Exploring the Intersection of Cybersecurity, Neurocapitalism, and Biodesign

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Abstract: The convergence of neurocapitalism and biodesign presents a promising future for the healthcare and technology industries. Neurocapitalism, a model characterized by monetizing neurological processes and behaviors, has profoundly impacted economies, technologies, and societal structures. Simultaneously, biodesign, which combines biology and design principles to develop innovative solutions, has emerged as a critical approach to healthcare innovation. Armed with the knowledge that neurocapitalism and biodesign rely heavily on data management, this commentary explores how insights from cyber security can protect the data involved. For this research, we delve into the foundational principles of neurocapitalism by elaborating on its core tenets and implications for various aspects of society, we establish a comprehensive understanding of biodesign by highlighting its significance in driving transformative advancements in healthcare, while simultaneously proposing strategies for enhancing the security of the sensitive information connected to the data used in both industries. Meanwhile, we identify intersections between neurocapitalism and biodesign through an interdisciplinary lens, revealing shared principles and potential synergies while proposing strategies for improving data safety. As we address the challenges and ethical considerations associated with combining neurocapitalism and biodesign, we also identify the security risks and the ethical implications that arise because of the lack of security. Looking ahead, we envision a future where the secure data used by neurocapitalism continues to shape the evolution of biodesign unethically. We also envision a future where by embracing a multidisciplinary approach and fostering collaboration across professions, the secure data can be used to create designs that work around neurocaptialism, unlocking new opportunities for innovation and addressing pressing healthcare challenges. By doing this, we are creating the possibility for more meaningful advances in cyber security, biodesign, and ultimately for individuals worldwide. As we conclude, we reflect on how the synergy between neurocapitalism and biodesign offers a fertile ground for exploration and innovation in healthcare and its data security. Through strategic integration and ethical stewardship, we can harness the critique of neurocapitalism to catalyze transformative change and usher in a more beneficial era of healthcare innovation.

Keywords: Neurocapitalism, Cyberbiocybersecurity, Biocybersecurity, Biodesign, Cybersecurity

1. Introduction

1.1 Definition of Neurocapitalism

Neurocapitalism is the private selling of the data collected from human users that is generated and stored using technology. Due to the digital space, social media, and smartphones, there has been a significant increase in data resources. With unfiltered access to all of the data, surveillance capitalism is becoming more and more of an issue (Lesaja & Palmer 2020). Lesaja and Palmer found that surveillance capitalism is when user data like personal information, browsing habits, purchases, and behavioral patterns are tracked and sold with limited user knowledge. This limited knowledge is due to the inaccessibility and coercion of the company's terms and conditions, which leads to machine learning algorithms using the sold data to build personalized systems for users (Lesaja & Palmer 2020). The algorithms use the collected neural and behavioral data to predict future user behaviors. One result of this modeling system is tailored communication. Tailored communication is a behavioral model used to personalize social media and its advertisements (Lesaja & Palmer 2020). While these concepts may sound cool, if the data involved is misused or abused, the consequences can be detrimental and might cause serious harm to users (Lesaja & Palmer 2020).

1.2 Explanation of Biodesign

Biodesign is an emerging field of study that works with living organisms and design principles to create innovative solutions that can be used across industries such as healthcare, art, product design, architecture, and educational institutions. The natural world's intelligence and adaptability has helped industries and designers create sustainable solutions that enhance our society (Anquetil, 2024). Some believe that biodesign is the 21st-century equivalent of interfaces, virtual worlds, and video games (Traldi, 2018). This comparison proposes that

biodesign, like the digital space, has been rapidly advancing by increasing access to previously expensive specialized procedures (Traldi, 2018). This increased accessibility is the direct work of designers simplifying the interfaces and usability so that the processes can be duplicated and shared with more people. Biodesign has brought the healthcare industry new practices such as precision medicine, computer vision, and drug discovery and development (Bohr & Memarzadeh, 2020). These inventions have connected biology and technology and are perfect examples of biodesign.

