

Cochlear Implants and Brain-Computer Interfaces: How society reacts to revolutionary medicine

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

Seth Hoisington
Fall 2021, Spring 2022

On my honor as a University Student, I have neither given nor received
unauthorized aid on this assignment as defined by the Honor Guidelines
for Thesis-Related Assignments

ADVISOR

Bryn Seabrook, Engineering and Society

Cochlear Implants and Brain-Computer Interfaces: How society reacts to revolutionary medicine

Introduction: Cochlear Implants and Brain-Computer Interfaces in Healthcare

Much like the mouse and keyboard revolutionized the way we interact with computers, the introduction of Brain-Computer Interface (BCI) technology in medicine has the potential to reshape the relationship between a person and their environment. By opening direct pathways between the brain and the user's environment, BCI technology serves the same role of arms and legs in allowing to manipulate the environment in sophisticated ways. This possibility has ramifications in the area of medical technology and in the lives of the approximately one in fifty people living with paralysis in the United States (*Paralysis Statistics*, n.d.). BCIs build upon enabling medical technology like cochlear implants—an early BCI which restores hearing capability to those with deafness—to supplement or replace natural appendages like arms and legs by allowing people with paralysis to control motor devices directly with their brain. Cochlear implants are a revolutionary technology in the healthcare of the deaf, and thus the potential for BCIs cannot be understated. Neuralink, a company pioneered by Tesla and SpaceX leader Elon Musk, has been developing an interface designed to allow people to directly control devices like their phones by reading and interpreting brain signals (*Science - Neuralink*, n.d.). The company's recent successes have spurred interest and speculation of a future in which people can communicate and control everything around them directly using brain pathways. It is necessary to understand how such a technology may constitute a paradigm shift and to understand and predict the potential issues and outcomes of widespread adoption of BCIs, specifically in the context of medicine.

This paper seeks to understand the effect that cochlear implants have had on the Deaf community. The analysis understands the introduction of cochlear implants as a paradigm shift in the treatment of deafness. From then, the paper abstracts the findings from the cochlear implant example to understand the effect that BCIs more generally will have on disabled communities, specifically those afflicted with paralysis and other motor disorders. The main keywords used to facilitate the research are “Deaf community,” “cochlear implants,” “brain-computer interfaces,” “paradigm shift,” “medical model of healthcare,” and “social model of healthcare.” The analysis first details the abstractions derived from the case study and justifies the claims made using elements of the case study. These abstractions are then applied to BCIs and their relationship with disabled communities.

Case Study Background

Cochlear Implants

The main example that is cited as a comparison for BCI-based medical technologies is the cochlear implant. Cochlear implants are similar to BCIs in that they serve to directly transmit auditory signals to the brain and bypass the patient’s non-functioning or damaged ears. The implant uses a microphone and audio processor to detect and isolate speech and other desired sounds and uses an electrode array implanted in the inner ear to directly stimulate different areas of the auditory nerve (*Cochlear Implants*, 2021). According to the National Institute of Health’s National Institute for Deafness and other Communication Disorders, the first cochlear implants were approved by the FDA for use in adults in the mid-1980s but now see widespread use. Worldwide, around 736,900 cochlear implants are now in use as of December 2019. Many implantations occur in children between 12 and 18 months of age which involves the decision-

making of parents, most of which can hear. For those who receive cochlear implants before 18 months of age and receive intensive therapy, it has been demonstrated that some patients can hear, comprehend sound and music, speak, and develop language skills at a comparable level to children with normal hearing. From the perspective of the hearing parent, this is a positive outcome. Overall, however, after implantation, hearing may range anywhere from minimal improvement to near normal hearing (“Benefits and Risks of Cochlear Implants,” 2021). By allowing its user to hear, this technology gives its user the ability to live within society without requiring the accommodations designed for deaf individuals. Given this ability, people with cochlear implants are less likely to learn sign language or other systems developed to allow deaf people to communicate—a trend which invites controversy among the deaf people who do identify with such systems.

The Deaf Community

People who are born deaf or lose their hearing early in life often learn to communicate with others through some form of sign language. Many deaf people also identify with the Deaf community, a distinct cultural group from the “deaf community” which is often taken to identify the group of people who are deaf. The Deaf community in the United States and Canada refers specifically to the group of people who identify with American Sign Language and a broader culture developed around signing and other aspects of life as a Deaf person (*The Deaf Community: An Introduction*, n.d.). The use of sign language in particular is a source of strength for the Deaf community. Sign language is seen as an extension of the dominant spoken language of the particular community’s native region, but in reality, sign language is distinct in many ways and facilitates expression in different ways. In the United States and Canada, American Sign

Language is studied alongside other foreign languages in academic spheres illustrating how ASL is viewed in the eyes of professionals and academics (Dolnick, 1993).

