Yeah, that would be interesting. At least like some attachments or something. The thing about my thesis is like, that I'm not an engineer. So in terms of fabricating technology and making sure logistics are there, I'm a little bit off. You know, my thesis is more to create a conversation about this idea of choice and personhood and individual complexity and stuff. So, you know, at the very least, maybe we could just ideate something and then, you know, you could run with it later if you choose to like adapt it to your attachments. But yeah, maybe we could set up another meeting. If you'd permit it then we could talk about ideas, or if I sketch up something you could tell me what you think.

PA: Yeah, that sounds fun. One thing we should also think about is how to make something like this, like the sleeve that doesn't cook my hand. That's one of the things I'm interested in tackling.

Right now, I'm still prototyping. So this is open. And, you know, it was kind of nice because, like, if this doesn't close, I could still be like my hand was still there and accessible. So I can still use it as a regular hand, and it didn't bake my hand. But that's like, if I have to add more in and I'd really like, I'd really like a prosthetic that just doesn't like hurt to wear.

S: Yeah, that's fair. Otherwise, you're not going to wear it anyway, right? So what's the point if it hurts and is terrible to wear?

PA: Yeah. Yeah.

S: We could, you know, I'll see what kind of comes out of this meeting, and either you or both of us can, like, you know, draw our sketch out ideas or whatever and then meet. And I was wondering, is there any other information that you would like to give me about like your experience? Prostheses, in general, maybe something we skipped over or…

PA: No, I think I covered everything. I'm sorry. I tended to talk over you a little bit.

S: No, no, no, I was supposed to interview you! So that's good you were talking lots here. You gave me lots of information. No, don't apologize at all. No, it was great. And is there anything you would like to ask about me or about the study or anything in general?

PA: Not now. I'm just interested in it in general.

S: Okay. Awesome. Well, if there's nothing else, maybe, we could end the meeting for now and then correspond and email maybe to set up another meeting in like two or three weeks to discuss like if there's any like ideation ideas or, you know, I could validate some ideas with you later. Kind of do a part B.

PA: Yeah, that sounds good.

S: Okay. Awesome. All right. Well then, I guess we'll end the meeting here. And also you can email me at any time about anything. If there's any other information you want to give me or any questions about the study in general, feel free to email me. So thank you so much, [redacted], for your participation in your time. I really appreciate it. You're helping me a lot in my thesis research. So, yeah, thank you.

PA: You're welcome. It was fun.

S: Yeah. Awesome. All right. So let's stay in touch. And I hope you have an awesome rest of your day.

PA: You too. Awesome. Thank you. Bye, [redacted].

S: Bye.

Participant Interview: Session 2
Participant A

PA: Hello.

S: Hi, [redacted].

PA: How are you?

S: Good. How are you? It's nice to see you again.

PA: Yeah, good to see you too.

S: Nice, thank you for meeting with me again. It's been a while since we had our first meeting. So it's been so much time in between. It's been a very, very busy time.

PA: Yeah, that's okay. I was in Salt Lake City for most of October anyway.

S: Oh my goodness. Just for vacation?

PA: No, I went to an AI conference.

S: Oh, interesting. Oh, that's so cool.

PA: That's the same one where I met [redacted].

S: Oh, so cool. Oh, that's really interesting.

PA: I actually tried to wear another prototype for my arm.

S: Yeah?

PA: It was similar to the last one.

S: Oh, so, like the Raptor hand?

PA: Yeah, basically the same one. I made some slight adjustments. I kind of learned that the cuff I was using was a bad idea because my arm swells.

S: Oh, really?

PA: So by the end of the day, it was like hard to pull off.

S: Oh my goodness. Yeah, so I guess there's a lot of prototyping. I guess you're your own lab rat. You get to test your designs and make adjustments personalized.
PA: Yeah, pretty much. And the conference is a good time to test it because it's like the longest I would wear it.

S: Yeah.

PA: Also the most people I would see wearing it. And I gotta say, a lot of people were uncomfortable with it.

S: Oh, with you wearing it?

PA: Yeah, like or like interacting with it.

S: Really? Like what do you mean?

PA: Well, some people thought it was cool when I had some conversations with it. But I also went to shake people's hands with it because everyone, you know, instinctively puts up the right hand and that's why kind of why I was wearing it. And it kind of threw people off guard.

S: Oh, interesting. Oh, I never thought about that.

PA: Yeah, like, people's reaction to wearing prosthetics, it's kind of interesting.

S: Yeah, yeah. I'm sure there's like a wide range of reactions, right? So yeah, actually, last time we talked, you mentioned that one of the biggest things maybe I took out of it was this idea of people doing like second-takes, and you had mentioned if you're wearing a prosthesis in terms of aesthetics, like might as well make it look cool. You know, so that really stuck with me. So I was like, oh, very interesting. Like, this idea of social perception and how people perceive you. Whether you're wearing a prosthesis or not. So yeah, you had mentioned aesthetics, like something robotic or Wolverine claws.

PA: Yeah!

S: I also talked a little about like function. So for instance, like the piano prosthesis I had prototyped. I had a left-hand version. So I said, okay, like 'I'll make a right-hand version'. So that notes can be played for a melody line. So I did some sketches, and I just wanted your feedback on them. If you like the designs for them, I'd also like to know how they can be improved upon so they match your function and aesthetic requirements. Yeah, so I will show my screen. Just have it on my iPad here.

S: *Shares screen with drawings*

S: So I had just sketched up this idea of aesthetics and I looked a lot into passive prostheses. And so basically people are paying a lot of money, like they're really expensive when I looked online for passive prostheses.

PA: Oh yeah.

S: Like they're so expensive, and they look very detailed, and they kind of replicate the other hand. And then you're talking about Wolverine claws. So I was thinking, like, okay, why can't passive prostheses be something cool and aesthetic? Or, you know, mimic like superheroes or Marvel or DC? And so the idea of this is just a 3D-printed fist, it's very straightforward. But it's got those Wolverine claws, and, you know, hopefully, it's not like a weapon. But I was thinking maybe a softer rubberized material, maybe a silicone at the top or something. So that is not this really harsh, sharp thing, but it's still aesthetic and it kind of replicates these Wolverine claws. You know, since it's printed out of resin or PLA, he's still very lightweight and it kind of screws onto the socket you were talking about with these attachments. Yeah, so it's in a fixed position, but it mimics these Wolverine claws. And then we were talking about, you mentioned something robotic and cool-looking. And so I was just kind of sketching, okay, what kind of like robotic aesthetic maybe cyborg hands can there be. And so again, this would just be dealt with aesthetics just for non functional purposes. It could be passive, but again, just like something cool, you know, and then variation in colour as well. So because of 3D printing, you can do a lot with 3D printing. And even the finishings you can put on them like you can with the auto body spray. You can make things look very glossy or matte. And, like, I've seen someone make this crazy hyper-realistic Iron Man helmet. It's got this really awesome gloss finish and matte kind of aesthetic to some of the sides. So just looking at aesthetics, and of course, I want your opinion on these because aesthetics are so personal. So these were just like some ideas of, you know, something robotic or cyborg or just something cool looking just for the purpose of being passive and aesthetic. So, of course, like color variations and stuff. So this was the aesthetic side of things. And then I drew a right-hand adaptation for the piano prototype that I was doing. I had originally done it for the left hand, so it was fixed at an octave. So you can play an octave on the keyboard. And so this one is just super, super, simple. As a designer, I have to say, okay, "what's like the lowest hanging fruit?" What is the easiest thing that I could design? What's the easiest thing that can be achieved? And so basically, it was this right-hand variation with just a single-note melody. So in a lot of music for right hand, there's this thing called voicing or just melody lines. And so just being able to press down the keys this way might help. And so the tip, has these silicone pads, I did a silicone mould. It's very similar to the 'give' that a finger has. It has a shore hardness of like 40 A, I think. So it's very soft. And I had pressed it on my piano. It's very reminiscent of like the give that fingers have. So that would be on the tip of that peg there. Yeah, and so then I had modelled it in Rhino just to kind of see how it would look in 3D. And then this is the left hand version that I had originally done. But I was thinking that the right-hand version could also probably benefit from, you know, an octave as well. Because a lot of music has octave notes in the right hand. So this is kind of how it sits like that, just as an example. So this was the left-hand prototype. These are the sketches that I have for now. I would love your feedback on it in ways that can be improved or personalized more. Especially just even to you, you know, because in my thesis I'm talking about this idea of personalization and personhood.

And what's important to people's personal aesthetics. So I'm just wondering about the general feedback before I ask you more specific questions.

PA: I like the cyborg hand because I like blue. So I kind of like the colour of that one. Yeah, so I think that that would look cool. Like, it's like glossy finish. The thing about the Wolverine Claws though is that they might be, they might get in the way.

S: Yeah.

PA: Yeah, so something too long. I mean, it just could be a hassle to deal with.

S: Yeah, yeah. I know this is completely like aesthetic purposes because, you know, even you said you had joked, “I was thinking about Wolverine Claws.” So I was like, okay, why not? But in terms of practicality, like every day, definitely not. You know, or maybe something that slides inwards into your hand or folds out.

PA: Yeah, just retractable Wolverine Claws.

S: Yeah, exactly.

PA: Just have a button at the bottom of the wrist.

S: Oh, yeah. Yeah, that may be difficult for me, at least as a designer, I was like, oh, the engineering behind it. But that would be cool. Something to slide or retract.

PA: I mean, it could just be like spring-loaded. So, you know, you just need a kind of lever that just latches onto it. And then when you press that lever, it opens, and it releases a spring.

S: Yeah. That would be an interesting solution. Spring-loaded.

PA: Yeah. When you want them to pop out.

S: Yeah. So, I'm just curious for you. Like, do you know, like seeing these designs, do you know of anything that kind of exists? Like, these that you've seen on the market?

PA: the hero hand.

S: Yeah!

PA: Yeah.

S: I actually, what is it? What is that company called? Hero, Hero Arm by Open…

PA: Open Bionics?

S: Open Bionics! Yeah. Yeah, I was looking at them a while ago, and I was thinking like, oh, they look quite… They look a little more like cyborg-y, a little more aesthetic, even though they're functional. But, yeah. So, I was wondering like, would these designs be useful to you hypothetically? Like, would you see yourself using these designs if they were available to you?

PA: Uh, yeah. Yeah, they look cooler than the one I have, so…

S: And I was just wondering, especially because me being a designer, the aesthetic side of things is a lot easier for me to do. Like, you had mentioned, what are the other things you had mentioned… Oh what is it called? VR controllers. And then even the socket that doesn't, like, cook your hand. And it's not so, so hot. Like, that stuff I was trying to come up with, I was like, oh my goodness. That is a lot more difficult, especially the VR stuff, because it boils down to dexterity with the fingers. So in terms of aesthetics, that was the one I kind of was like, okay, I'll focus on this low-hanging fruit. You know, what I'm able to do with my set of skills and my limitations and stuff. So yeah, I was just wondering in terms of aesthetics, would this match your personal aesthetics? And how can they be improved to really be personalized to you?

PA: Um, I mean, to me, I think the one you're showing right now is a bit more detailed. Like, it has a lot of details. I would, like, generally wear, usually, I go more streamlined. It's like something like that. [referring to drawn iteration]. And I really like the color. My favourite color is blue, so I would definitely gravitate more toward blue than red.

S: Yeah. Okay. Interesting. So I was just wondering if I should draw more designs for this or if this is something close to what you would be interested in, like, hypothetically, if you were to pick out a prosthesis., I would love to draw more designs so that it would be personalized to you. If there's inspiration from somewhere, you know, like to match a TV show or a certain aesthetic or sub-culture.

PA: Yeah, I'd wear something like this.

S: Okay. So, like, what is your opinion on passive prostheses like this, then? Because this is only meant to be passive because in terms of my capabilities, making bionic things is outside this scope. But even the discussion of why can't people have very cool-looking robotic passive prostheses or why they have to be realistic hand-looking. So I just kind of wanted your opinion on this in terms of something passive.

PA: Well, I've worn, I've recently just worn a passive prosthesis for about a few days. You know, as long as it's light and not encumbering, it's usually not too bad. The only problem I really had once was when I had to carry a tray and open a door. And that, that kind of, that was kind of difficult because I had to balance it on my arm. But, you know, I mean, I was wearing it mostly just for fashion and also to have something there if someone went to shake my hand.

S: Okay. Interesting. So, with the passive prostheses, do you usually want them in a sort of fixed position or for the fingers to be able to move for you to adjust the fingers?

PA: So the one that I've been wearing I at least want the fingers to be open. But, yeah, you know what, being able to adjust it to maybe a fist or something would be useful.

S: Okay. Interesting.

PA: Or, like, maybe adjust the fingers for whatever purpose. As long as they're not too easily moved.

S: Yeah, because I had modelled these ones off of… so I have a 3D printed hand here. And so it has strings like these elastic strings. And so you can kind of mimic the hand movements. I was like, oh, that would be interesting. Not as easy as this, because this is very easy to move. But something that maybe could be adjusted was a little more force, of course, just to kind of get different hand movements, whether you want it all open, or, like, all closed. So maybe something like that instead of just a fixed position, something in between very, very easy or just fixed.

PA: Make it, make it do, like, yeah.

S: Like this [moves fingers on nail prosthesis hand]

PA: Yeah. Yeah, basically, or like, a thumbs up as close as possible.

S: Yeah, kind of, yeah, like this.

PA: Give someone the finger!

S: Yeah!

PA: Yeah, you know!

S: I see, yeah! So, like, adjusting those hand gestures, so it's not fixed. Because the way that I drew these, I was wondering what your opinion was on a fixed position or one that kind of moves around. So, yeah.