2. Understanding Neurocapitalism

2.1 Overview of Neurocapitalism and its Principles

2.1.1 Definition and origins

Before we go any further, let's define capitalism. Capitalism is an economic and political system where private owners control trade and industry to make a profit. Capitalism has shown itself to be not only exceptionally adaptable and crisis-resistant but also dominant and capable of analyzing and mitigating the "malfunction" its subjects are prone to (Hess & Jokeit, 2010). When capitalism is connected with technology and politics, neurocapitalism arises. Giorgio Griziotti, author of *Neurocapitalism Technological Mediation and Vanishing Lines,* posits that because our economy has become based on knowledge and information, spending time in front of a screen is a form of production (Motherboard). A subform of neurocapitalism is surveillance capitalism. Surveillance capitalism is the monetization of data created by all user's movements and behaviors, both online and in the physical world (Barney, 2024). Surveillance capitalists profit off of the fragile relationship between an individual's public and private space (Pepperdine, 2024). They acquire and package the "private" everyday experiences gathered by users and sell them to behavioral markets for future use (Pepperdine, 2024). Surveillance capitalism invalidates the rights associated with a person's autonomy, exposes how much information is readily available for public use, and makes very clear the importance of data security.

2.1.2 Key principles and features

Neurocapitalism has two key principles. The first is that the technology we use in our everyday lives is now seen as a source of productivity and labor. As human-computer interaction (HCI) is studied, one of the ideas is that workplace and consumer cultures make use of the brain sciences to root out the evils of inefficiency (Sapmson, 2016). This explosive mode of capitalism is associated with the introduction of cognitive and neurological models that have corresponded with the rise of the digitalization of work and consumption (Sampson, 2016). As we acknowledge that the digital space has gone from a tool used only for interaction to a part of our subjective space, it's hard not to notice that smartphones and their ability to provide permanent work have eliminated the boundary between private life and work (Motherboard). This disappearance allows the technological space to have and possibly manipulate our attention using algorithms (Motherboard). A new addition to the digital space is the ability to read an individual's senses and emotions. With the smartphone and smartwatch able to connect to an individual's emotions and body directly, a company's monitoring capabilities could include using this technology to find inefficiencies and create better productivity so that labor increases. The second is the collecting, storing, and selling of the neural data created using technology. Earlier, it was discussed that surveillance capitalism is becoming more of an issue as technology evolves and grows into more spaces. This latest form of capitalism mines the user's personal information, browsing habits, purchases, and behavioral patterns, or "big data," to analyze and create a prediction product that is then sold to the highest bidder (Zuboff, 2015). Brain-computer interfaces (BCIs) are devices that provide a direct link to the brain and its behaviors through external devices. BCIs provide data connected directly to brain activity and signals, while HCIs provide data connected to the user's interaction with technology. All of this information is stored and sold, which makes neurocapitalism so invasive (Cassidy, 2021). The dangers of neurocapitalism continue to grow as invasive BCIs, like Neuralink, which was founded by Elon Musk, make their way to the market. Neuralink was initially created to be used for therapeutic purposes, allowing amputees and those with spinal cord injuries to control bionic prosthetics (Cassidy, 2021). However, Neuralink can be seen as a significant threat to human consciousness as it can read and monitor users' neural data constantly. At its worst, this could be used to exploit or control a user's thoughts through computer-executed commands.