The Social and Medical Models of Healthcare

The main conflict involving deafness and cochlear implants is understood in terms of two competing models of disability as presented by the Office of Developmental Primary Care at the University of California, San Francisco (UCSF) (*Medical and Social Models of Disability / Office of Developmental Primary Care*, n.d.). The first model is the Medical Model of Disability which holds that “disability is a defect within the individual.” This view supports the idea that disabilities are a personal problem which is treated by medical procedures and individual care and encourages the development of medical treatments which seek to restore traits which are considered normal by the general public. On the other hand, the second model is the Social Model of Disability views disability as “the inability to participate fully in home and community life.” This view holds that the afflictions of conditions are separate from the disabilities themselves, which are “physical and social barriers” imposed by society. This model looks to solve these issues by appealing to “education, accommodation, and universal design.” Education serves to eliminate discrimination and stigma faced by those with disabilities, and accommodation and universal design serve to remove the physical barriers faced by those with disabilities. The UCSF article argues that the Medical Model views disability negatively which can lead to feelings of lower self-worth among disabled people due to “messages of pity or shame” from the perspective of “the media, by people in our own communities, and sometimes by health care professionals.” These attitudes compound people’s fears of becoming disabled which reinforces the negative feelings towards disability and furthers stigma against those with

disabilities. The Social Model is preferred by the UCSF article as it encourages acceptance of disability as an aspect of human diversity, quoting disability advocate Alison Kafer as framing disabilities as “alternative ways of being in the world” thus moving away from the inherently negative framing of the Medical Model.

When the models are applied to the condition of deafness, the cochlear implant reflects an application of the Medical Model of Disability to deafness which creates a controversy among those within the Deaf community who see their deafness as part of their identity and reject the notion that their deafness is an impairment. Instead, Deaf people rely on cultural institutions and shared language to communicate and live their lives. As a consequence, almost none of the approximately 1,200 deaf children born to Deaf parents in America in a given year receive cochlear implants before adulthood (Zimmerman, 2009, p. 30). Despite this resistance, the general public, led by the medical community, is embracing cochlear implants and shifting away from social means of care.

Paradigm Shift Theory and its Applications in Healthcare

In order to understand the complex dynamics involved in the introduction of groundbreaking technology, BCIs are analyzed as a paradigm shift in the treatment of paralysis and broader motor disability. For the purposes of this paper, “disability” is taken to mean “motor disability” unless stated otherwise. The Paradigm Shift framework is introduced by Thomas Kuhn in 1962 in his book *The Structure of Scientific Revolutions*. Kuhn contends that scientific process is nonlinear in nature, featuring a recurring cycle of normal scientific progression followed by dramatic shifts in understanding. The theory is rooted in the idea that science by its very nature of deductive reasoning through experiment often eschews rules or laws in favor of

norms. This tendency is a result of the inability to know with certainty, resulting in frameworks and definitions that are agreed upon by a field and upon which research is built. The Kuhn cycle is a useful description of the paradigm shift which describes its effects on a discipline. First, either within a new field after a recent paradigm shift, theories and ideas are varied, and none are dominant. This stage is referred to as the “pre-science” stage. The next (and longest-lasting) stage features “normal science” where the old paradigm gives rise to a useful model that has explanatory power in experiments and enables the development of new ideas. The next stage is referred to as “model drift.” Over time, more experiments begin to demonstrate gaps in understanding under the old paradigm. Then, a “model crisis” occurs when a glaring gap is exposed and the model must be changed to reconcile it. If this involves ushering in a new paradigm, then a paradigm shift has occurred (McLeod, 2020).

An example of such a norm is the description of gravity as a force. This norm remains useful in many fields, but in astrophysics, this norm was replaced by the understanding of gravity as a perceived effect of curved spacetime, as described in Einstein’s theory of general relativity. This paradigm shift explained a discrepancy in observations of the precession of Mercury, but resulted in a completely new perspective of the structure of the universe and led to a whole new understanding of physics.