PA: Yeah, I mean, if anything that at least wanted to be a little, like, stay open or closed, I just don't want, like, fingers, you know, kind of…

S: Flop around?

PA: Yeah. Being able to just kind of stay on one hand, one hand position for whatever I'm doing. I don't know, like maybe wrap it around something if I need to. That would be useful.

S: Yeah. That would be very useful.

PA: Also, material. Because I've been printing with PLA, and I attempted to make one with Ninja Flex, which is, like, a flexible filament. But I couldn't quite get it to not fall apart when it took out the supports needed.

S: Oh, I haven't heard of Ninja Flex.

PA: It's a, it's a, I think its material name is technically, like, TPU.

S: Oh.

PA: It's a flexible filament.

S: Oh, okay, got you.

PA: Yeah. And I think I think it's called the aida hand. So it's, like, a flexible hand with hardback and, like, wrists that you can screw it onto.

S: Interesting. Oh, okay. Yeah, I worked with TPU once, and it was a nightmare to print with.

PA: It's, it is difficult. I screwed up a bunch of times. But, yeah, even you just made silicon moulds that you can put on. So, like, I don't know, a feel maybe, maybe it depends. I don't know. The friction might be a problem at some point. It depends on where you put it. That might be good, especially on the front of the hand or the fingertips, maybe.

S: Yeah.

PA: Like, you found out.

S: Yeah. Actually, I wasn't thinking about that for these hands, but yeah, that would be good, actually, because I had cast them just for the piano prosthesis. But, yeah, having this kind of grippy, it's very, very grippy. It is also very soft; having that maybe on the finger pads of the aesthetic models would actually help too. Especially if the aesthetic models can be adjusted to close over something. Yeah, that would be a good addition.

PA: A pro tip. If you, um, if you want to screw something soft into something hard, you can get thread inserts. And then take a hot soldering iron and just kind of put it, like, in a pre-made hole and then just press the soldering iron in. And it'll melt the material around it.

S: Oh, interesting. I didn't know that.

PA: That’s how you get ninja flex onto PLA.

S: Oh, interesting. Oh, that's a good tip. Because I imagine it might be hard to connect those things. Okay, so good feedback on this one. And I was just wondering, especially for this was kind of the functional one that I had designed. Um, because you had mentioned you were interested in tinkering around with your keyboard and stuff. So maybe just, like, your opinion on this one. I mean, like, just made the 3D model of it.

PA: Uh, well, I'm not good at keyboard [laughs] So, you know, I mean, as long as the base isn't too wide, I don't think it would get in the way. My elbow kind of has a good up-and-down motion. You can make it go really quickly. So I think that'd be good. I'm curious how the right-hand one would work on the left hand, or the left-hand one would work on the right hand. I wonder how much I'd be able to, if I'd be able to, like, if my turn would be enough.

S: Oh, like in terms of, like, playing one note with the two-pegged one.

PA: Yeah.

S: Oh, interesting. That's interesting. Because I haven't thought about someone doing it like that because I had designed it set an octave. But yeah, you're right, like, interesting to kind of switch it over and play a single note.

PA: Uh, so something else you can look into is, as far as piano playing is, um, someone made an ultrasound hand. So most bionic hands including the one that I've tried to make, uses a myoelectric armband. Usually called the myo from a company that no longer makes them. Uh, but I saw a paper and a demonstration of someone playing the piano with the prosthetic hand that took commands from, like, ultrasound in the arm.

S: Oh, oh, I think I know what you're talking about.

PA: And that, that gave individual finger control.

S: Yeah. I had watched that video. And it was like a full hand, right, with each individual finger?

PA: Yeah.

S: Yeah. And I had watched it, and I was thinking, like, oh my goodness. Like, looking at it, I was thinking that the delay is a lot. You know, when you have more moving parts, the signal from the brain, the muscle, and then the muscle to the hand to kind of move it. Like, playing all those notes in time or even quickly, I was thinking it must be so difficult. So that's why I was like as far as my limitations go, staying away from that kind of stuff. Because I wouldn't be able to figure out how to get the movement. It's so complex, but that's why I stuck with something super, super simple. Because there's no moving parts in it, you know, it's just body-powered.

PA: Yeah

S: But yeah, that video, I remember seeing it. I was like, oh my goodness. They're making, like, progress at least. But, yeah.

PA: I'm also thinking about, like, so I could make something with the left-hand one, where I actually stick my hand in and have a lever for a third button. That I can pull up and down just by moving my hand if I wanted to. And I could get some control with that. Like, that probably wouldn't be too hard to… design.

S: So, like a third, a third lever for another one of those pegs to come out?

PA: Yeah. Or just moving one of them, one of those pegs, somehow.

S: Oh, okay, see. So it switches from, like, an octave to then, like, a single note.

PA: Yeah.

S: Interesting. Oh, okay. No, I love that. I love this feedback because it's stuff I haven't completely thought of. Because sometimes, it's funny, as designers, we get tunnel vision. And then it's hard to look outside of the design. So, you know, I love all this feedback. So yeah, that'd be cool. Something like those Wolverine claws, something retractable. Or something that flips up.

PA: Yeah

S: So, um, so I would probably do some more sketches then because maybe, I don't know if we'll need another full meeting for them. But maybe I'll just email you some more stuff to you and get your feedback. Because it's just at this point, refining some designs and stuff. And I don't know if you have any more feedback from me on any of the sketches or, you know, how they can be improved, especially for you personally.

PA: Um, not really. I'm kind of curious. They're just drawings. I'm kind of curious how they would be printed.

S: Mm-hmm.

PA: So, that's interesting. And also, uh, how the different colors would kind of be manufactured. But that's, you've said, it's just a bit outside ofyour expertise.

S: Yeah. Uh, well, in terms of the thesis, I have so only limited time, you know? So if I have more time, I would definitely try to manufacture even one of the aesthetic robotic hands. And as you mentioned, 3D printing is great because it's so lightweight for your hand. It doesn't weigh down your arm. And so, keeping within, like, 3D printing realm and then finishing the pieces with primer, sanding them, and auto body paint. Because the stuff that I've watched on YouTube with people, and even some of the prints that I've done finishing them, is that you can get them to look really nice and smooth and finessed with some metallic auto body paint and some primer and sanding.

PA: Yeah.

S: So, you know, going that way, you can keep the material's light because if we want a metallic from metal, then it would get really heavy.

PA: Oh, I mean, yeah, you can metal plate things. I've seen videos of people doing it. I have no idea how that works.

S: Yeah.

PA: Like, you put it in, like, a solution with some metal and some electricity. I think the thing that's worth considering is, who's going to take the effort to make it look like that?
I mean, if you're selling it, but if you're just making a hand, sanding a 3D print is really time-intensive.

S: It's true. But, I think everything's comparative, though, because we have to imagine how much time a prosthetist is taking filling in all these little hairs and details on the hands and stuff.

PA: Oh yeah, that’s true.

S: So it's like the idea of what if that effort was spent into making a cool hand, you know? Is it the same amount of effort? Is it more, or is it less? Like, it could be actually the same amount of time, if we think about it, you know.

PA: Yeah, that makes sense.

S: Like, each passive prosthesis realistic hand is personalized to that individual. So it's the idea of, like, well, why can't this new robotic hand be something completely special for this person? And give that same amount of time and energy to this certain aesthetic, you know? So, yeah,

PA: That makes sense.

S: It’s just kind of shifting the conversation a bit, shifting the focus into people's personalities and the sense of style or aesthetics.

PA: Yeah.

S: Yeah, so if there's no feedback, maybe I'll take the feedback that you've given me today. Maybe I can email you new images and stuff instead of meeting because it might just get, like, shorter and shorter, you know, as we go.

PA: Yeah.

S: This is narrowed down.

PA: It's up to you. Uh, send STLs.

S: STLs? Oh, yeah, for sure!

PA: Yeah, send files so I can print.

S: Okay, for sure. Yeah, I can send you, especially since I have these piano ones in Rhino, so I can send them to you.

PA: Yeah.

S: And you can kind of tweak them and personalize them to fit, you know, your socket or whatever you're doing. So, I'd be more than happy to send them. Yeah.

PA: Yeah

S: Well, thank you so much, [redacted], if there's, like, no other…

PA: Uh, yeah, I want to show you one thing.

S: Oh, yes, definitely!

PA: We talked about VR, and I got back into VR.

S: Oh, great.

PA: Because I decided to do more research on that. So, most, like, VR attachments are like this one for Beat Saber. It's the cup that you… You can just kind of put… Like, you put it the string though.

S: Oh, is Beat Saber the one you're hitting the arrows to?

PA: Yes.

S: Oh, okay.

PA: That is the one.

S: Interesting.

PA: So, you know, it just puts a cup in, and this one has a thing where you… Put the string in here, and then just twist it.

S: Yeah.

PA: So, like, you know, this cup doesn't interact with any of the buttons. And, basically, how I'm solving my VR problem right now is… I just duct-taped Velcro to the controller.

S: Oh, interesting.

PA: It just, like, kind of sits there, and so I can pull the trigger.

S: Yeah.

PA: And it stays with my arm.

S: Oh, interesting. So, you wrap it around your wrist that way?

PA: Yeah, this has, like, a belt where you can string it through and then wrap it around and hold it tight. And getting the angle where it's important. So I can keep pressing the button. I'm still working on the accessibility features. But, basically, I'm just going to print a cup where I can string the Velcro through and then strap it around my arm.

S: Oh, that's a cool solution.

PA: And, yeah. I'm still having some trouble with some of the button inputs, because you can actually now remap buttons, which is nice.

S: Oh, oh, I see. Okay, so you can, instead of pressing B or whatever, you can change that button to another button.

PA: Yeah.

S: Okay.

PA: So, if I need to grip on the right hand, I can, like, change that to a button on the left hand.

S: That's cool.

PA: So, yeah, that's how I'm handling VR at the moment.

S: Yeah. And this is, like, just specifically for that one game? Or does it apply to all games?

PA: Well, with Beat Saber, you just need the controller strap to your arm. Because you're just swinging it. So, as long as it's stable, I was trying to play a game called SuperHot, which is a game where it's like a shooting game where time only moves when you do. And you're usually surrounded by people. So, you know, you can pick up a gun, shoot it, and then the guy's gun, who's flying, and everything is only moving when you do. So, as you go to reach the gun, other guys are coming for you. And they can shoot you, and then if you move slow enough, you can dodge the bullets.

S: Oh, I see! Okay.

PA: So, I had my right hand in a fist for most of the game. Yeah. So, I could just use that to punch people. And then I got to a point in the game where, I guess there's a mechanic where you can just hold your hands up and then, like, kind of force-push people. And I think it requires multiple button inputs.

S: Oh, I see.

PA: But I'm not sure which ones to map it to, because just how they both first close isn't working. I think I need to press the buttons too.

S: Oh, like simultaneously.

PA: Yeah, and you can only map one button to one button. And so, I'm kind of interested… I'm kind of wondering how I'm going to get past that one.

S: Oh, interesting. You can only do one for one button? Because I was thinking, like, okay, I'm wondering if you can do combinations for a single button, like, press it twice to signify one combination or press once to signify this button or something.

PA: So, the remapping options inside the quest only let you do one button, just that you switch one button. It was a long time ago, I was playing with the Vive before they had all these options. And basically, I just attached the tracker to a wristband. And then, the wristband sent signals to my computer, which I had changed, and assigned keys, which then triggered buttons.
So, that was more used. That was a bit more customizable.

S: Yeah.

PA: I'm wondering how I can, you know, and other ways to press buttons than just the remapping tools, and also keep the tracking of the controllers.

S: Yeah. This is interesting. When you brought up that issue with VR, I was thinking is this something to do with *you* adapting to the controller? Or is it just a matter of maybe the controller or the program needs to adapt for the *person*? And so, maybe this is an instance where in terms of button remapping, there needs to be something work done, so that, you know, one button isn't just for one button. Maybe it's a combination of one button or something like that. So, I was thinking, oh, maybe the actual VR set has to have more accessibility features than someone adapting to it, you know? So, that's why I was like, I don't know how to tackle this in terms of, like, prostheses and stuff.

PA: Yeah, the question is basically an Android phone. So, what I'm thinking about, if I can, like, I think a new controller needs to be a new way of inputting controls needs to be added, because aside from the, like, limitations of remapping, remapping is weird in VR. Because, you know, it's supposed to be as close to one-to-one as possible. So, pressing the button on my left hand to close my right hand will never not feel weird.

S: Yeah.

PA: It's just odd.

S: Yeah. Fair enough. But you came up with, like, an interesting solution for that Beat Saber thing that was, you know… Modern problems require modern solutions!

PA: Yes, duct tape, duct tape is a very modern solution!

S: Yeah, that's awesome! It's a good example of design ingenuity. Anyone can be a designer. So, yeah. Well, it was really great talking with you, [redacted]. And there's nothing else for, like, feedback or any comments or anything, you know, I'll let you go enjoy the rest of your day. I really appreciate you meeting with me again.

PA: No problem was fun.

S: Yeah, and I'll reach out. I'll reach out sooner or later if I have some more sketches or refinements and stuff, and we can discuss further.

PA: And don't forget to send those models.