2.2 Impact of Neurocapitalism on Economy, Technology, and Society

2.2.1 Positive and negative effects

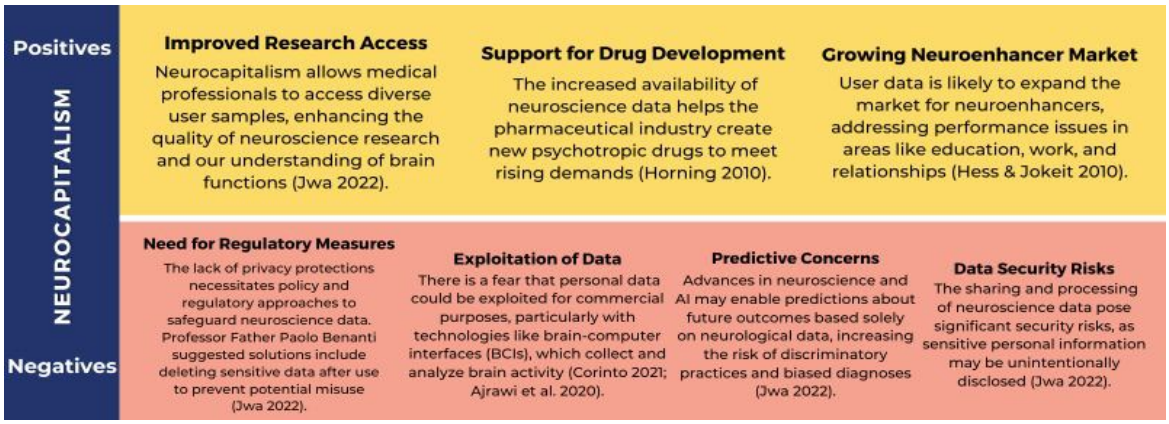

Figure 1: Positives and Negatives of Neurocapitalism

Neurocapitalism offers several benefits, including increased access to diverse neuroscience data, which is vital for medical discoveries (Jwa, 2022). The enhanced availability of data can also improve the rigor and reproducibility of research, leading to a better understanding of brain function. Additionally, this research supports the pharmaceutical industry in developing psychotropic drugs to meet growing demand (Horning, 2010). Furthermore, as societal pressures for performance rise, the market for neuroenhancers is expected to expand in areas like education and aging (Hess & Jokeit, 2010). Ultimately, the purchasing of user data serves a dual purpose, benefiting both the medical and pharmaceutical sectors by providing crucial insights for tailored research and drug development.

Neurocapitalism presents several significant drawbacks. One major concern is the lack of security for sensitive neuroscience data, which is heightened by increased sharing and the use of AI and big data analytics (Jwa, 2022). This combination also raises the risk of personal information disclosure, potentially violating privacy rights. Moreover, the predictive use of neurological data could lead to discriminatory practices and biased diagnoses (Jwa, 2022). There are fears of exploitation for commercial gain, particularly with advancements in BCI technology (Corinto, 2021). As BCIs convert brain signals into commands, the reusability of processed data poses additional data protection challenges (Ajrawi et al., 2020). Calls for better data protection policies highlight the need for privacy assurances, while suggestions, such as the deletion of sensitive data post-use, aim to prevent future exploitation (Jwa, 2022).

2.2.2 Future implications

As we have discussed, neurocapitalism is present in all data collection professions. Outside of the medical research and AI fields, neural data is used in different industries, including marketing, the gaming industry, facial recognition, deep learning, stock market predictions, sales forecasting, social media, healthcare, weather forecasting, E-commerce, and many more (Kaushik, 2021; Skovhøj, 2022; Samuel, 2019). However, as helpful and informative as this data is to all professions, neurocapitalism is invasive to daily life. Outside of the very limited federal medical regulations, there is currently no way to protect the personal sensitive information that is attached to the data that is sold. This gap becomes even more concerning when companies can use the data to deploy BCIs without regulation (Witley, 2024). This has caused some neuroethicists and neuroscientists to call for regulation and user rights protection. This information gold mine for companies needs to be politically regulated for privacy and ethically correct practices. Once regulated, neural data and the human users of that data can be protected across all professions.

3. Biodesign Principles

3.1 Definition and Scope of Biodesign

3.1.1 Overview of biodesign

Biodesign has a different definition depending on who you talk to. However, our working definition of biodesign is that it combines the interdisciplinary interests of the fields of life sciences and design principles. This multidisciplinary approach has created a relationship between the natural world, the design process, and

