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Neurofeminism in BCI and BBI Ethics as a Prelude to Political Neuroethics

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Recent years have witnessed incredible progress in the fields of neuroscience and neurotechnology, which has affected society as a whole. This chapter discusses the existing sexist and androcentric biases within neuroscientific research. We highlight the fundamental role of neurofeminists in challenging the prevalent neurosexism. We take a feminist materialist approach to explore the dynamic human–technology relationship. By focusing on brain-to-brain interfaces (BBIs) as a case study, we investigate the techno-socio-cultural entanglement of the different agential actors. We employ Karen Barad's theory of agential realism to re-conceptualize the brain as a co-constitutive active actor, as opposed to an independent one, and introduce BBIs as a hybrid phenomenon. In addition, we discuss the political perspective in neuroethics to address potential sexist (and racist) problems that may ensue upon the deployment of BBIs. This chapter concludes by emphasizing the importance of explicitly tackling the socio-political worldviews underscoring research and development, which help to provide sound ethical guidance and ground the discussion in scientific facts.

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5.1. Introduction

Neuroscience is a rapidly developing field that is redefining what it means to be a human today. There is an increasing tendency to appeal to the authority of neuroscience to better understand how humans should act (Hoffman and Bluhm 2016). The general findings and applications of neuroscience (e.g. neuroplasticity) have affected society as a whole (Schmitz 2016). Advancements in neurotechnologies motivate the theorizing about socio-political clashes that need to be addressed in neuroethics scholarship, and neurosexism is a relevant case here.

Neuroscience also inspired neurosexism, a belief that Fine (2010) explains as the fundamental fixed differences between male and female brains, leading to the supposition that men are intellectually superior, resulting in damaging stereotypes in society. Such biased and gendered categorizations that devalue women are often perceived to be hardwired (Fine 2008). Hardwired traits are problematic and create controlling images, as they suggest that gender differences are permanent, innate and genetically determined (Bluhm et al. 2012).

Feminist research has much to offer to the field of neuroscience in general and in response to neurosexism, in particular. Feminists have long examined the gender roles and social relations in neuroscientific research. According to feminist science studies, sex is neither solely a physical nor a material construction, but is "deeply interwoven with social and cultural constructions" (Fausto-Sterling (2012), as cited in Schmitz and Höppner (2014)). Given the prevalent idealization of the masculine figure, feminist neuroscientists have sought to examine the implications of neuroscientific research on gender. Neurofeminism, in contrast to neurosexism, reassesses such gendered assumptions and underscores the entanglement between the "development of biological matter and social influences" (Schmitz and Höppner 2014, pp. 1–2). Moreover, neurotechnologies traverse the boundaries between biology and technology. Accordingly, to overcome gendered stereotypes, feminists seek to understand the relationship between gender and the brain by embracing the concept of brain plasticity, which transcends biological determinism (Schmitz and Höppner, 2014). Neuroplasticity posits that "brain structures and brain functions are not […] determined by evolution or remain unchanged during a life span" (Schmitz and Höppner, 2014, p. 4). In other words, the brain is not completely fixed; it is malleable and can respond to the environment (Bluhm et al. 2012).

The purpose of this chapter is twofold. First, we take a critical approach to explore the prevalent sexist attitudes in neuroscience and discuss the neurofeminist response. We adopt a materialist feminist approach to discuss the dynamic human–technology relationship. We focus on BBIs which represent a useful test-case to investigate the techno-socio-cultural inseparability by looking at brains, human bodies, neuroimaging, computers and stimulation devices. We employ Barad's (2007) onto-epistemological framework of agential realism to understand the agency of the various actors which intra-act to create BBIs as a hybrid becoming. Our second purpose in this chapter is to discuss the political perspective in neuroethics so as to address potential sexist and racist problems that may surface upon the widespread deployment of brain–computer interfaces and BBIs. Up until now, the political perspective in neuroethics has been construed (and defended) in terms of a Rawlsian framework of justice (see Dubljević (2019a)), which may alienate scholars from the traditions of critical theory and feminism (see Dubljević (2019b)). More specifically, Mannette (2022) agrees that there is a need for a "political neuroethics", but asserts that a Marxian analysis of "assigned sexual, familial, and economic ideological considerations" (Mannette 2022, pp. 38–39) is necessary to offer an expanded account. Thus, at a minimum, a "feminist political neuroethics" needs to be sketched.