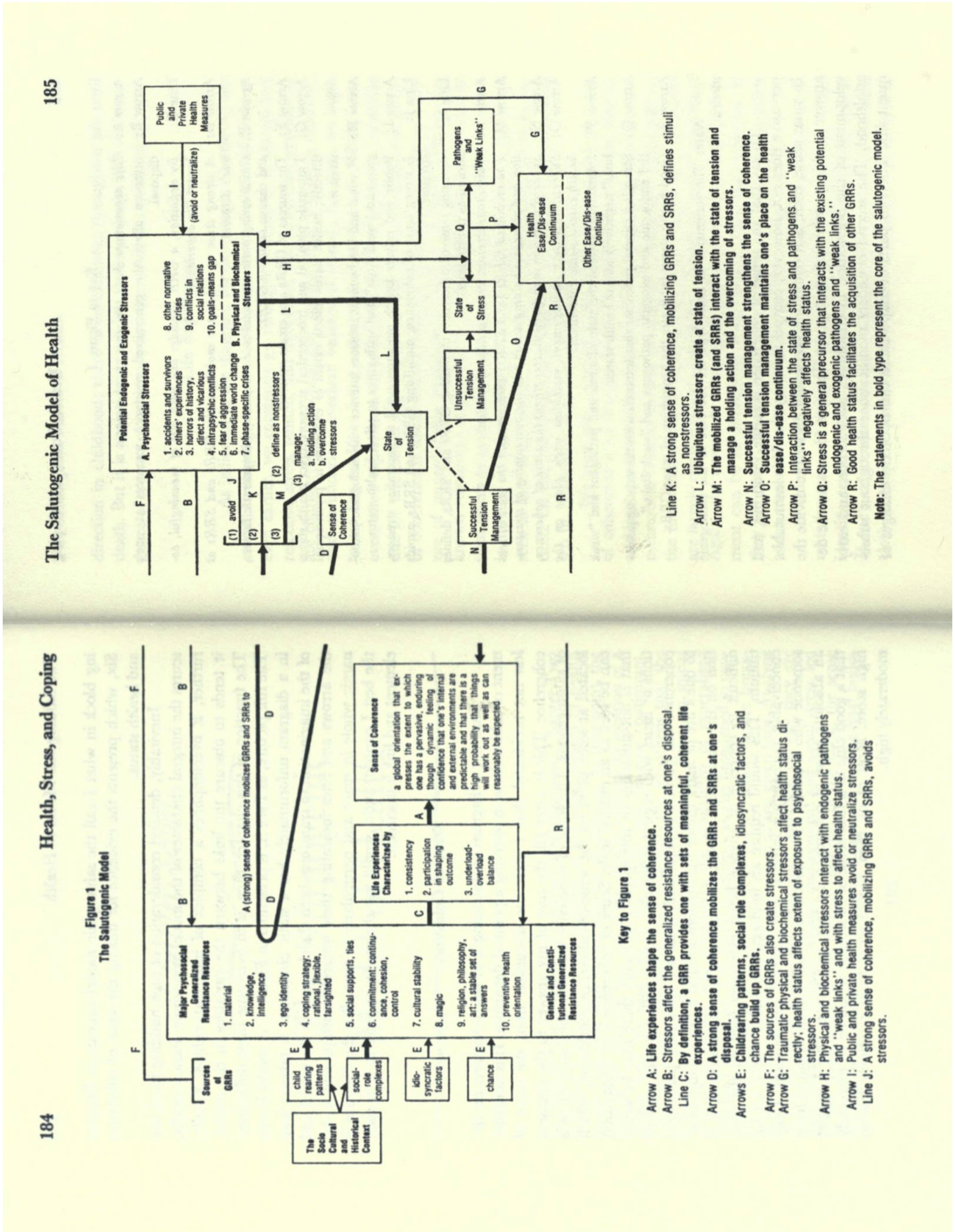
S: I'll write it down right now. STL files. I won't forget. Sounds good. Awesome. Well, thank you so much, [redacted]. I hope you enjoyed the rest of your day.

PA: Thanks. You too.

S: All right, bye.

PA: Bye.

3.0 The Salutogenic Model



Key to Figure 1

Arrow A:	*Life experiences shape the sense of coherence.*
Arrow B:	Stressors affect the generalized resistance resources at one's disposal.
Line C:	*By definition, a GRR provides one with sets of meaningful, coherent life experiences.*
Arrow D:	*A strong sense of coherence mobilizes the GRRs and SRRs at one's disposal.*
Arrows E:	*Childrearing patterns, social role complexes,* idiosyncratic factors, and chance *build up GRRs.*
Arrow F:	The sources of GRRs also create stressors.
Arrow G:	Traumatic physical and biochemical stressors affect health status directly; health status affects extent of exposure to psychosocial stressors.
Arrow H:	Physical and biochemical stressors interact with endogenic pathogens and "weak links" and with stress to affect health status.
Arrow I:	Public and private health measures avoid or neutralize stressors.
Line J:	A strong sense of coherence, mobilizing GRRs and SRRs, avoids stressors.
Line K:	A strong sense of coherence, mobilizing GRRs and SRRs, defines stimuli as nonstressors.
Arrow L:	*Ubiquitous stressors create a state of tension.*
Arrow M:	*The mobilized GRRs (and SRRs) interact with the state of tension and manage a holding action and the overcoming of stressors.*
Arrow N:	*Successful tension management strengthens the sense of coherence.*
Arrow O:	*Successful tension management maintains one's place on the health ease/dis-ease continuum.*
Arrow P:	Interaction between the state of stress and pathogens and "weak links" negatively affects health status.
Arrow Q:	Stress is a general precursor that interacts with the existing potential endogenic and exogenic pathogens and "weak links."
Arrow R:	Good health status facilitates the acquisition of other GRRs.

Note: The statements in italic type are the core of the salutogenic model.

4.0 Orientation to Life Questionnaire

Source: Sense of Coherence -Orientation to Life Questionnaire.
gustolifegroup.files.wordpress.com/2015/05/soc-questionnarie.pdf.

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Sense of Coherence – Orientation to Life Questionnaire

The Orientation to Life questionnaire has 29 questions regarding different areas in your life. Each question has 7 alternative answers – circle the answer (only one answer) that you feel is the answer closest "to heart" for you. There is no "right" or "wrong" answer so be honest to yourself.

1. When you talk to people, do you have the feeling that they don't understand you?

1 2 3 4 5 6 7

Never — Always have this feeling

2. In the past, when you had to do something which depended upon cooperation with others, did you have the feeling that it:

1 2 3 4 5 6 7

Surely wouldn't get done — Surely would get done

3. Think of the people with whom you come into contact daily, aside from the ones to whom you feel closet. How well do you know most of them?

1 2 3 4 5 6 7

You feel that they're strangers — You know them very well

4. Do you have the feeling that you don't really care about what goes on around you?

1 2 3 4 5 6 7

Very seldom — Very often

5. Has it happened in the past that you were surprised by the behaviour of people whom you thought you knew well?

1 2 3 4 5 6 7

Never happened — Always happened

6. Has it happened that people whom you counted on disappointed you?

1 2 3 4 5 6 7

Never happened — Always happened

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7. Life is:

1 2 3 4 5 6 7

Full of interest — Completely routine

8. Until now your life has had:

1 2 3 4 5 6 7

No clear goals or purpose at all — Very clear goals and purpose

9. Do you have the feeling that you're being treated unfairly?

1 2 3 4 5 6 7

Very often — Very seldom/never

10. In the past ten years your life has been:

1 2 3 4 5 6 7

Full of charges without your knowing what will happen next — Completely consistent and clear

11. Most of the things you do in the future will probably be:

1 2 3 4 5 6 7

Completely fascinating — Deadly boring

12. Do you have the feeling that you are in an unfamiliar situation and don't know what to do?

1 2 3 4 5 6 7

Very often — Very seldom/never

13. What best describes how you see life?

1 2 3 4 5 6 7

One can always find a solution to painful things in life — There is no solution to painful things in life

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14. When you think about your life, you very often:

1	2	3	4	5	6	7
Feel how good it is to be alive						Ask yourself why you exist at all

15. When you face a difficult problem, the choice of a solution is:

1	2	3	4	5	6	7
Always confusing and hard to find						Always completely clear

16. Doing the things you do every day is:

1	2	3	4	5	6	7
A source of deep pleasure and satisfaction						A source of pain and boredom

17. Your life in the future will probably be:

1	2	3	4	5	6	7
Full of changes without knowing what will happen next						Completely consistent and clear

18. When something unpleasant happened in the past your tendency was:

1	2	3	4	5	6	7
”To eat yourself up” about it						To say ”ok that’s that, I have to live with it” and go on

19. Do you have very mixed-up feelings and ideas?

1	2	3	4	5	6	7
Very often						Very seldom/never

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20. When you do something that gives you a good feeling :

1 2 3 4 5 6 7

It's certain that you'll go on feeling good — It's certain that some-thing will happen to spoil the feeling

21. Does it happen that you have feelings inside you would rather not feel?

1 2 3 4 5 6 7

Very often — Very seldom/never

22. You anticipate that your personal life in the future will be:

1 2 3 4 5 6 7

Totally without meaning/purpose — Full of meaning and purpose

23. Do you think that there will always be people whom you'll be able to count on in the future?

1 2 3 4 5 6 7

You're certain there will be — You doubt there will be

24. Does it happen taht you have the feeling that you don't know exactly what's about to happen?

1 2 3 4 5 6 7

Very often — Very seldom/never

25. Many people – even those with a strong character – sometimes feel like sad sacks (losers) in certain situations. How often have you felt this way in the past?

1 2 3 4 5 6 7

Never — Very often

26. When something happened, have you generally found that:

1 2 3 4 5 6 7

You over- or underestimated its importance — You saw things in the right proportions

27. When you think of the difficulties you are likely to face in important aspects of your life, do you have the feeling that:

1	2	3	4	5	6	7
You will always succeed in overcoming the difficulties						You won't succeed in overcoming the difficulties

28. How often do you have the feeling that there's little meaning in the things you do in your daily life?

1	2	3	4	5	6	7
Very often						Very seldom/never

29. How often do you have feelings that you're not sure you can keep under control?

1	2	3	4	5	6	7
Very often						Very seldom/never

Results

The results are counted by the following method: Start by "turning the numbers around" for questions 1, 4, 5, 6, 7, 11, 13, 14, 16, 20, 23, 25, 27 – alternative 7 will give you 1 point and alternative 1 will give you 7 points. Do this for all the above mentioned questions. For the remaining questions the points are counted in the order they are mentioned – alternative 1 will give you 1 pint and alternative 7 will give you 7 points.

Write down the total sum of your points for questions 4, 7, 8, 11, 14, 16, 22 and 28 next by the letter M below.

Write down the total sum of your points for questions 1, 5, 10, 12, 15, 17, 19, 21, 24 and 26 by the letter B below.

Write down the total sum of your points for questions 2, 6, 9, 13, 18, 20, 23, 25, 27 and 29 by the letter H below.

M: .... points **B: .... points** **H: .... points**

Count the totals for M + B + H and add the points for question 3. Write your total amount below.

SOC: .... total points

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Interpretation

M relates to your perceived meaningfulness of life, B to your perceived understanding of your existance and H relates to your perceived ability to handle/control events in your life. Combined, these three areas together form the foundation for our "sense of coherence" (SOC). It's been scientifically proved that our sense of coherence has a very strong connection to our perceived sense of happiness and good health.

A perceived healthy and happy individual ranges around 140 points. If your points are between 160 to 190 your SOC is very strong . This means that you are more likely to better handle "hardships" or challenges than an individual with totals ranging between 70-120 points. Any totals above 190 points or below 70 points are considered to be faulty, possibly due to misinterpretation of the instructions or untruthful answers to the questions asked.

5.0 Thesis Exhibition Documentation

5.1 Exhibition Posters

This exhibition explores how to integrate salutogenesis and design into healthcare solutions by using disability devices of the hand as examples. The objectives are to:

- Explore the need for the integration of salutogenesis into healthcare
- Investigate four different case studies and a participant study to see how concepts of salutogenesis can be incorporated within a design framework to achieve interesting solutions.
- Contemplate the importance of salutogenesis and how it can be integrated into other disciplines

Why is this research important?

Disability affects around **8 million** people in Canada and around **1.3 billion** people globally. Those who are disabled experience higher rates of obesity, physical and mental health conditions, and higher rates of poverty than those who are not.

Mental health rates of those with disabilities are also much higher than those of the non-disabled population, with mental distress reported **five times more often** for the disabled population.

46% of adults who have a disability are obese, as opposed to **29.6%** of adults without a disability. There are higher rates of heart disease, diabetes, and smoking for those who have a disability than those who do not.

People with disabilities may encounter **negative social interactions**, such as receiving unwanted glances or stares, comments, and treatment that would typically not be the same as someone without a disability.

Despite physical, social, and mental health being important, healthcare is focused on **'pathogenesis'**: how a disease or illness affects and spreads around the physical body. In other words, the healthcare system is only concerned with the physical body.

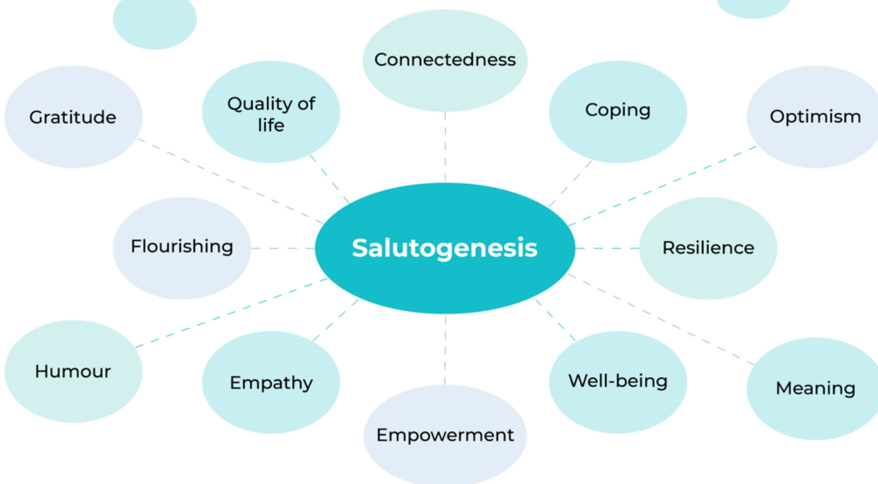
Unfortunately, this means that solutions are focused on survival, that one is 'free' of illness rather than how one can thrive.