biotechnology. These new relationships have allowed for a deeper understanding of the intelligence and adaptability of the natural world (Anquetil, 2024). They also have helped us understand how tapping into sustainability can create innovations like self-repairing designs (Anquetil, 2024). This approach is vital to innovative healthcare solutions and new practices in art and design, bio-engineering, architecture, and many other fields. The AHA Center for Health Innovation believes that by adopting a comprehensive data strategy, hospitals and health systems can improve a patient's experience and outcomes and reduce costs. By doing this, healthcare systems can build an analytics system that can not only keep up with the needs of healthcare data but can also help enhance the value of the innovations created with this data and provide fresh insight on how to prevent disruptions when meeting the future needs of patients (AHA, 2024). In healthcare, biodesign can be seen in portable and wearable electronics and devices. Given the benefits of personalized healthcare monitoring, such devices range from (bio)electronics placed on or within the body to wearables and clothing intended to monitor health or lifestyle parameters (Brooks et al, 2022). These personalized monitoring systems are HCIs, and sharing the health data they collect creates threats to the privacy and security of personal data (Rathbone, 2023). Due to the sensitivity of the data being created from all sides of the healthcare field, the information must be protected from most if not all, data threats.

3.1.2 Key principles and features

Biodesign is built on the design process which identifies a need, invents something to solve that need, and implements the invention into everyday life. One of the leading spaces for biodesign is the Stanford Byers Center for Biodesign (SBCB). SBCB broke the design process into 6 phases: needs finding, needs screening, concept generation, concept screening, strategy development, and business planning. SBCB shares that needs finding and screening happen during the identification phase. In this phase, scientists identify an unmet health need and do extensive research to get a better understanding of how the unmet need affects not only the patient but also the provider and the system. The scientists use this knowledge to build a concept that not only challenges the status quo but also provides a solution to the unmet need. As the concept is being built during the invention stage, it goes through multiple stages of trial and error and is continually tested to ensure that it meets the needs of everybody involved, and will have sustainability. Finally, the concept is implemented and turns from a lab invention to an innovation the public can use. This innovation becomes a business, and strategies are made to ensure the intervention is accessible to the community that needs it. Some examples of biodesign in healthcare are seen through medical device innovation, improvements in patient safety and treatments, and reduction in time and cost (Gupta et al.,2023). Surprisingly, biology itself is being called the new digital, based on simple historical evolution (Traldi, 20218). According to Joi Ito, the director of the MIT Media Lab, when computers became something the public could afford, designers began to simplify interfaces, which led to more users and the beginning of the digital age. She posits that these simplifications are happening in the biology field as designers are creating simplifications to expensive, extensive, and specialized procedures and interfaces, which leads to more usage across the industry (Traldi, 20218). The biodesign process leads to the simplified procedures used to identify, innovate, and implement solutions while providing continuous support to ensure the need is met.

3.2 Importance of Data Security for Biodesign in Healthcare

3.2.1 Applications of biodesign in healthcare and data security

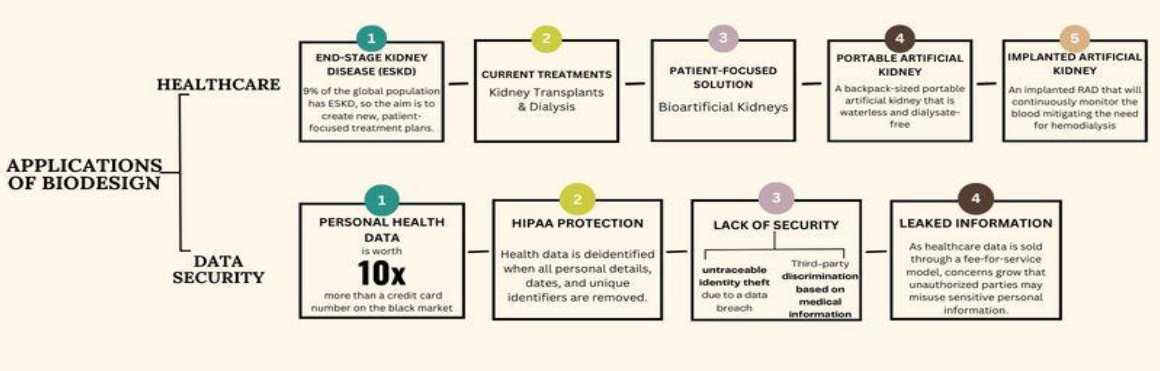

Figure 2: Applications of Biodesign

Portable Artificial Kidney: Scientists at UCLA are developing a portable artificial kidney that fits in a backpack. Led by Dr. Ira Kurtz, along with CEO Roland Ludlow and researcher Jamie Hestekin, this innovative device is both

waterless and dialysate-free (UCLAHealth, 2021). Its self-contained design eliminates the need for water or living cells, making it easy to transport and potentially lowering dialysis costs (UCLAHealth, 2024). The device mimics the filtration and transport processes of the kidneys (UCLAHealth, 2024).