This feminist-inspired exploration of BBIs will be discussed in four sections. First, we introduce BBIs as a particular development of brain–computer interfaces (BCIs). In the second section, we shed light on some of the existing sexist and androcentric biases within neuroscientific research by discussing neurosexism and highlighting how it necessitates a feminist intervention. Third, we build on Barad's agential realism to discuss the mutual shaping of the brain, bodies, technology and society when intra-actively creating BBI as a hybrid phenomenon. Finally, we connect the neurofeminist scholarship with the recently proposed political perspective in neuroethics (see Dubljević et al. (2021)). Such work is a much-needed addition to the field and highlights potential social concerns, as well as questions that neuroethics scholarship should address.

5.2. Brain-to-brain interfaces

Recent technological advances in neuroscience have set the stage for novel ways to cognitively enhance and augment humans. While the notion that brains can connect and directly communicate with a computer or another brain may feel like an episode of a science fiction show, it is not. Today, brains integrate technologies via their connectivity to machines. One such technology that is of increasing interest to researchers, engineers and clinicians is brain–computer interface (BCI) (Burwell et al. 2017). By coupling human brains with computers, the purpose of BCI is to enhance or restore human performance (Glannon 2014). BCI interprets brain activity through invasive or non-invasive monitoring devices (Shih et al. 2012). In addition, BCIs are used for medical purposes to provide alternative ways for patients to interact more fully with the world, as well as for non-medical uses such as gamers (Coin et al. 2020). Researchers have highlighted that BCI demonstrates the possibility of "decoding motor, visual, and even conceptual information from neural activity via a range of recording techniques" (Rao et al. 2014). A specific development of BCI is brain-to-brain interface (BBI) (Coin et al. 2020). While BCI enhances the human's capacity to handle cognitive tasks (Maksimenko et al. 2019), BBI allows for direct communication between human brains. BBI combines BCIs with computer-to-brain interfaces (CBIs) as well as multi-BBIs (Coin et al. 2020) to improve the human-to-human interaction with the aid of neuroplasticity. BBIs allow certain content to be extracted "from the neural signals of a 'sender' brain, digitizes it, and delivers it to a 'receiver' brain" (Jiang et al. 2019, p. 1).

Brain-to-brain interfacing (BBI) has the potential to allow for a network of brains to detect signals in the neural system from one brain and transmit these signals to another brain linked to the same network (Hildt 2019). While this appears to be a figment of the imagination, it is technically feasible, although it must be noted that the research is still in the "emerging" stage. Crucially, research funding for clinical and military uses of BBI is available. For instance, the National Institutes of Health (NIH) actively fund research on assistive devices that could allow paralyzed patients limited but direct brain communication (see Hildt (2019)). Similarly, the Defense Advanced Research Projects Agency (DARPA) is actively funding cutting-edge brain–computer interface and BBI research that could enhance human capacities (see Trimper et al. (2014)).

BBI systems transfer neural signals from one brain to a computer-based program where they are translated and executed, usually with the use of neurostimulation devices (Dubljević 2015), effectively transferring commands to another brain (Coin et al. 2020). The first "proof of principle" study was conducted on networks of animal brains. In an early experiment, animals exchanged information and served as a foundation for social interaction by using computing devices. This study by Pais-Viera et al. (2013) was the first to demonstrate a real-time transfer of information from one subject to another through the utilization of BBI. The research community was impressed with the results, which "indicate that animal brain dyads or even brain networks could allow animal groups to synchronize their behaviors following neuronal-based cues" (Pais-Viera et al. 2013, p. 6).