Scan to read more in Chapter 1 and 2

Physical health is indeed important, but what about mental and social health and well-being? Is there a term like pathogenesis that instead focuses and all three realms of health and well-being?

Saluto • genesis

'**Salutogenesis**' is a term coined by sociologist Aaron Antonovsky in 1979. Salutogenesis is the origins of health and well-being in relation to all realms of health (physical, social, and mental) in relation to one's values, upbringing, relationships, emotions, and subjective interpretations of the state of one's health.



Salutogenesis promotes the health of the person inside the body rather than the objective body. This goes beyond what people need to overcome illnesses and instead explores what the person needs to overcome psychological or emotional stress and live a fulfilling life. Salutogenesis asks:

- What makes people healthy beyond the absence of illness and disease in the physical body?
- Where do people get the strength?
- How do people manage to stay reasonably healthy?

"If, then, we can begin to understand this mystery– the mystery of survival, the mystery of why some people's health is such that they go through life for some of the time with relatively little pain and suffering– we might begin to think about applying this understanding to reduce pain and suffering among the rest of us."

\- Aaron Antonovsky 1979

Aaron Antonovsky created a model with **four main concepts** that make up salutogenesis: the origins of someone's health

01

Ease/*Dis*-ease Continuum

Rather than a pathogenic scale of diseased/non-diseased of the person's body, the ease/*dis*-ease continuum is the 'easiness' (ease) or 'difficulty' (*dis*-ease) of which someone navigates their well-being and perceived health. It is a multi-dimensional continuum of health and well-being that is ever-changing.

02

Stressors and Tension

Just like viruses, diseases, wounds, or other pathological occurrences that push us towards ill health, "psychological pathogens," are called 'stressors.' Examples of stressors are things like war, job loss, the death of a loved one, or even a minor daily hassle. Stressors result in an emotional response and manifest as physiological stress in the body. This manifestation is called "tension".

03

General Resistance Resources

General Resistance Resources (GRRs) are conceptual 'tools' that everyone has in order to combat stressors. GRRs are something that one has, or characterizes one. Example of GRRs are intelligence, money, social supports, self esteem etc. which can be used to combat a wide variety of situations of stress before they lead to tension.

04

Sense of Coherence

The SOC reflects a person's view of life and capacity to respond to stressful situations. Someone with a strong sense of coherence will see life as understandable, controllable, and significant; in which they are flexible and able to adapt well to life's challenges, and that they are able to effectively cope with adverse experiences to maintain good health.

There are three components to the Sense of Coherence

Comprehensibility

The understanding the problem, challenge, or situation.

Manageability

The belief that one has the resources to combat the stressors.

Meaningfulness

To find that life is meaningful enough to combat stressors.

Scan to read more in Chapter 3

Now that we know what salutogenesis is wand the important components of the salutogenic model, how does this relate to design and how can it be integrated in healthcare?

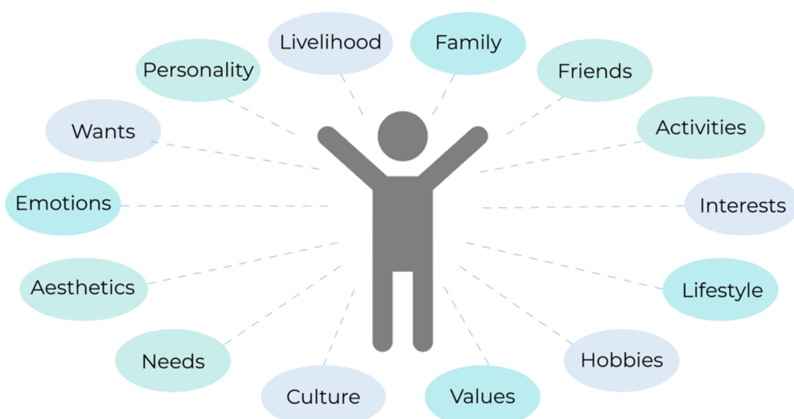
How does salutogenesis relate to design?

The **salutogenic model** explores why people stay healthy and resilient to life's stressors and possibly how uncovering that could benefit others. In its essence, the salutogenic model looks at the complexity of each individual, acknowledging the person inside the body who has a unique personality and sense of personhood.

User-centred design focuses on the wants and needs of an end-user. This could be a specific group of people, or one individual. Throughout the design process, the needs and wants of the end-user are at the forefront of each design decision to ensure that the solutions appropriately serve their intended purpose.

Further, the driving force of this thesis and a concept that interconnects design and salutogenesis is personhood. The idea of a human inside the body, an intricate personality with emotions, values, wants, and needs.

Think about what makes you, 'YOU'



Contemplate a disability or amputation of the hand. Would you be able to enjoy the things you are able to before? What would this disability do to your mental, physical, and social health? How would you be able to manage it? Or would it be life-shattering to your sense of self?

Scan to read more in Chapter 4

Unfortunately, commercially available prostheses and devices do not take into consideration the importance of aesthetics and functionality exceeding basic functions of gipping and holding. They are a pathogenic solution that focus on basic survival functioning. What if the focus was shifted to salutogenesis and design?

Salutogenesis and Design

The scope has been narrowed to hand disabilities due to their highly visible and functional properties. It is hard to hide hands as they function in almost all our daily activities, even in daily social setting. Due to the highly visible and functional properties, physical prototypes were created to address issues with functions and aesthetics. 3D printing is used to prototype the models to explore the low cost and customization capabilities of the technology. These prototypes will be known as **Specific Resistance Resources** (SRRs) since they are used in specific situations of stress and tension.

Function is essential because it facilitates what someone can do and accomplish. It can determine the extent of ability.

Aesthetics are essential because they are the visual representation of a design. It influences how one perceives and experiences things.

Throughout this research, four fundamental problems are identified:

- People with disabilities face a healthcare system that is pathogenically oriented, therefore only focusing on their physical functioning for survival.
- People with disabilities face higher rates of obesity, illnesses and diseases, social stigmas, and mental health problems.
- People with disabilities face higher poverty and unemployment rates and, therefore, do not have the funds to access the devices and aids that they need.
- There are limited choices of prostheses and devices and limited function and aesthetics of those devices.

"Utilizing a salutogenic approach and user-centered design, how might we create personalized disability devices and prostheses that are low-cost, accessible, and truly personalized to the individual's wants, needs, and lifestyle?"

5 Stage Design Process

Empathize ▸ **Define** ▸ **Ideate** ▸ **Prototype** ▸ **Test**

Scan to read more in Chapter 5

Utilizing the 5-stage design method, a user-centred design approach, and a salutogenic orientation, four case studies aim to create personalized disability and prosthesis devices. They explore how prostheses and disabilitiy devices need to improve to truly serve the preferences, needs, wants, hobbies, and interests of the wearer.

Case Study I: Nail Prostheses

Why do people paint or get their nails done in a salon? This answer depends on each person. It may be simply because they like the way the nails look. Self-expression through colours and textures, matching particular aesthetics or clothing, dressing up for social events, or even the relaxing experience of getting nails done at a salon could be a simple driving force as to why someone would like their nails done. However, commercially available prostheses do not consider the importance of nails.

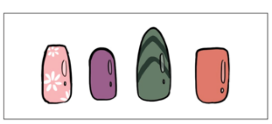
Simply having one's nails done could be important to one's sense of self and personhood. The stressors or psychological pathogens that people face tied to this aesthetic issue could be:

- Body Image
- Social media influence
- Status
- Feeling "left out"
- Lack of self-expression

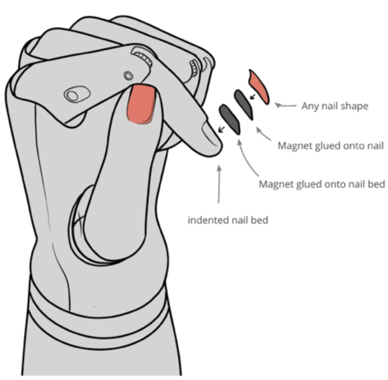
Prototype 1

This first idea was a simple and easy first teration. This solution could allow someone to change nail shape and colour to match the nails, on the other hand, while also taking them off entirely for a "bare" nail bed.

I 3D printed a jointed hand prototype and created some holes for magnets in the nail bed. Another magnet was glued on a corresponding nail.



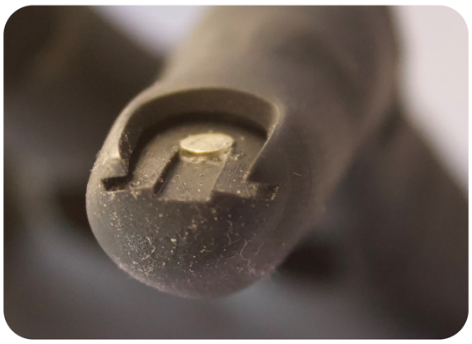
Different shapes and length of nails



The magnets were strong enough that the nails snapped onto the prosthesis nail beds without any issues. The different nail shapes, lengths, and colours changed the aesthetics of the hand. However, in a real scenario, someone would have these on during the day or on a night out, and the nails would most likely not hold up if they accidentally brushed up or knocked against something.

Prototype 2

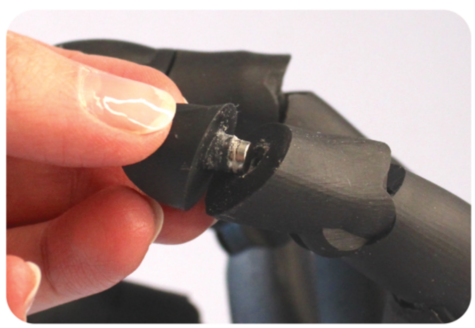
The following iteration has a sliding and 'locking' system that allows for the nail to slide into the nail bed under two rails, which would prevent the nail from being knocked off, and the 'lock' would come from a magnet component on the nailbed and the nail itself.



The interchangeable nails displayed different aesthetic options depending on the selected nail set. However, if this design solution were integrated into a real prosthesis, the wearer would have to purchase nails and glue on a magnet system themselves.

Prototype 3

The third iteration of prosthesis nails referenced the first ideas with the swappable fingertips. In this iteration, rather than the whole knuckle being interchangeable, the last knuckle would be sliced in half, allowing different fingertips to be made without interfering with inside hardware.



Each finger was made with three finger caps for three different options of nails: a long nail, a short nail, and an indented nail bed. The indented nail bed would allow for adequate space for users to apply press-on nails, where they could pick the length, shape, and colours of these nails. The other two caps would have the nails printed into them.

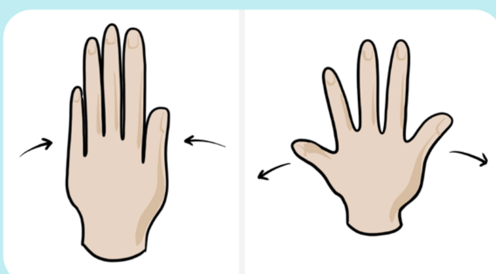
Scan to read more
of Case Study I

Case Study II: Piano Prosthesis

This case study explores important aspects of personhood, such as lifestyle and hobbies. The hobby of playing the piano is of interest since it requires the function of the hands in ways that commercial prostheses cannot provide. Why should someone never be able to partake in their hobbies again due to an amputation? Moreover, why should someone miss out on learning instruments and developing hobbies just because they were born without a limb?

The stressors involved with being unable to participate in activities such as playing the piano can be devastating to someone who once played before. The potential stressors involved with this scenario are:

- Feeling “left out”
- Lack of self-expression
- Feeling like they “lost” an ability (for those who lost a limb)
- Feeling like they do not have an opportunity to pick up this new skill (those with congenital limb differences)
- Job loss, if playing piano was part of someone’s income
- Sense of identity or lifestyle may be lost



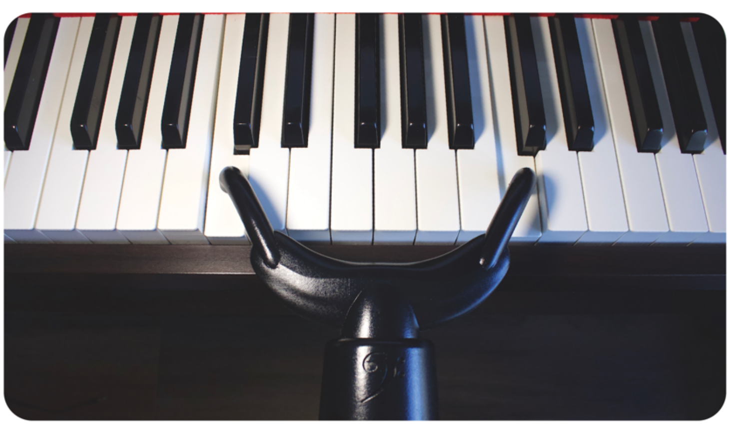
For commercial prostheses, there is no sideways movement of the fingers, which is important for the left hand. This sprawling motion of the fingers allows octaves (range of 8 notes), chords, and progressions to be played simultaneously and quickly.