Implantable Bioartififical Kidney: The University of California San Francisco (UCSF) and The Kidney Project are developing a miniature external Renal Assist Device (RAD), a bioartificial kidney that combines a membrane hemofilter with human renal tubule cells to replicate key kidney functions (UCSF, 2024). This surgically implanted device will continuously process and monitor blood, reducing reliance on hemodialysis and minimizing the need for extensive medical oversight (UCSF, 2024). Such advancements in artificial kidneys aim to provide essential support for patients with end-stage kidney disease, easing the burden of transplants and dialysis (UCLAHealth, 2021).

Privacy Issues: Concerns are rising in the healthcare industry about data management and the risks of sharing data for biodesign. Healthcare data management encompasses the lifecycle of health data, from creation to destruction (ACTIAN, 2024). The sharing of unprotected health data highlights the need for strong data security. While HIPAA's Privacy Rule mandates strict deidentification for research, it only applies to covered entities like health plans, leaving non-covered entities such as wearable tech unregulated. This creates risks of unauthorized data use and reidentification, particularly with genetic information, threatening individuals' health privacy. Privacy advocates argue that true deidentification may be unachievable in the digital age, as sensitive data could expose compromising health details. For example, a child discovering a risk for a serious condition may inadvertently share that information with employers or insurers, affecting their future (Silverman, 2004). This situation underscores the urgent need for robust data security in healthcare.

4. Intersection of Neurocapitalism and Biodesign

4.1 Exploration of Common Grounds

4.1.1 Overlap of principles

As different as neurocapitalism and biodesign seem on the surface, they surprisingly have some overlap in their principles. These overlaps are: being influential within the healthcare community and sharing neural data to further innovation. The neural data being sold affects the healthcare industry by providing the data to create new inventions that can define diseases more precisely, identify high-risk patients, and predict drug safety (ABE, 2021). It can also be used to create implanted microchips that can contain the effects of neurodegenerative diseases, enhance perceptions, save memories, and amplify or selectively erase them (Corinto, 2021). In terms of machine learning, this data helps to create a recursive cycle of gaining user information to build a better product, which brings in more users and information (Lesaja & Palmer, 2020). These innovations can be the first steps into a new age of biology, however, the lack of security involving a person's medical records and biological information is a huge issue. Especially, since the information sold might have an impact when determining future implications of a person's life, including a possible stolen identity and denial of access to necessary resources.

4.1.2 Potential collaborations

The most common collaboration between neurocaptialism and biodesign is biocapitalism. Biocapitalism is a late capitalistic idea that describes the exploitation of biological knowledge (Wiki, 2024). This was seen in the monetization of the Human Genome Project (HGP). HGP was a $2.7B public-domain, international comprehensive project that was focused on studying the DNA of a select set of organisms so that researchers could do human genetics at less cost (Cara, 2023; Cook-Deegan, 2003; HGP, 2024). HGP ended in 2003 and significantly opened the door for private companies to commercialize genetic information. There is a significant market for human genetic information, as the global genomics market was valued at $39.53B in 2024 (BioSpace, 2024). Pharmaceutical companies are buying genomic data at as little as $75 per unit from genetic companies such as 23andMe (Medium, 2024). Getting this genetic data means the advancement of research and a better understanding of genetic diseases, however, a person's medical information is worth 10x more than their credit card number on the black market (Medium, 2019). This is because of the amount of information in medical records. Medical records not only include sensitive information like a person's social security number, birth date, addresses, credit card numbers, telephone numbers, and medical conditions but, they also are easily stolen and it can take years to undo the damage (Zabel, 2024). This was seen recently when a ransomware attack caused a shutdown of all Change Healthcare services. Change Healthcare is a platform that provides clinical connectivity solutions to the patient records of 1 in every 3 Americans and processes 15 billion healthcare transactions annually (CH, 2024). This ransomware attack has caused disruptions to the U.S. Healthcare system --hospitals,