It was not long before a successful human study followed (Rao et al. 2014). However, a more exciting development was the "brain net" study by Jiang et al.

(2019), in which three human brains were communicating and influencing each other through the use of transcranial magnetic stimulation (TMS), in order to defeat a common computer game. BrainNet works by having two "senders" and one "receiver", with the receiver making a decision based on the senders' information. Even though there are current limitations to the technology, most notably the low bandwidth ultimately reducing communication to binary responses, future developments are striving towards a hive connected mind where information is shared by all through a linked neural network. In the words of neuroengineers at the forefront of this endeavor: "BrainNet allows Receivers to learn to trust the Sender who is more reliable, in this case, based solely on the information transmitted directly to their brains. Our results raise the possibility of future brain-to-brain interfaces that enable cooperative problem solving by humans using a 'social network' of connected brains" (Jiang et al. 2019).

Unsurprisingly, neuroethicists have identified numerous prospective applications of BBIs, such as gaming, human enhancement, user state monitoring and encryption. They have voiced a number of ethical and safety concerns, including, but not limited to: safety, agency, shared control, accountability, privacy and identity (see Trimper et al. (2014); Hildt (2019)). The consensus position is that multi-person BBIs further complicate ethical issues. In what follows, we argue that neuroethics scholarship needs to adequately incorporate a distinctively political perspective (Dubljević et al. 2021, see also Dubljević (2019a)) in order to appreciate the full extent of ethical and social issues raised by BBIs. Although research is underway to explore how to use BBIs to "deliver more complex information such as semantic concepts" (Jiang et al. 2019), we do not have to imagine future developments to appreciate how BBIs may further entrench existing biases and odious positions such as sexism and racism. Namely, even with limited, binary communication, "like" or "dislike" responses in the emerging multi-brain network may enable receivers to block or reduce certain types of senders. The use of social networks has rapidly facilitated sexist and racist content in the past (see Misselhorn 2018), and there is no reason to doubt that this will also be the case with BBIs. Due to reasons of space, and a lack of neuroethics scholarship on that particular topic, we will not discuss neuroethics of race but merely issue a call for a more relevant scholarship. However, there is an established body of neuroethics scholarship on neurosexism, to which we now turn.

5.3. Neurosexism

There is a widespread belief in the general public that men and women have irreconcilable differences that are difficult to overcome. Typically, men are portrayed as uncaring, logical and incapable of multitasking, while women are portrayed as emotional, empathetic and good listeners (Fine 2008). These are some of the gendered and sexist beliefs that have never really disappeared and have, in fact, began to resurface, couched in (neuro)scientific terms. The supposition that we can "sex" a brain, that is, to understand a brain as "male" or "female" and attribute certain characteristics and abilities to one sex or the other, has permeated our intellectual history. Female brains have been persistently described as undersized, underdeveloped and generally defective, resulting in the understanding of women as inferior and vulnerable (Rippon 2019, p. 10). In his article *Hegemonic Masculinity on the Mound*, Nick Trujillo offers an important insight into (neuro)sexism by exploring media representations of baseball pitcher Nolan Ryan, which underscores the extent of hegemonic masculinity in sports. Trujillo argues that media have functioned hegemonically by embodying Ryan as an "archetypical male athletic hero" (Trujillo 1991, p. 290).

The sexist practices and understandings in neuroscience are what Cordelia Fine labels "neurosexism" (Rippon 2019, 98). The term neurosexism describes "the phenomenon of using neuroscientific practices and results to promote sexist conclusions" (Hoffman and Bluhm 2016, p. 716). The investigation of male/female differences has an "unsavory past", which led to unjustified scientific claims that further proliferated gender stereotypes (Fine 2012, p. 369).