The first step was to prototype a device to show that a song can be played with octaves and still sound like a complete song. The catch: I had to create something to show how to do this without the direct use of my fingers. To show that this would work, I built an apparatus with two “fingers” an octave apart, somewhere to put my hand on or in it, and inhibit using my fingers.

I modelled a device with two “pegs” that were an octave apart. A model of two pegs and a wrist piece was built in Rhino and 3D printed with PLA. I added two rings on each peg where my fingers would rest. These rings kept my fingers stuck in place, so I could not move them out of habit.

For this design, we simply needed two pegs attached in the middle and a clear view of the keys in the middle, and it must be attached to the wrist of the socket. The sketch on the right is refined by adding more soft and curved, smoothing harsh edges, and providing a more streamlined look.

The prototype was simple, which allowed function to be the most critical component of the design. The pegs perfectly line up at an octave and allow for full views of the keys underneath it. The rough prototype was printed in Polylactic Acid, and the final prototype was printed in standard black resin. It was coated in automotive paint for a glossy finish. Silicone pads were moulded for the ends of the pegs to emulate the softness of real fingers.



Scan to read more of Case Study II

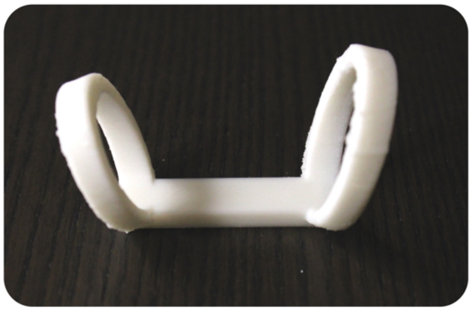
Case Study III: Ring Splints

During research, finger splints for joint conditions stood out for their aesthetic potential. Available options range from bulky fabric to plastic or silver rings. The plastic rings seem to only come in one pale skin tone. Someone with arthritis, Ehlers-Danlos syndrome, or other joint conditions would need finger splints for functional support. Finger splints are worn for prolonged periods throughout the day, yet there are few aesthetic options.

This is a problem concerned with aesthetics just as much as functionality. However, the aesthetics need improvement. Specific stressors someone could experience are:

- Body image
- Lack of choice
- “Standing out”
- Social perceptions

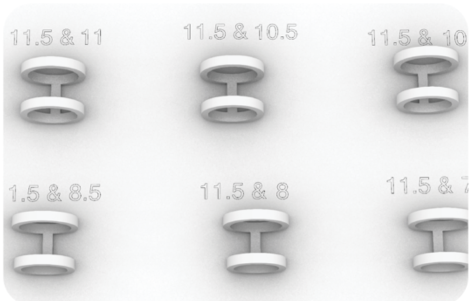
For this case study, I wanted to explore customizability and accessibility and give even more control to the wearer. The question is now: “How might we create ring splints that are accessible through open-source websites and 3D printing services to increase accessibility and customizability control of the wearer?”

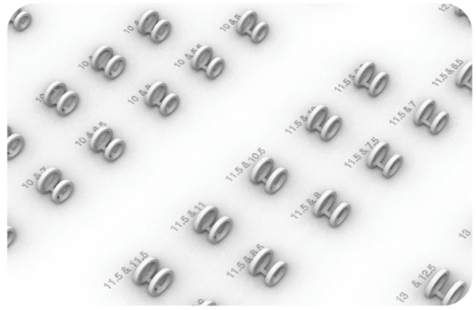


To start, I modelled rings following the forms from other companies and makers, which are two rings attached by a bar in the middle.

The idea behind this case study would be to make these 3D model files accessible from an open-source site, in which anyone would be able to download, print, and decorate to their own personal taste.

These rings were a good start, but the model had to be fixed because the rings were too far apart. Instead, the rings should be closer to the knuckle to stabilize it.

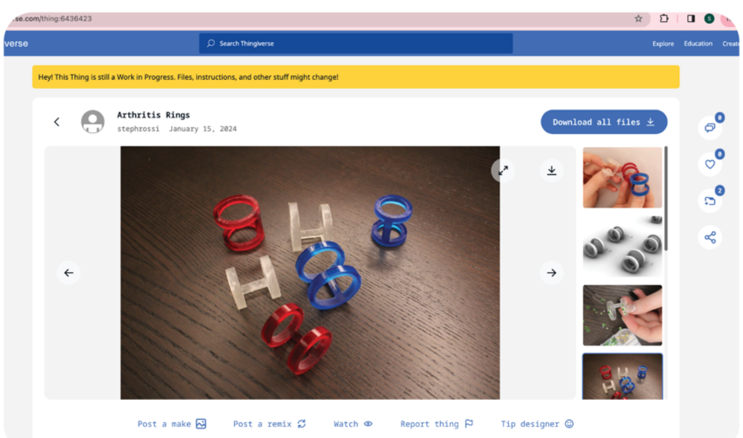




This second version has rings that are closer together. A combination of sizes ranging from 3.5 to 13.5 were modelled in Rhinoceros 6. The two rings would need to be different sizes based on the width of each finger, which resulted in 186 combinations of sizes.

A handful of rings were printed in Vero on a Stratasys J750. Vero is a polymer material similar to acrylic, providing excellent detail and smoothness. This material can be printed in colour or a combination of colours in transparent/clear and opaque. Printing in colours could be an excellent way for someone to personalize their ring further.

The files were uploaded to a site called Ultimaker Thingiverse under a Creative Commons license. Anyone can download these files and print them through online printing services or if they have access to 3D printers in their school or public library. In the future, I will keep updating the files when necessary, whether to add more files or fix and update the models. The user can adjust these models themselves if they upload them to a 3D modelling software.



Scan to read more of Case Study III

Case Study IV: Rowing Device

Increasing physical activity for those with hand disabilities may not be as simple as walking or running. After all, a disability or condition of the hands may also affect the function of the legs, as many conditions affect numerous areas of the body. It is also unfair and wrong to reduce a demographic to one kind of physical activity or assume that they do not want more choices in activities. Increasing choices in activity for those with disabilities would increase the chances of someone finding the exercise routine and activity they enjoy, resulting in greater adherence.

The stressors that someone without access to devices for physical activity could face are:

- Poor physical health
- Poor mental health (as a result of physical health)
- Lack of choice
- Stigma
- Isolation
- Body image

Why machine rowing?

Why machine rowing? There is no prosthesis or device meant for machine rowing. Rowing is an excellent exercise because it is a low-impact, seated exercise. The exercise requires movement of the whole body using the legs, core, and arms. Rowing is both a cardiovascular exercise and muscle-strengthening exercise

The only downside is that it requires grip strength to hold and pull the handle towards the body. Even though the resistance can be lowered, people may still not have the required strength in their hands. This was an area for design intervention.

Version 1

For Version 1 (V1), I prototyped a simple fabric strap sewn onto an existing wrist brace. The strap then velcros into the brace to form a loop around the rowing handle. However, a simple test proved that the fabric and Velcro were weak. Tugging on the fabric loop caused the Velcro to rip out of the brace. Surely, it would not withstand the pull force of the rowing machine.

Version 2

For version 2 I 3D modeled and printed a hook that fit the circumference of the handle. The pieces include a Velcro strap looped inside the brace twice, rather than outside of the brace once like V1, and a 3D printed PLA piece to hold the hook. The hook would slide into a keyhole on the plastic piece, and the pull-force of the paddle would keep the hook from coming off of the plastic piece.

However, this version was still not strong enough to withstand the pull-force of the machine.

Version 3

For Version 3, a clip was sewn onto the bottom of the brace with nylon. The brace held up reasonably well when rowing, and it was again tested with and without my use of fingers. It did not fly off like Version 2, but after a few minutes of rowing, the nylon at the bottom pulled the wristband up due to the force of the hook pulling forward. This caused the bottom of the brace to lift and fold up.

Version 4

Version 4 (V4) was greatly simplified. A saying within design goes, “The best design is as little design as possible.” The hook was once again updated for a smaller circumference to always stay in contact with the handle. In V4, the hook was attached to the brace at the top with nylon and sewn shut on both ends. Instead of having interchangeable hooks, this would mean that this prototype would have to come in different sizes to accommodate different hands.

V4 was tested on a rowing machine. The device was working better than V3, as the change in nylon placement prevented any lifting. However, after a few minutes of rowing, the brace would slide up from the pull-force of the handle, causing some discomfort in the base of the wrist.

Version 5

For Version 5, I used a brace that was intended for carpal tunnel syndrome. It was much larger than the brace used for V1-V4, as it went all the way to the mid-forearm. Increasing the surface area with three velcro straps to tighten would mean that the force could be distributed across a larger arm area instead of the wrist. The hook was sewn with nylon on a "V" pattern to accommodate the metal bar inside the brace.

Version 6

Version 6 included the width adjustment of the hook. It was now wide enough for the whole hand to fit.

5-6 layers of Plasti-Dip were sprayed onto the hook for extra grip. This was done out of caution, in case the hook slides so close to the edge that it slides off the handle completely.

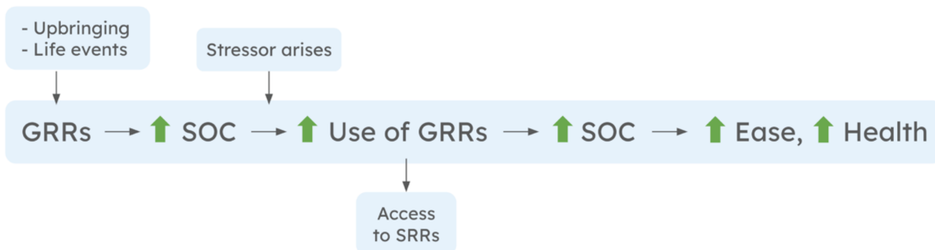
Final Prototype

Version 7 is the final design. It is a minimal refinement from V6, where the sharp corners on the opening of the rowing hook are tapered off for a smoother aesthetic. There are three different sizes of hooks, as larger hands need a larger circumference around the hook. Some minor details were added to the middle of the medium and large hooks for aesthetic appeal. These details also allowed less printing material, as the printer did not have to fill those empty spaces with material. This model helped alleviate pressure from the fingers and the wrist, and was able to be used without the use of any fingers at all.

Scan to read more of Case Study IV

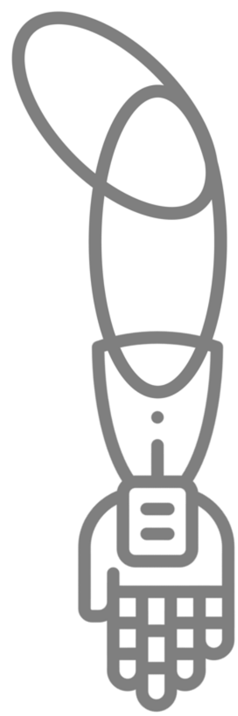
Discussion of Case Studies

When one has General and Specific Resistance Resources (GRRs and SRRs), one can combat stressors before they lead to physiological tension in the body. Overcoming stressors in our lives increases our Sense of Coherence (SOC) by increasing our comprehension of the problem, feeling we can manage it to overcome it, and feeling that overcoming the stressor is meaningful. This strong orientation to life pulls us towards ease and, ultimately, towards good health. **This is the simplified theory of the salutogenic model:**



These four case studies looked at specific scenarios of function and aesthetics, which led to solutions that may otherwise not be considered without a salutogenic orientation to each problem. Each solution is a specific resistance resource (SRR) that can combat specific stressors. Despite the specificity, the stressors can break down the sense of coherence. Body image, personal aesthetics, and participating in hobbies and activities may not seem important from a pathogenic perspective, but they are indeed important in salutogenesis and for people to thrive rather than just survive.

The simple solutions in the case studies propose a question of what aesthetic and functional possibilities there could be if resources and effort went into salutogenic outcomes, where the person inside the body with needs, wants, emotions, dreams, hobbies, and lifestyle are considered.



However, to fully demonstrate the complexity of personality, lifestyle, interests, and values of someone with a hand disability, it would be helpful to talk to someone in this demographic to truly understand how they feel about devices function and aesthetics.

Participant Study

Moving forward from the case studies, I wanted to get the perspectives of someone with a hand disability. The study was structured to have an initial interview session, ideation and analysis stage, and then following interviews to discuss the design ideas. The initial interview discussed the participants' experiences with prostheses, their thoughts on aesthetics and function, how prostheses could be improved, and brainstorming ideas for personalized prostheses.

Here are the key takeaways from the interview with Participant A:

- There needs to be more choice for prostheses
- 3D printing is excellent at keeping prostheses lightweight
- 3D prints are becoming more accessible through online sources
- PA likes different tools to serve different purposes
- Stay away from realism
- PA would like aesthetic and functional prostheses on either end of the spectrum

"I think that I would like one on either end of the spectrum [of aesthetics and function] and less than the middle... And when I'm walking around without a prosthetic, if I pay attention, I can catch people double looking, **'Oh wait, something is different.'** And I might get less of it with this [prosthesis] slightly less, though I can hide my regular hand pretty easily."