smaller practices, pharmacies, and medical billing companies-- as it shut down services for e-prescribing, processing claims, providing verifications, reimbursements, and other transactions which further impacts all patient records that Change Healthcare has access to (May, 2024). This attack, and any others, can be prevented by strengthening cyber security using robust IT security measures, developing an incident response plan, training the staff, and conducting regular audits and updates (May, 2024). The information gained from this cyber attack continues to perpetuate the ideals of neurocapitalism and show the pitfalls of the current data security systems that are "guarding" the nation's healthcare records.

4.2 Leveraging Neurocapitalism Principles in Biodesign

4.2.1 Examples of integration

As discussed above biocapitalism occurs when neurocapitalism is used in a biodesign setting. Two familiar examples of consumers engaging in biocapitalism are 23andMe and AncestryDNA (Ancestry). Both companies use a saliva sample, transported by self-serve kits, to determine a wide range of information. 23andMe finds ancestry, health predispositions, wellness reports, and blood panel testing, while Ancestry only reports geographic origins, potential populations, and relatives (23andMe, 2024; Ancestry, 2024). However, the tests have sparked discourse about privacy concerns and the limits of the tests (Resnick, 2019). Both tests locate ancestral roots and help identify the geographic similarities between the provided sample and the stored data. Even though the results are based on self-reported and other imperfect data, the genetic ancestry tests convey accurate estimates of lineage that help guide further ancestry searches (Resnick, 2019). No matter how precise the tests are, the absence of security surrounding the data in the kits is concerning. In 2023, 23andMe had a data breach that compromised 6.9 million profiles (Carballo, 2023). After the data breach, 23andMe shared that the breach happened because some users recycled logins and passwords that had already been hacked on other websites (23andMe, 2024). To increase customer security 23andMe is making customers utilize email 2-step verification as an added layer of protection to their account. Both companies enforce strict consumer-focused privacy conditions including not sharing data with employers, insurance companies, or third-party marketers without explicit consent, not sharing personal information with the labs or law enforcement, and being able to delete your DNA data with your account (23andMe, 2024; Ancestry, 2024). Now let's look at the benefits and the risks of integrating neurocapitalism into biodesign.

4.2.2 Benefits and risks

A benefit of integration is the emergence of neurotechnology. Neurotechnology is where biotechnology is being used to advance the treatments of neurological diseases and conditions through advancements like Cognitive Biotechnology (CBT). CBT enhances human capabilities and is utilized in BCIs to support military applications, such as mental control of equipment and recovery from PTSD and OCD (NATO, 2021). In biomanufacturing, it contributes to neural tissue engineering (NTE), which uses innovative bio-scaffolds to promote tissue repair and regeneration (Papadimitriou, 2020; Poongodi et al., 2021).

Previous work has been done to elaborate the concrete risks of cyberattacks in the healthcare space (Barnett, et al., 2024). A categorical look at the breaches reported to US Health and Human Services (HHS) is publicly available (US HHS Office for Civil Rights, 2024), however, only breaches that affect 500 or more people are required to be reported. Two breaches that we found interesting were reported by HealthEquity and Acadian Ambulance. These two breaches affected a combined 7.2 million people (Adler, 2024). The breach at Acadian Ambulance was significant because it was a ransomware attack, where the perpetrators demanded a $7 million ransom (Enfinger, 2024).

This paper highlights serious risks in neurocapitalism and biodesign, particularly around data security and privacy. The integration of these technologies exacerbates ethical concerns regarding data responsibility. While companies like Apple and Microsoft prioritize user consent and data protection (Atlan, 2024), Google and Ascension demonstrate negligence through their Project Nightingale, which accessed over 50 million identifiable health records without consent (Brush, 2020). This lack of transparency raises significant doubts about Google's intentions and past failures to safeguard user privacy (Brush, 2020). Although HIPAA offers some protection, its loopholes allow for unethical data sharing, undermining trust in healthcare systems (Schneble et al., 2020). Ultimately, the responsibility lies with Google and Ascension for their failure to secure explicit consent and protect sensitive data.