Within the field of healthcare, a 2018 *ClinMed* article discusses a paradigm shift occurring in healthcare due to the increased focus on patient-centered care and technologies allowing better access (Al Muammar et al., 2018). The article begins by discussing some of the more formidable trends in modern healthcare. For instance, healthcare costs are rising rapidly due to consumerist, indulgent lifestyles and aging population. In fact, these trends are particularly burdensome given that they precipitate the development of chronic diseases and

conditions requiring long-term care. Other issues include the transmission of disease within hospitals and the evolution of antibiotic-resistant bacterial diseases in hospitals. More broadly, the article also highlights that access to affordable quality healthcare is not a reality for many segments of the population and remains a “distant dream” worldwide. The article then identifies certain points of improvement, the most novel point being a movement towards “patient-centered healthcare,” which is described as “respectful” care that responds to the patients’ “preferences, needs and values.” The article then cites research supporting a correlation between more patient-centered approaches and greater patient compliance, patient recovery, and lower readmission. The shifts toward patient-centrism show the direction that norms in healthcare have shifted.

Another major paradigm shift identified in the article is the emergence of digital healthcare and telemedicine. Access to healthcare has vastly increased in rural and less-accessible regions due to the shift away from treatments requiring brick-and-mortar healthcare institutions like hospitals. Telemedicine in particular encourages a shift away from solely physician related care to include nursing and pharmaceutical services, as well as health education and promotion. Other more recent shifts include the incorporation of smart phones and smart watches which enable users to closely monitor their health without requiring tests or regular visits to physicians or clinics. This example demonstrates the way that paradigm shift theory is used to describe scientific progression. Until the introduction of telemedicine, the scientific progression of healthcare always assumed that care was delivered in-person face-to-face by a highly-skilled healthcare professional. This paradigm created issues as healthcare became more advanced and outpaced its expansion to the developing world. Which motivates the development of more long-distance options for rural communities in the developing world and caused a paradigm shift in healthcare delivery. Allowing for a much more decentralized

approach using telephones and the internet greatly increases healthcare quality and access. This analysis identifies and explains the sudden jump in healthcare accessibility. Today, the old paradigm of healthcare is largely confined to the developed world or in dense communities.

While paradigm shift is useful for understanding scientific progression, it is criticized for its reductive view of scientific fact. According to Martin Cohen, Kuhn's theory is extreme in that it reduces scientific fact to simple political positions. He observes and argues that since peoples' beliefs are informed by social and political pressures, that science itself is no different. In the example of climate change, Cohen argues that people who decry the current scientific consensus as political can justify their position with Kuhn's theory. This notion is a result of the fact that Kuhn understands the current scientific consensus as a norm because science largely relies on the opinions of scientific professionals and is not inherently objective. In a more radical interpretation of Kuhn's theory, most scientific knowledge is not objective and is simply the shared opinions of a field (Cohen, 2015).

Analysis of the Case Studies

Introduction: What cochlear implants reveal about BCIs

In the case study of the Deaf community, the social model founded upon private schools, institutional support, and cultural tools for communication is being challenged by the relatively new medical intervention—the cochlear implant—which can grant deaf members of society the ability to hear. The analysis in this paper understands this progression as a paradigm shift and later explores how the introduction of BCIs may cause a similar progression to occur for paralyzed members of society. To understand and make predictions about this transition, the paradigm shift in the case study for deafness is described and abstracted to a general transition

from a social model of care to a medical model of care for a given condition due to advances in treatment. This model is then compared to the introduction of BCIs and its effect on disabled communities.

General Description of Conditions treated with the Social Model of Healthcare

First, to facilitate analysis, a general characterization, drawing upon the examples of deafness and paralysis, to which this paradigm shift could be seen is described. Some important properties include a long-term to life-long prognosis, onset at any point but more likely in the later stages of life, and that the condition necessitates a drastically different lifestyle than one which is considered normal. Also, the condition is considered common, with widespread public knowledge and policy awareness within the society. Both deafness and paralysis fit the mold defined by these traits.

The described model features a transition in sociotechnical structures over time, and features two distinct periods: a period of normal science preceding the shift and a period after the paradigm shift which reckons with the model crisis. Prior to the paradigm shift, the care of those affected by the condition is largely guided by the social model of healthcare. Under this type of care, as a result of prior advocacy by interested groups, the general public is taught to show care and compassion towards people with the condition. In tandem, groups of “affected people” with the condition form “affected communities” to serve as advocacy groups and develop cultural and social institutions to care for the affected population and help them navigate a society which is largely unaffected. This is normal scientific progression under the paradigm of social care of deafness.