Neurosexism can take multiple forms that can support gender stereotypes and often exaggerate gender differences. One of the forms of neurosexism is exaggerating or even fabricating brain differences between men and women. This assumes that brain differences depend on a gender binary, which incorrectly posits that gender categories are mutually exclusive "essences" (Hoffman and Bluhm 2016). Not surprisingly, the categorization of genders is not as clear-cut as many may think, as the male–female binary remains contestable. Similarly, neurosexism holds that there is a categorical difference between male and female brains (Hoffman and Bluhm 2016, p. 718). Nevertheless, this remains a mistaken assumption, as differences in the brain concern brain size rather than sex since "male and female brains are [...] far more similar than they are different" (Fine 2010, p. 171). Furthermore, it is also pertinent to highlight that the phenotypic variation between individual brains renders the gender-based classification of brains unrealistic. A phenotype is understood as the observable and dynamic expression of an individual's genotype, which is influenced by both the genes and the environmental factors (Wojczynski and Tiwari 2008). In the past two decades, "genomic analyses have identified thousands of genetic variants that contribute statistically to variation in complex phenotypes" (as cited in Rosenberg et al. (2019, p. 27)). Such variation in phenotype underscores the fact that ascribing brain differences to gender is a misconception.

Remarkably, social pressures in neuroscience research seem to be tailored to highlight the differences, and not the similarities, between genders (Fine 2010, p. 171). For instance, gender stereotypes may motivate research questions or unconscious bias in the interpretation of data. Thus, there seems to be a myriad of ways in which neuroscience can accentuate the differences. Neuroscientific research and its various interpretations in publications and media outlets often promote sexist views engendering neurosexism (Hoffman and Bluhm 2016, p. 716). For instance, in 2004, Victoria Brescoll and Marienne LaFrance explored over 250 articles from multiple U.S. newspapers which discussed whether a given sex/gender was innate or acquired. Their research concluded that the ideological stance of the newspapers impacted the publication of scientific research. Conservative newspapers, for example, had the predisposition to ascribe sex differences to biological factors (Brescoll and LaFrance (2004), as cited in Jordan-Young and Rumiati (2012)). More often than not, neuroscientific studies that fail to find categorical differences between genders do not get published, whereas other studies that get published are misinterpreted either by researchers themselves or by the media (Hoffman and Bluhm 2016, p. 719). In the same vein, Fine (2008) maintains that some books draw on neuroscientific research that claims that the differences between sexes are hardwired. Brizendine's (2006) book *The Female Brain* is one example that draws on scientific research to further advance views on brains being gendered and having different structures. Brizendine rejects the presence of a unisex brain and insists that males' and females' brains are different by nature. Girls are wired as girls, and boys are wired as boys. She discusses how a three-year-old girl was presented with unisex toys such as a firetruck as opposed to a doll. Rejecting the role of the environment and the socialization process in shaping the brain and accentuating the differences between males and females, Brizendine's notes that the little girl started cuddling the firetruck wrapped in a blanket. This is to say, the girl's brain dictated her behavior.

Another form of neurosexism posits that the brain differences between men and women are permanent and that gender/sex traits are unalterable (Hoffman and Bluhm 2016, pp. 721). In other words, neurosexism contributes to the belief in "hardwiring" (Rippon 2019, pp. 288). The term hardwiring has enjoyed popularity in reference to sex differences and has become associated with traits of innateness, essentialism and immanence (Grossi 2017, p. 1050). Hardwiring explains the development of the human mind by emphasizing the permanence of the correlation between sex and gender, on the one hand, and the function or structure of the brain, on the other hand, and thus overlooks the effect of the social world in creating the sex/gender differences (Bluhm et al. 2012, p. 115). In this context, hardwiring understands the differences between male and female brains as fixed, and consequently results in reinforcing stereotypes (Rippon 2019, p. 288). This is the product of scientific explanations that defer gender differences to biological materiality (Bluhm et al. 2012, p. 235). For instance, some studies suggested that exposure to hormones during the fetal development phase resulted in a permanent yet dissimilar development pattern for male and female brains. Sociobiology, an influential and controversial position (see Kitcher (1985)), aggravated the situation by highlighting that the basis for hormonal sex differences was genetic (Bluhm et al. 2012, pp. 232–235). Such deterministic perspectives resulted in feelings of cynicism towards neuroscientific understandings of sex differences (Bluhm et al. 2012, p. 231).