"They just kind of gave [the prostheses] to me. **If there was any choice, I wasn't aware of it."**

"I mean, it's a little something I noticed wearing the prosthetic around... **That people still looked. They've got the double-takes.** And, you know, you're probably going to get that. Like, you're still probably going to get that if you're wearing something semi-realistic. So you know, **if people are going to look at it, it might as well look cool."**

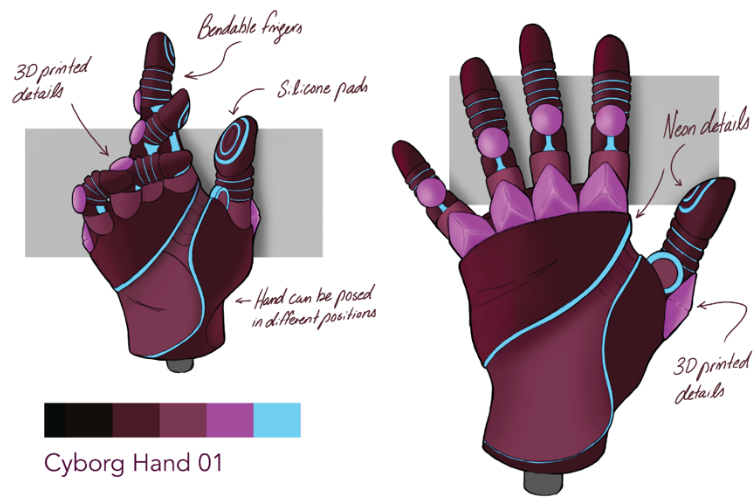
Interests of Participant A for ideation

- Superheros, especially Wolverine claws
- Robotic aesthetics stay away from realism
- Interested in learning piano

Ideation: Round 1

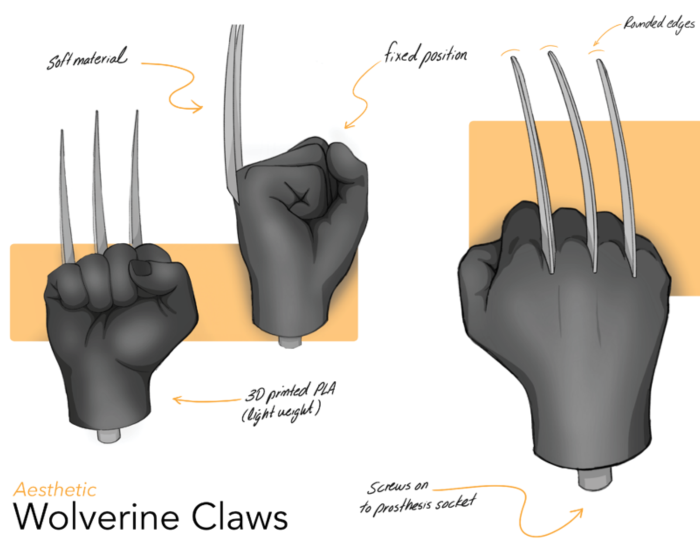
Just like passive prostheses, these "Cyborg" Hands are non-functional, but stray from the normal realistic skin aesthetics.

Cyborg Hand 01

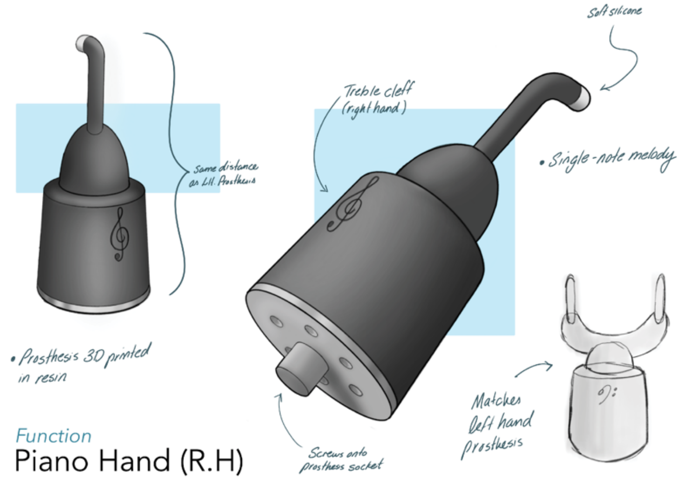


Cyborg Hand 01

Though weapons are not encouraged, the Wolverine claws create a discussion around aesthetics and what people are truly interested in.

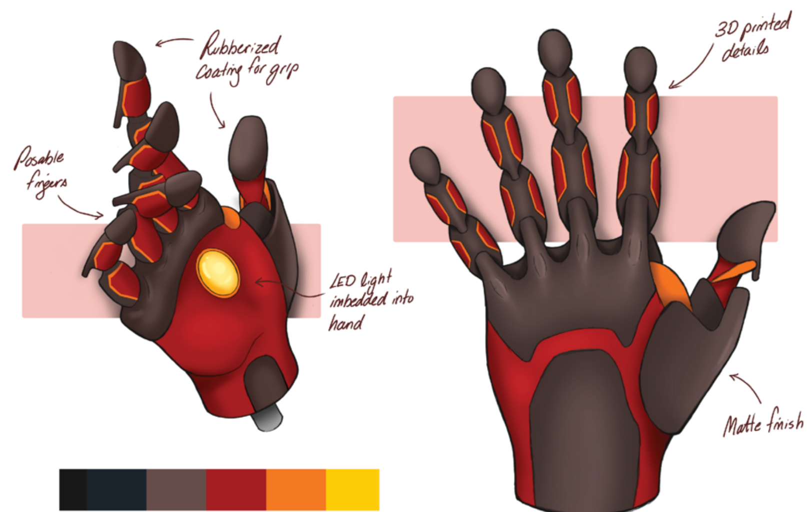


Aesthetic
Wolverine Claws

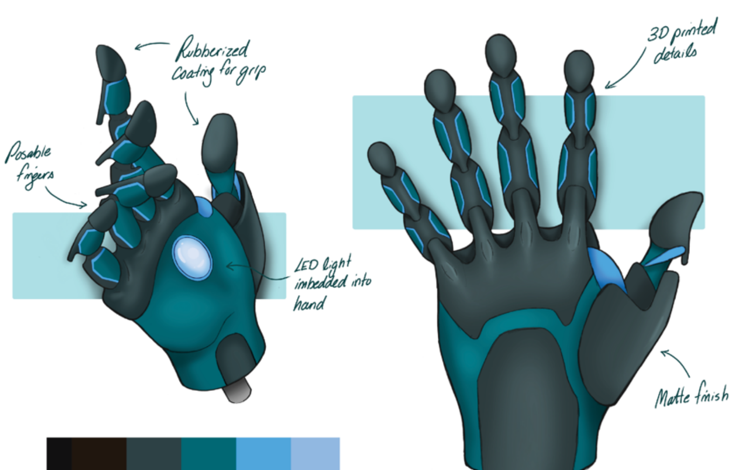


Function
Piano Hand (R.H)

Participant A has a limb difference of the right hand, and is interested in playing piano. This is a simple right hand version for playing single-note melodies. It matches the Piano Prosthesis of Case Study II.



Cyborg Hand 02



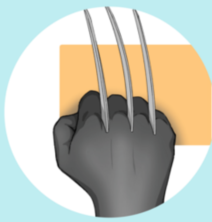
Cyborg Hand 02

A more minimalist Cyborg hand was drawn to see what aesthetics Participant A gravitated towards.

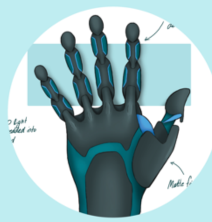
Participant Meeting #2

The second interview aimed to get feedback from Participant A on the ideations and discuss how prostheses could be improved by discussing aesthetics and functionality in more detail. While presenting, PA looked excited and was smiling throughout the slideshow. When I was done presenting the ideations, I asked for general feedback, and then we could go into the details of the drawings.

Here are the key takeaways from the interview with Participant A:



Participant A said that he would like the claws retract into the prosthesis so they are not exposed all the time. We discussed having a lever, button, or springs that would move the claws in and out of the hand, which would be a consideration for the next set of ideations.

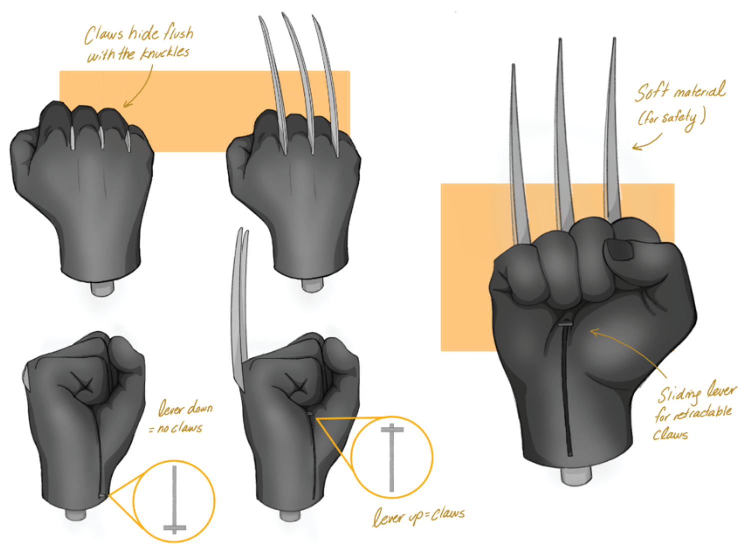


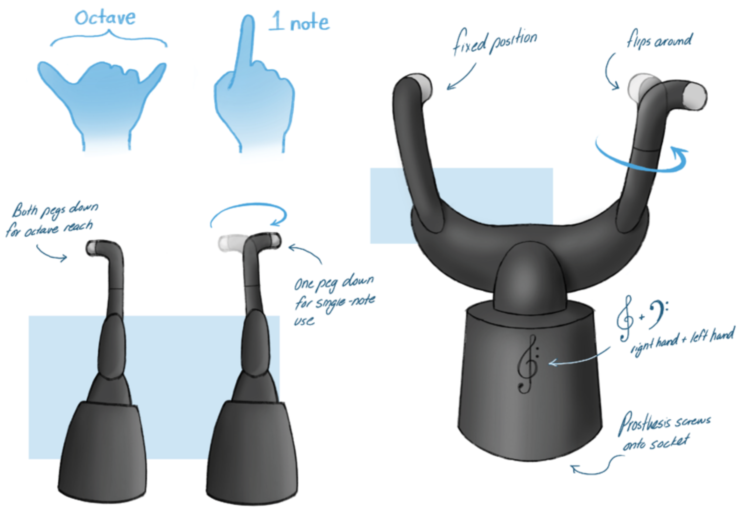
When we moved to the Cyborg Hands, he gravitated towards Cyborg Hand 02 in blue. He likes 'streamlined' aesthetics rather than something. highly detailed, like Cyborg Hand 01. He said, "They look cooler than the one I have, so... Yeah I'd wear something like this".

Participant A and I discussed having the second peg on the piano prosthesis turn around or flip so the user can switch between playing single notes and octaves. The next ideation would be something similar to Case Study II, but this time with a peg that can move.

Ideation: Round 2

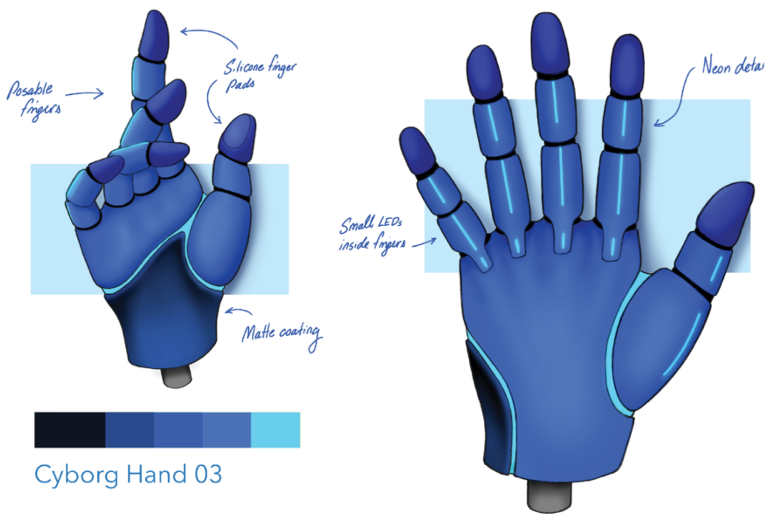
A simple concept of a sliding lever to push the claws in and out of the closed fist.



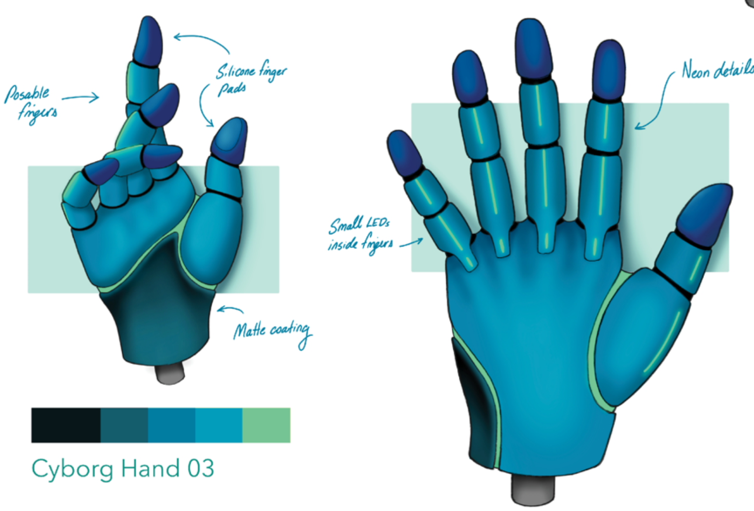


The Piano Prosthesis from Case Study II has been updated to accomodate single-note melodies

Another “streamlined” Cyborg Hand was drawn. Participant A liked the simplicity of the second hand, rather than the complexity of the first.