Then, new medical technology is introduced which significantly improves an affected person's condition. This begins the model drift, as the old paradigm is initially still dominant. As the technology is developed and improved, an increasing number of affected people—particularly those outside of affected communities—seek these treatments to enable them to more successfully navigate an unaffected world. As this trend continues, the social model of care is largely neglected in favor of the medical model which is enabled by the new medical intervention, eventually resulting in a model crisis. Adapting to this new paradigm spurns certain consequences for the affected community and society more broadly such as declining social infrastructure and community, increased socioeconomic inequity for affected groups, and discrimination.

What does the paradigm shift mean for the Deaf?

Each consequence will be described in general terms and will be supported by examples from the case study on deafness.

As more people seek treatment, there is less political will and social pressure to support societal accommodations and welfare programs. People with the condition lose the social support that they had previously enjoyed. This shift results in the erosion of the institutions that bind the affected community together which in turn accelerates the adoption of medical treatment among those who have access to it. This positive feedback loop further denigrates the social infrastructure which supports the affected but untreated demographic. Evidence for this trend is supported by the observation that schools for the deaf are declining in popularity or closing altogether. Writing for the Guardian, Frances Perraudin cites statistics which show that from 2017 to 2019, the number of in-school facilities for deaf children has declined by 8%.

Furthermore, the number of specialists in these facilities has declined by 21% since 2014. Perraudin quotes a charity, The National Deaf Children's Society, which argues that such decline has resulted from a lack of promotion by schools and other authorities as well as a lack of government attention to ongoing issues within Deaf schools (Perraudin, 2019). Likewise, in the US, an NPR article summarizes a long-term trend as a consequence of the popularity of cochlear implants: "More than 80 percent of children who are or were hearing impaired now attend their local schools. Just a couple decades ago, 80 percent of hearing impaired children attended deaf schools" ("Cochlear Implants Redefine What It Means To Be Deaf," 2012). This evidences a broader trend of declining support for specialized schools and greater support for integrated solutions.

The declining trend in social care infrastructure is coupled with a decline in community. Shifting away from a social model and towards a medical model weakens affected communities. Apathy from the general public, alongside the fact that medical interventions increasing popularity necessarily shrinks the community's base, delegitimizes and shrinks the affected community's influence over policy. Furthermore, this apathy threatens the cultural institutions and in turn, cultural identity among the affected population.

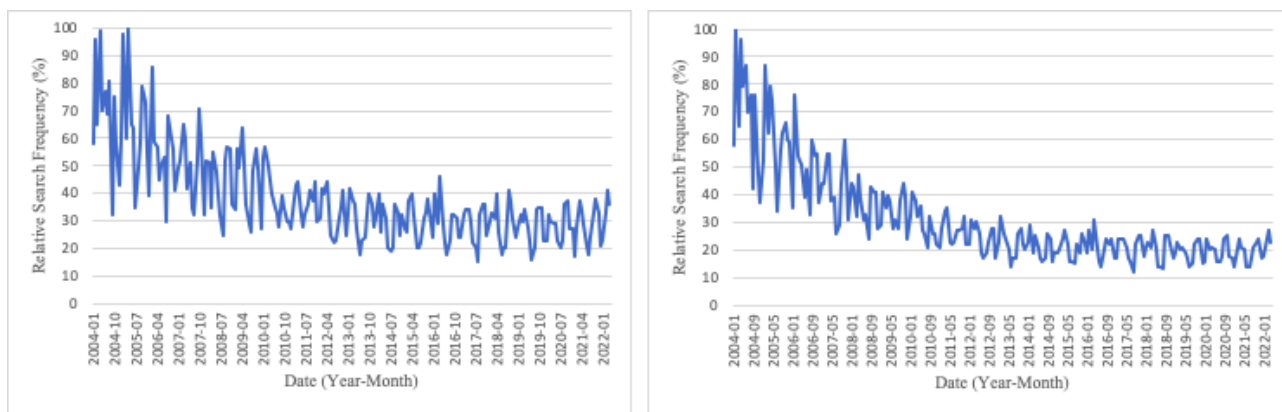
This effect is demonstrated by the case study on Deafness. Before cochlear implants, deafness was universally accepted as a condition that one lives with throughout their whole life. This reality enables the development of community through shared experience. From this understanding, it is apparent as to why the Deaf community's strength is undermined. The general public ceases to view deafness as a lifelong condition, and thus the need for social support is no longer regarded with the same level of importance. Evidence for increasing apathy toward the Deaf community is seen in research and interest trends in recent years. According to

Google Search Trends, both worldwide and within the US, the query “Deaf community” is only searched approximately one-third as frequently in 2021 as compared to 2004 (Figure 1).