5. Challenges and Ethical Considerations

As we explored the risks associated with neurocapitalism, we also worked to find cybersecurity strategies that could address the unique challenges posed by neurocaptialism and biodesign. One such strategy is the zero-trust security model. Zero-trust security is an IT security approach that assumes all users, network devices, and applications are untrusted until they are explicitly verified as trustworthy (Azad et. al., 2024). This model is particularly effective because it operates in a dynamic environment, requiring continuous verification and authentication of all users, devices, and applications before granting access to resources (Azad et. al., 2024).

In our research, we considered the 2015 Anthem Blue Cross data breach as a case study. This breach exposed the sensitive information -- social security numbers and medical records -- of 78.8 million individuals, including minors under age 18, underscoring the potential risks to personal data in healthcare systems. One of the ways to safeguard zero-trust security is to train the staff that will be using the systems every day. Trainings and simulations, like the AERAS project, give trainees hands-on experience with real-world exercises (Frati, et. al,). The AREAS project is a cyber range training platform for medical organizations and systems security (AREAS, 2024). This project aims to develop a realistic and rapidly adjustable cyber range platform for systems or organizations in the critical healthcare sector (AREAS, 2024). This project helps healthcare professionals learn about the various types of cybersecurity threats, as this enhances their alertness and promotes proactive measures to mitigate risks (Nma, 2023).

Unethical uses of personal data highlight the need for clearer legislation to address HIPAA's loopholes. The biotechnology industry's rapid growth also poses challenges in establishing ethical boundaries, particularly concerning financial interests. With billions invested annually in healthcare improvements and biotech innovations, setting appropriate corporate boundaries becomes increasingly difficult (MacDonald, 2012). Rising healthcare costs strain both researchers and patients, forcing patients to forgo necessary treatments when medications become too expensive (Silverman, 2004; WGU, 2024). The commercialization of research, driven by the Bayh-Dole Act and corporate funding, further complicates this landscape (Askew, 2024). Consequently, researchers must balance financial innovation with ethical responsibility, especially during clinical trials where patient safety is at risk (Garwood, 2024).

6. Future Outlook

As we look ahead, the security of the data involved with both neurocapitalism and biodesign will continue to be at risk. With the interdisciplinary support of cybersecurity, there can be a safer tomorrow. As we work to build a security standard for the industry, we can use past data breaches as a reference on how to create something better, whether that be a new security data standard or individual security structures that can support the growing needs of these evolving fields. Outside of the necessary security upgrades, it is clear that biodesign needs to shift away from neurocapitalism. Without neurocapitalism, biodesign can be used to create affordable medications and innovations, instead of products that cost thousands of dollars and can not be used by everyday people because of the price. Without neurocapitalism, biodesign goes back to being research for change, not research for profit. Cyber security should be added to protect the data created by biodesign, and there is a chance to balance research, development, funding, and distribution in a field that is rapidly growing.

7. Conclusion

In this paper, we talked about the positives and negatives of neurocaptialism. We also talked about biodesign and its applications. With these two base ideals, we discussed the differences and similarities between neurocapitalsm and biodesign, the results of their collaboration, and how their lack of data security is dangerous for people everywhere. In conclusion, we found that neurocapitalism should not be integrated into biodesign, because patients everywhere are at risk of medical identity theft and they are not getting the help they need due to their inability to pay for the interventions. It is important that when neurocapitalism and biodesign do collaborate the patient's needs are not taken advantage of for profit and any data created is secure and deidentified. Neurocapitalism and biodesign can collaborate when brain innovations are happening because of the data collected through neurocapitalism. However, suppose neurocapitalism continues to have a hold on biodesign. In that case, the patients will not be able to afford the revolutionary treatments being created, making them inaccessible to those not in the 1%.

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