Cyborg Hand 03



Cyborg Hand 03

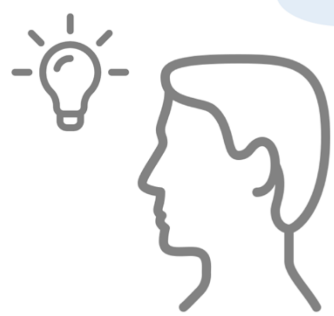
Participant A said that blue was his favourite colour. There are two different hues to choose from.

Scan to read the study in Chapter 7

Discussion

These iterations, though simple, could be effective in facilitating the functions and aesthetics wanted by Participant A. These prostheses could be relatively inexpensive due to 3D printed materials like PLA or resin. Shiny, bright colours would be achievable due to the possibilities of post-processing. Like the Case Study II: Piano Prosthesis, the prints can be sanded, primed, and sprayed with autobody paint. It allows for an aesthetically pleasing finish, and autobody paints offer various colours, metallics, mattes, and pearls. Silicone moulding could also be an option for softening the fingertips. Rubber coatings, as used in Case Study IV: Rowing Device, would be a great way to achieve a different texture and aesthetic finish.

This small study with one participant showed interesting perspectives and validated the need for different aesthetic and functional devices. Participant A had ideas and opinions on devices that could differ from another prosthesis wearer. Wolverine Claws, blue, streamlined robot hands, and a modular piano prosthesis were exclusive to his interests and desires. Of course, these ideations are not significant to his survival, but they highlight the unique complexities of his personality. This is the importance of a salutogenic orientation.



Salutogenesis asks deeper questions about well-being to find ways to promote further health. Pathogenesis asks if Participant A is healthy or ill and if the prosthesis “works” for daily tasks. Meanwhile, salutogenesis asks:

- Can these devices help enrich his life by facilitating new hobbies?
- Could they help him express his sense of identity and interests?
- Could these small details in function and aesthetics greatly improve his quality of life and overall well-being?

The salutogenic model nurtures all aspects of well-being (physical, mental, and social), while pathogenesis is exclusively physical. Salutogenesis, with the help of design, guides the creation of SRRs and GRRs that can increase one’s sense of coherence, move up the ease/*dis*-ease continuum, and reach health—a life where people are thriving rather than just surviving. As Antonovsky puts it,

> **“The more the patient is perceived as a total person, the better. The more the focus is on the needs of the patient, the better. The more decision-making power rests in the hands of the patient, the better”**
>
> - Aaron Antonovsky, 1979

Scan to read the conclusion in Chapter 8

Conclusion

Salutogenesis promotes health and advocates for the person inside the body rather than reducing them to the physical body. The four case studies and this participant study evoke the question of what other prototypes and solutions are possible with a salutogenic and design perspective and what lies dormant due to the pathogenic orientation.

Though the case studies show small areas of intervention, the solutions can have a meaningful impact on the person. The proposed functional and aesthetic solutions display that even the simplest solutions may be effective in combating psychological pathogens like body image, mental health, physical health, and stigma. Though these are only prototypes, they show a salutogenic orientation and design intervention that can improve someone's capacity to comprehend, manage, and find meaningfulness in their lives. Ultimately, focusing on the 'person' inside the body unveils the genuine problems that must be addressed

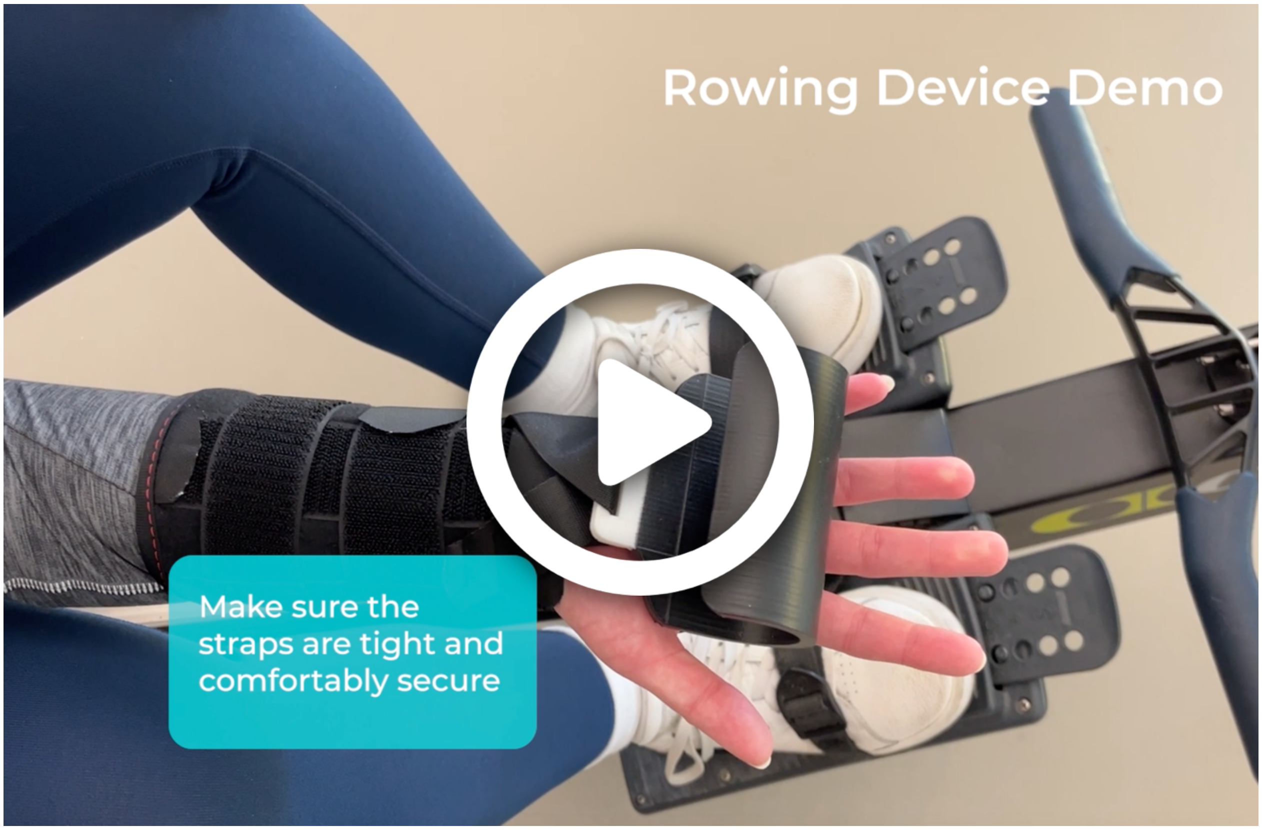
What could healthcare solutions look like if concerns with body image, interests, stigma, ability, and other salutogenic concepts are addressed? What kind of SRRs can combat these stressors to increase one's sense of coherence? The case studies conveyed how the designer could be a General Resistance Resource (design expertise applied to many areas) to create Specific Resistance Resources (function and aesthetic-specific devices) that apply to specific situations to ease stressors for an individual, increase the sense of coherence, and help move towards ease and health.

In what other disciplines could salutogenesis and design prove to be valuable?

5.2 Video Demo of Piano Prosthesis Prototype

Video Link: https://vimeo.com/921203987

5.3 Video Demo of Rowing Device

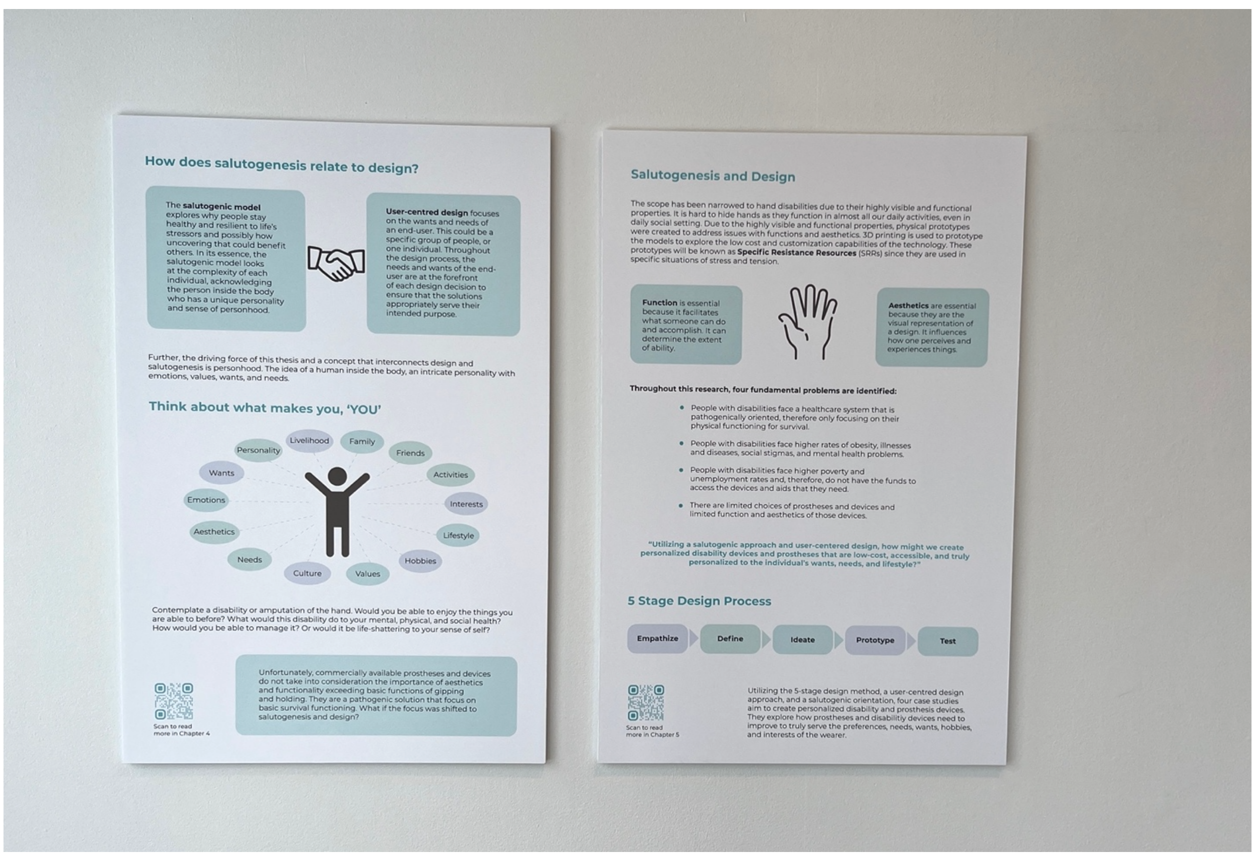


Video Link: https://vimeo.com/921211701

5.4 Thesis Exhibition

This exhibition was held in the Fine Arts Building Gallery at the University of Alberta.