Similarly, according to a Google Books Ngram search, the total number of uses of the term “Deaf Community” has declined over recent years as well. The use of sign language is a preeminent example of cultural expression which draws strength from the Deaf community. The same is said for other aspects of Deaf culture, like art and dance etc. As the community shrinks, appreciation for and production of such cultural elements will also shrink. The strength of cultural cornerstones like language and other media are essential to maintain one’s cultural identity; therefore, this trend can only serve to compound that harm to the community.

Figure 1.

Google Search Trends in the United States (left) and the world (right) for the query "Deaf community" (case-insensitive)



Note. Graph by Hoisington, Seth (2022). Data from Google Search Trends.

The decline of social infrastructure and community is complicated by the issues pertaining to access to medical treatment for an affected person. Widespread adoption of the medical model of treatment is likely to disadvantage poorer and more rural communities. Disadvantaged communities face many difficulties that all contribute to the issue of treatment.

One major factor is that disadvantaged communities have less access to healthcare (*Technologies and Health Inequities / Annual Review of Sociology*, n.d.). Another factor is infrastructure. Since infrastructure quality is correlated with poverty, then the communities of people without quality infrastructure overlap with the communities without quality access to healthcare. Therefore, the decline of the social care resources will affect the same communities that have lack sufficient access to medical treatments, leaving lower-income affected adults or families with affected children particularly vulnerable to such a paradigm shift. Pertaining to deaf people in the United States, while most insurance entities cover cochlear implants today (“Frequently Asked Questions,” 2018), they are still likely out of reach for most of the 28 million uninsured Americans as of 2020 (Keisler-Starkey & Bunch, 2021) due to the high cost of the procedure (*Cochlear Implant Cost – Insurance and Factors to Consider / Babyhearing.Org*, n.d.).

During the model drift and model crisis, those who either lack access, are not good candidates for surgery, or who, often out of attachment to the affected community, opt out of treatment are likely to face discrimination and a reduced quality of life due to a combination of the erosion of social support and the lack of medical correction. Discrimination, broadly, results from the decline of the affected community. It is reasonable to assume that as the community shrinks, the political power as well as the community’s representation in popular culture and the media are diminished as well. This leads to greater ignorance among the general public of the affected community which in turn magnifies the severity of the discrimination experienced by the affected community and accelerates the neglect of the social healthcare structures.

Additionally, the introduction of medical treatments informs a different, less tolerant perspective on the ethics of opting out of treatment. In many or most cases, affected people would have access to medical treatment. If successful in seeking treatment they would ideally

not need to rely on the social care system which welcomes the view amongst the general public that people who do not receive medical intervention are instead choosing to rely on social structures. While this view is ignorant of the many reasons why treatment is unavailable to a given affected person, it is nonetheless prevalent among unaffected individuals with regards to Deafness (Edwards, 2005). This attitude is also present in the related situation when parents are making similar decisions with regards to their affected children. According to the healthy perspective, opting out of treatment it is often seen as deliberate action in a manner contrary to the child's best interests. This attitude, despite its pervasiveness in the healthy world, would be wholly rejected within the affected community for the reason that the community does not view their condition negatively and accepts it as part of their being.

This situation is already present in the example of the Deaf community. From the hearing perspective, it is considered unethical to opt out of treatment because the lack of hearing is seen as a detriment. The attitude is summarized in this quotation from an article by R. A. R. Edwards published in 2005 in *The Journal of American History*:

The [medical] model reflects the view of most hearing people, who see deafness as the lack of an important sense and as an insurmountable barrier to communication with hearing people. Deaf people need to be restored to society; the preferred way to do so is to make them hearing, to make "them" more like "us" (p. 893).

This perspective is the opposite of the Deaf community which view their deafness as a trait rather than a medical condition which supports the fact that Deaf parents almost never choose for their children to receive cochlear implants if they are born deaf. Within the Deaf community, children are taught to communicate using ASL regardless if they are hearing or deaf, so within the community it is a natural choice not to receive implants given the support structure in place around that child. Deaf community members often cite past forms of discrimination as typically involving the hearing society forcing integration of Deaf members of society into hearing

society. Past examples of this include forcing American Deaf children to learn English, rather than ASL in schools. This practice is named “oralism” and wholly rejected by the Deaf community. Another controversial practice, seen as a compromise between the hearing parents of a deaf child, is called “Cued English.” Deaf speakers are taught to lip-read English, and hearing speakers use eight signs around the mouth to differentiate between similar-looking words. This practice is also rejected by many members of the Deaf community who view it as a watered-down oralism and a “slap at ASL” (Dolnick, 1993). In a similar manner, the Deaf community views medical intervention through cochlear implants is seen as an attempt of hearing society to force integration of Deaf people. Cochlear implants are seen as a direct threat to their culture (*The Cochlear Implant Controversy*, n.d.) because they inform the notion that Deaf communication through sign language is an inherently lesser form of communication.

In conclusion, one of the largest advantages of the social model is its values of compassion and acceptance. These values are consistently found in the other areas where the social model is applied, namely in the care of disabled individuals.

How will BCIs change the care of the disabled population?

The paradigm shift caused by BCI technology can be studied closely within Kuhn’s framework to understand and predict BCI technology’s effects on disability. Today, the care of people with disabilities is largely incumbent upon social and political systems. These programs, exemplified by the Americans with Disabilities Act (ADA) are predicated upon the assumption that certain abilities that most people have cannot be assumed for everyone. As such, the normal scientific progression involves improving access to infrastructure and developing technology like wheelchairs to help accommodate disability. Then, with the introduction of BCI-based medical

interventions for the treatment of motor disability begins to nullify this assumption. Anyone who is eligible for such treatment will have access to certain abilities—for example, the ability to use stairs—which had been previously discounted. Eventually, as access to BCI-based interventions becomes accessible to the mainstream, society begins to reorganize itself, assuming these abilities. At this point, the old model of disability is in crisis. Society’s beliefs and norms regarding those disabilities is drastically changed. Using the example detailed by cochlear implant technology, it can be predicted that this change results in a decline in social infrastructure and community, increased socioeconomic divide for disabled groups, and increased discrimination.

In a future where a medical model is applied to disability care, then the above trends would imply less political will by organizations and governments to expand social care programs like the ADA. Over time, such neglect will put a lot more pressure on people with disabilities to seek medical treatments like BCIs, instigating a positive feedback loop which will inevitably drain support—both among the general public and within the disabled community—for social care.

For those with disabilities, there exists a community which views its purpose to be very similar to the stated purposes of the Deaf community. Steven Brown, in an article published in *Disability Studies Quarterly* writes:

People with disabilities have forged a group identity. We share a common history of oppression and a common bond of resilience. We generate art, music, literature, and other expressions of our lives and our culture, infused from our experience of disability. Most importantly, we are proud of ourselves as people with disabilities. We claim our disabilities with pride as part of our identity. We are who we are: we are people with disabilities (Brown, 2002).

This quote summarizes a similar attitude shared by the Deaf community: people with disabilities are simply a group of people who face certain challenges. From the article, Brown also quotes

and interprets other authors who identify with disability culture and extol its value for supporting and advocating for those with disabilities.

Comparisons are drawn to aspects of culture in the disabled community like the Paralympics and accessible sport. Consider wheelchair basketball. Inspired by the traditional sport of basketball, wheelchair basketball is catered to the paraplegic community and uses a different set of rules to better suit its participants. Since wheelchair basketball employs different rules, it is distinct from its parent sport in the same way that American football is different than rugby. Wheelchair basketball players develop different skills than traditional basketball players, and many of the skills do not translate from one sport to the other. Similar arguments are made comparing Paralympic sports like swimming to their inspirations in the Olympics. Traditional swimming for example requires the coordinated use of many muscles throughout the body while its Paralympic variants adapt traditional swimming to be accessible to those who lack any particular bodily functions that traditional swimming employs to enable fair competition between its athletes.

For new technologies, it is likely years between when the technology is first available to when healthcare insurances cover it, and it is not guaranteed that the uninsured will ever have easy access to the technology. This class inequity dimension to BCI access may be exacerbated given the difficulty of surgery and the likely years of therapy needed to ensure successful treatment. The current iterations of the technology require brain surgery which is expensive and risky. All of this may be out of reach for lower-class Americans who typically lack access to quality healthcare or for those who feel that the risks associated are too great.

According to the disabled community, ableism—defined as discrimination against people with disabilities—is deeply rooted in the view that disabled people are in need of “fixing” is a

(Eisenmenger, 2019). This view is analogous to the view that lack of hearing is a detriment, which is seen by the Deaf community as a root of very similar discrimination in oralism. Given that BCIs offer such a “fix,” it is logical to assume that greater instances of ableism would be experienced by the disabled community.