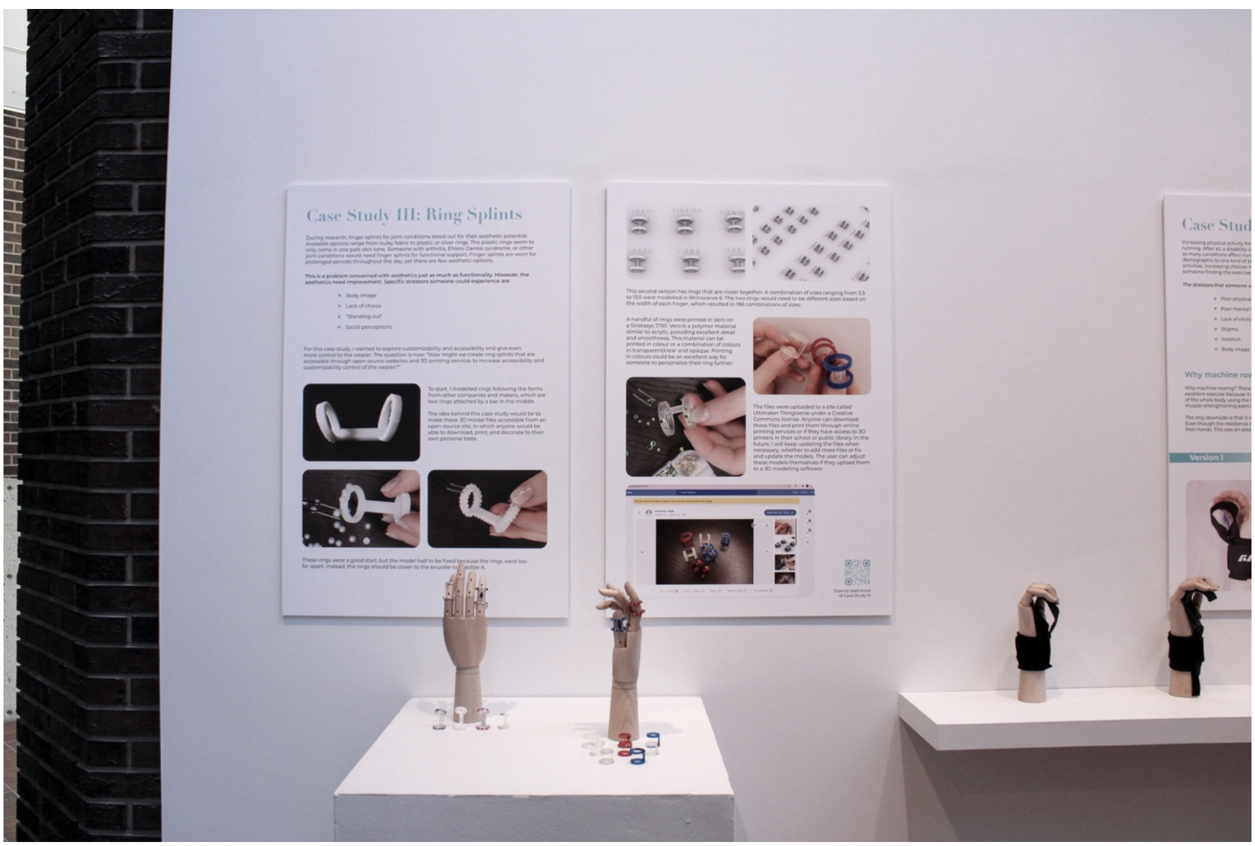

Case Study II: Piano Prosthesis

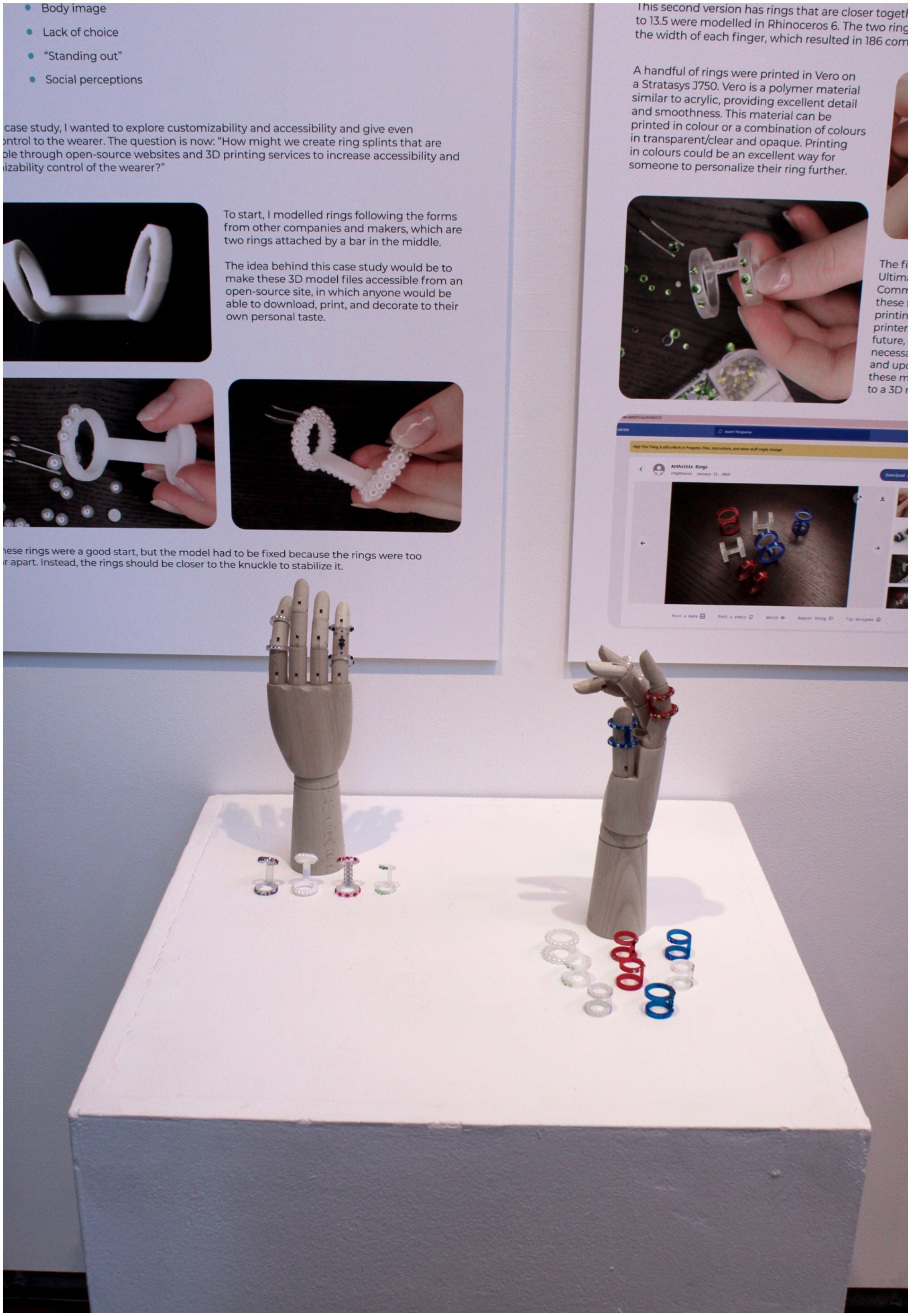

How does salutogenesis relate to design?
The salutogenic model explores why people stay healthy and resilient to life's stressors and possibly how uncovering that could benefit others. In its essence, the salutogenic model looks at the complexity of each individual, acknowledging the person inside the body who has a unique personality and sense of personhood.
User-centred design focuses on the wants and needs of an end-user. This could be a specific group of people, or one individual. Throughout the design process, the needs and wants of the end-user are at the forefront of each design decision to ensure that the solutions appropriately serve their intended purpose.
Further, the driving force of this thesis and a concept that interconnects design and salutogenesis is personhood. The idea of a human inside the body, an intricate personality with emotions, values, wants, and needs.
Think about what makes you, 'YOU'
Livelihood
Family
Personality
Friends
Wants
Activities
Emotions
Interests
Aesthetics
Lifestyle
Needs
Hobbies
Culture
Values
Contemplate a disability or amputation of the hand. Would you be able to enjoy the things you are able to before? What would this disability do to your mental, physical, and social health? How would you be able to manage it? Or would it be life-shattering to your sense of self?
Scan to read more in Chapter 4
Unfortunately, commercially available prostheses and devices do not take into consideration the importance of aesthetics and functionality exceeding basic functions of gipping and holding. They are a pathogenic solution that focus on basic survival functioning. What if the focus was shifted to salutogenesis and design?
Salutogenesis and Design
The scope has been narrowed to hand disabilities due to their highly visible and functional properties. It is hard to hide hands as they function in almost all our daily activities, even in daily social setting. Due to the highly visible and functional properties, physical prototypes were created to address issues with functions and aesthetics. 3D printing is used to prototype the models to explore the low cost and customization capabilities of the technology. These prototypes will be known as Specific Resistance Resources (SRRs) since they are used in specific situations of stress and tension.
Function is essential because it facilitates what someone can do and accomplish. It can determine the extent of ability.
Aesthetics are essential because they are the visual representation of a design. It influences how one perceives and experiences things.
Throughout this research, four fundamental problems are identified:
People with disabilities face a healthcare system that is pathogenically oriented, therefore only focusing on their physical functioning for survival.
People with disabilities face higher rates of obesity, illnesses and diseases, social stigmas, and mental health problems.
People with disabilities face higher poverty and unemployment rates and, therefore, do not have the funds to access the devices and aids that they need.
There are limited choices of prostheses and devices and limited function and aesthetics of those devices.
"Utilizing a salutogenic approach and user-centered design, how might we create personalized disability devices and prostheses that are low-cost, accessible, and truly personalized to the individual's wants, needs, and lifestyle?"
5 Stage Design Process
Empathize
Define
Ideate
Prototype
Test
Scan to read more in Chapter 5
Utilizing the 5-stage design method, a user-centred design approach, and a salutogenic orientation, four case studies aim to create personalized disability and prosthesis devices. They explore how prostheses and disabilitiy devices need to improve to truly serve the preferences, needs, wants, hobbies, and interests of the wearer.


Case Study I: Nail Prostheses
Why do people paint or get their nails done in a salon? This answer depends on each person. It may be simply because they like the way the nails look. Self-expression through colours and textures, matching particular aesthetics or clothing, dressing up for social events, or even the relaxing experience of getting nails done at a salon could be a simple driving force as to why someone would like their nails done. However, commercially available prostheses do not consider the importance of nails.
Simply having one's nails done could be important to one's sense of self and personhood. The stressors or psychological pathogens that people face tied to this aesthetic issue could be:
Body Image
Social media influence
Status
Feeling "left out"
Lack of self-expression
Prototype 1
This first idea was a simple and easy first teration. This solution could allow someone to change nail shape and colour to match the nails, on the other hand, while also taking them off entirely for a "bare" nail bed.
I 3D printed a jointed hand prototype and created some holes for magnets in the nail bed. Another magnet was glued on a corresponding nail.
Different shapes and length of nails
Any nail shape
Magnet glued onto nail
Magnet glued onto nail bed
Indented nail bed
The magnets were strong enough that the nails snapped onto the prosthesis nail beds without any issues. The different nail shapes, lengths, and colours changed the aesthetics of the hand. However, in a real scenario, someone would have these on during the day or on a night out, and the nails would most likely not hold up if they accidentally brushed up or knocked against something.
Prototype 2
The following iteration has a sliding and 'locking' system that allows for the nail to slide into the nail bed under two rails, which would prevent the nail from being knocked off, and the 'lock' would come from a magnet component on the nailbed and the nail itself.
The interchangeable nails displayed different aesthetic options depending on the selected nail set. However, if this design solution were integrated into a real prosthesis, the wearer would have to purchase nails and glue on a magnet system themselves.
Prototype 3
The third iteration of prosthesis nails referenced the first ideas with the swappable fingertips. In this iteration, rather than the whole knuckle being interchangeable, the last knuckle would be sliced in half, allowing different fingertips to be made without interfering with inside hardware.
Each finger was made with three finger caps for three different options of nails: a long nail, a short nail, and an indented nail bed. The indented nail bed would allow for adequate space for users to apply press-on nails, where they could pick the length, shape, and colours of these nails. The other two caps would have the nails printed into them.
Scan to read more of Case Study I


Case Study II: Piano Prosthesis
This case study explores important aspects of personhood, such as lifestyle and hobbies. The hobby of playing the piano is of interest since it requires the function of the hands in ways that commercial prostheses cannot provide. Why should someone never be able to partake in their hobbies again due to an amputation? Moreover, why should someone miss out on learning instruments and developing hobbies just because they were born without a limb?
The stressors involved with being unable to participate in activities such as playing the piano can be devastating to someone who once played before. The potential stressors involved with this scenario are:
Feeling "left out"
Lack of self-expression
Feeling like they "lost" an ability (for those who lost a limb)
Feeling like they do not have an opportunity to pick up this new skill (those with congenital limb differences)
Job loss, if playing piano was part of someone's income
Sense of identity or lifestyle may be lost
For commercial prostheses, there is no sideways movement of the fingers, which is important for the left hand. This sprawling motion of the fingers allows octaves (range of 8 notes), chords, and progressions to be played simultaneously and quickly.
The first step was to prototype a device to show that a song can be played with octaves and still sound like a complete song. The catch: I had to create something to show how to do this without the direct use of my fingers. To show that this would work, I built an apparatus with two "fingers" an octave apart, somewhere to put my hand on or in it, and inhibit using my fingers.
I modelled a device with two "pegs" that were an octave apart. A model of two pegs and a wrist piece was built in Rhino and 3D printed with PLA. I added two rings on each peg where my fingers would rest. These rings kept my fingers stuck in place, so I could not move them out of habit.
For this design, we simply needed two pegs attached in the middle and a clear view of the keys in the middle, and it must be attached to the wrist of the socket. The sketch on the right is refined by adding more soft and curved, smoothing harsh edges, and providing a more streamlined look.
The prototype was simple, which allowed function to be the most critical component of the design. The pegs perfectly line up at an octave and allow for full views of the keys underneath it. The rough prototype was printed in Polylactic Acid, and the final prototype was printed in standard black resin. It was coated in automotive paint for a glossy finish. Silicone pads were moulded for the ends of the pegs to emulate the softness of real fingers.
Scan to read more of Case Study II


Case Study III: Ring Splints
Case Study IV: Rowing Device


Case Study III: Ring Splints
Version 1



Body image
Lack of choice
"Standing out"
Social perceptions
case study, I wanted to explore customizability and accessibility and give even
ontrol to the wearer. The question is now: "How might we create ring splints that are
ble through open-source websites and 3D printing services to increase accessibility and
izability control of the wearer?"
To start, I modelled rings following the forms from other companies and makers, which are two rings attached by a bar in the middle.
The idea behind this case study would be to make these 3D model files accessible from an open-source site, in which anyone would be able to download, print, and decorate to their own personal taste.
hese rings were a good start, but the model had to be fixed because the rings were too
r apart. Instead, the rings should be closer to the knuckle to stabilize it.
This second version has rings that are closer togeth
to 13.5 were modelled in Rhinoceros 6. The two ring
the width of each finger, which resulted in 186 com
A handful of rings were printed in Vero on a Stratasys J750. Vero is a polymer material similar to acrylic, providing excellent detail and smoothness. This material can be printed in colour or a combination of colours in transparent/clear and opaque. Printing in colours could be an excellent way for someone to personalize their ring further.
Arthritis Rings


Even though the resistance can be lowered, people may still not have the required strength in their hands. This was an area for design intervention.
Version 1
For Version 1 (V1), I prototyped a simple fabric strap sewn onto an existing wrist brace. The strap then velcros into the brace to form a loop around the rowing handle. However, a simple test proved that the fabric and Velcro were weak. Tugging on the fabric loop caused the Velcro to rip out of the brace. Surely, it would not withstand the pull force of the rowing machine.
Version 4


Participant Study
Ideation: Round 1
Wolverine Claws

Participant Meeting #2
Ideation: Round 2
Discussion
Conclusion


Stephanie Rossi | MDes Industrial Design
Saluto-genesis
01
02
03
04
Salutogenic Design:
Bringing the 'Person' Into Personalization in Healthcare
by Designing for Disabilities of the Hand

Department of Art & Design
University of Alberta, 2024