While these effects seem to follow logically from the general characterization of a condition treated by the social model, it is important to consider potential factors that may change the outcome of the BCI paradigm shift. One of the most glaring differences between the disabled community and the Deaf community is the degree of organization. The Deaf community has a highly organized and distinct culture which is nurtured and developed in special schools and departments for Deaf people. Furthermore, Deaf people have a unique regional sign language for facilitation of their shared culture. This is not the case for the disabled community. While there are elements of disabled culture and members of the disabled population for which expression about their disability is important, the community is less strong for a number of reasons. Most importantly, there is no such shared language by which disabled people communicate, and there are fewer dedicated schools for the education of disabled children. Furthermore, disability is a broad term. Even just considering motor disabilities, there are different kinds and severities. Whereas within the Deaf community nearly all members share the same experiences and difficulties. This heterogeneity limits the closeness and size of an analogous disabled community, and thus may dilute the shared attitudes that define the Deaf community. While these are differences, they are still alike in their dependence on and strong preference for the social model of care. Additionally, the broader disabled community is broad but unified. If BCIs began to dominate, it may distinguish a smaller subset of the disability

community that strongly identifies with their disability. For example, Paralympic athletes may reflect these attitudes through pride for their particular Paralympic sport.

Implications of Research Limitations and The Need for Future Work

While the case of cochlear implants and Deaf culture can be well understood today, the same is not true for BCI technology and disabled society. We can make predictions based in the case study of deafness but this cannot account for the differences between the two cases. As such, the differences between the two studies cannot be accounted for. This becomes much more of an issue when considering more hypothetical applications of the theory. Another limitation is rooted in Kuhn's theory. Paradigm shifts are transitions between norms, and these norms are not predictable based on previous norms. Furthermore, they are often affected by social attitudes and psychology (McLeod, 2020).

The need for future research is predicated on the fact that there are many "conditions" that are treated by a social model of care, many of which are not traditionally thought of as "conditions" by the general populace. Two such examples are provided.

While the two cases in this paper describe issues that affect a subset of the population, this model can be used to apply to certain traits of humanity which are commonplace. Some potential examples are BCI implants in healthy people or anti-aging therapy. Theoretical uses for BCIs in healthy people have been explored to perform various functions. Certain examples include an a much more intimate interface with digital devices or supplementing other conventional interfaces like a mouse and keyboard (Allison et al., 2008). In this example, the "affected person" is a fully healthy person without any medical conditions and the social model simply accommodates peoples' inability to interface directly with computers. People with

implants would have a specific advantage in technology usage over people without implants, a relationship which has the potential to cause discrimination against fully healthy people like job discrimination, especially given that so many jobs involve computer usage. Another potential direction is immortality. Suppose that, in the future, anti-aging research advances to a point where, through invasive medical intervention, people can stop or reverse aging. Then, ordinary, mortal humans would again find themselves in the “affected” community of mortality. Currently, every human ever born has been mortal, so the healthcare system to deal with mortality is completely reliant on the social model. Death is understood as a completely natural part of life. After a paradigm shift, mortality may be seen as a lesser quality of humans and discriminated against, especially if the condition is relegated to the lower levels of society.

Conclusion

By analyzing the case study of cochlear implants and the Deaf community, the decline of community, increased socioeconomic divide, and increased discrimination are inherent outcomes of paradigm-shifting medical technology. Considering the large investments by governments and other parties indicate popular support BCIs, it is likely that these questions must be dealt with in the future in the case of the disability community. If the medical model were to dominate in the near future, then in the same way that the ASL and Deaf culture are threatened by cochlear implants, BCIs will threaten aspects of disabled culture. Similar questions may also be asked for hypothetical medical interventions of the future like sensory enhancement, BCIs in normal humans or even methods of immortality. While these medical advances are powerful tools and can largely replace existing social structures, they are much less effective at tackling social issues like community decline, inequality, and discrimination. Overall, this supports the

conclusion that in a future dominated by the medical model of treatment for BCIs, that support for social structures alongside support could help prevent these social issues from developing.

Bibliography

- Al Muammar, A. M., Ahmed, Z., & Aldahmash, A. M. (2018). Paradigm Shift in Healthcare through Technology and Patient-Centeredness. *International Archives of Public Health and Community Medicine*, 2(1). <https://doi.org/10.23937/iaphcm-2017/1710015>
- Allison, B., Graimann, B., & Graeser, A. (2008). *Why use a BCI if you're healthy?* 23, 7–11. *American Deaf Culture*. (n.d.). Retrieved March 21, 2022, from <https://clerccenter.gallaudet.edu/national-resources/info/info-to-go/deaf-culture/american-deaf-culture.html>
- Benefits and Risks of Cochlear Implants. (2021). *FDA*. <https://www.fda.gov/medical-devices/cochlear-implants/benefits-and-risks-cochlear-implants>
- Brown, S. (2002). What Is Disability Culture? *Disability Studies Quarterly*, 22(2), Article 2. <https://doi.org/10.18061/dsq.v22i2.343>
- Clark, N., Quiroz, L., Guevara, M., Doubek, J., & Kwong, M. (2020, July 27). In Their Own Words: How The Americans With Disabilities Act Changed People's Lives. *NPR*. <https://www.npr.org/2020/07/27/895651325/americans-with-disabilities-act-examining-its-impact-3-decades-later>
- Cochlear Implant Cost – Insurance and Factors to Consider | Babyhearing.org*. (n.d.). Retrieved May 3, 2022, from <https://www.babyhearing.org/devices/cochlear-implant-cost>
- Cochlear Implants*. (2021, March). NIDCD. <https://www.nidcd.nih.gov/health/cochlear-implants>
- Cochlear Implants Redefine What It Means To Be Deaf. (2012, April 8). *All Things Considered from NPR News*. <https://www.npr.org/2012/04/08/150245885/cochlear-implants-define-what-it-means-to-be-deaf>

- Cohen, M. (2015). *Paradigm Shift: How Expert Opinions Keep Changing on Life, the Universe, and Everything*. Imprint Academic.
- Dolnick, E. (1993). Deafness as culture. *Atlantic (02769077)*, 272(3), 37. Academic Search Complete.
- Edwards, R. A. R. (2005). Sound and Fury; Or, Much Ado about Nothing? Cochlear Implants in Historical Perspective. *The Journal of American History*, 92(3), 892–920.
<https://doi.org/10.2307/3659972>
- Eisenmenger, A. (2019, December 12). Ableism 101 - What is Ableism? What Does it Look Like? *Access Living*. <https://www.accessliving.org/newsroom/blog/ableism-101/>
- Frequently Asked Questions. (2018). *FDA*. <https://www.fda.gov/medical-devices/cochlear-implants/frequently-asked-questions>
- Keisler-Starkey, K., & Bunch, L. N. (2021). Health Insurance Coverage in the United States: 2020. *United States Census Bureau*, 40.
- Kuhn, Thomas. (1962). *The Structure of Scientific Revolutions*. University of Chicago Press.
- McLeod, S. (2020, September). Thomas Kuhn—Science as a Paradigm. *Psychology Today*.
<https://www.simplypsychology.org/Kuhn-Paradigm.html>
- Medical and Social Models of Disability | Office of Developmental Primary Care*. (n.d.). Retrieved March 21, 2022, from <https://odpc.ucsf.edu/clinical/patient-centered-care/medical-and-social-models-of-disability>
- National Association of the Deaf—NAD*. (n.d.). Retrieved March 29, 2022, from <https://www.nad.org/resources/american-sign-language/community-and-culture-frequently-asked-questions/>

- Novic, S. (2021, October 10). Opinion | Don't Fear a Deaf Planet. *The New York Times*.
<https://www.nytimes.com/2021/10/10/opinion/deaf-population-integration.html>
- Padden, C., & Humphries, T. (Tom L.). (1988). *Deaf in America: Voices from a culture*.
Cambridge, Mass. : Harvard University Press.
<http://archive.org/details/deafinamericavoi00padd>
- Paralysis statistics*. (n.d.). Reeve Foundation. Retrieved December 9, 2021, from
<https://www.christopherreeve.org/living-with-paralysis/stats-about-paralysis>
- Perraudin, F. (2019, February 6). Teaching units for deaf children keep closing, report finds. *The Guardian*. <https://www.theguardian.com/society/2019/feb/06/teaching-units-for-deaf-children-keep-closing-report-finds>
- Science—Neuralink*. (n.d.). Retrieved October 24, 2021, from <https://neuralink.com/science/>
- Technologies and Health Inequities / Annual Review of Sociology*. (n.d.). Retrieved October 24, 2021, from <https://www.annualreviews.org/doi/10.1146/annurev-soc-121919-054802>
- The Cochlear Implant Controversy*. (n.d.). Retrieved October 24, 2021, from
<https://www.cbsnews.com/news/the-cochlear-implant-controversy/>
- The Deaf Community: An Introduction*. (n.d.). National Deaf Center.
<https://www.nationaldeafcenter.org/sites/default/files/The%20Deaf%20Community-%20An%20Introduction.pdf>
- Zimmerman, A. (2009). Do You Hear the People Sing? Balancing Parental Authority and a Child's Right to Thrive: The Cochlear Implant Debate. *Journal of Health & Biomedical Law*, 5(2), 309–330.