Gender discrimination is very much alive, and bias still underpins much of the neuroscience of sex difference. Many neuroscientific studies on sex differences seem to only exacerbate the gender gap (Bluhm et al. 2012, p. 105). The deeply embedded beliefs in stereotypes still result in researchers designing studies and interpreting data in terms of male–female characteristics (Rippon 2019, p. 11). Imaging technologies such as functional magnetic resonance imaging (fMRI), which were used to investigate sex differences, are a case in point. The results of critical reviews demonstrated that imaging research was biased and reinforced gender stereotypes, resulting in further accusations of neurosexism (Fine 2012, p. 370). In the same vein, in developing the empathizing–systemizing hypothesis, Baron-Cohen (2003) emphasized that gender inequalities are not strictly due to culture or the socialization process. According to this view, biology, as well as essential differences between men and women, play a significant role (p. 92).

Neurofeminists have been challenging the prevalent neurosexism and the belief that biology is destiny (Rippon 2019, 13–17). A central approach they employ to challenge and deconstruct neurosexism is through the emphasis on neuroplasticity, a concept which underscores the idea that the brain is changeable and malleable in response to environmental pressures (Bluhm et al. 2012, p. 35). The theory of brain plasticity was first proposed by James (1890). James noted that "organic matter, especially nervous tissue, seems endowed with a very extraordinary degree of plasticity" (p. 64). That is, the brain is endowed with an extraordinary degree of plasticity and can be influenced. It was not until 1948 that Polish neuroscientist Jerzy Konorski coined the term "neuroplasticity", suggesting a theory by which "neurons which have been activated by closeness of an active neural circuit, change and incorporate themselves into that circuit" (Konorski (1948), as cited in Demarin et al. (2014)).

Neuroplasticity today questions the essentialist-gendered constructions, as well as the reductionist biological traits, and underscores the "influences of experiences and social interactions on the structural and functional developments in the brain"

(Schmitz 2016, p. 142). Insufficient attention to the theory of neuroplasticity has resulted in a bias towards understanding gender differences as fixed and reinforcing gender essentialism (Fine 2012, p. 370).

Empirical data shows that the brain responds to the environment, which affects its structure, such as its size and weight (Bluhm et al. 2012, p. 35). The brain's neural circuits develop and are changed by experience (Fine 2012, p. 397). The "gendered life experiences and social constructions of gender (such as leisure activities, educational interests, poverty and status) have material effects on the body, including the brain" (Fine 2012, p. 397). For instance, the performance of females in mathematics can differ across different social contexts where sometimes performance is improved when tests downplay the stereotype that males are better at math. This is to say that the social context impacts gendered behavior (Fine 2012, p. 397).

While the concept of neuroplasticity is useful in overcoming neurosexism and reframing sexist bias in neuroscience research, it may be interpreted to imply that the brain is a passive organ by indicating that social experiences impact the brain's structure (Schmitz 2016, p. 143). In other words, neuroplasticity may be interpreted as another form of essentialism, if it reifies the cultural influences on behavior by shaping the neurobiology of the brain, which is only a passive recipient. This understanding results in framing the brain as a "passive reactor to the attribution of gendered (and intersected) significations" (Schmitz 2016, p. 143). To counter this (mistaken) view, and demonstrate that the brain is an active actor, we take a new materialist approach to re-evaluate the meaning of brain plasticity by applying Barad's onto-epistemological framework of agential realism to BBI. We reconceptualize brain plasticity as an intra-active phenomenon that results from the entanglement of multiple agential forces.

5.4. Agential realism

Materialist feminists hold that there are "mutually implicating relationships that exist in the dynamics that constitute the discursive and material world" (Trites, Roberta Seelinger 2017). Materialist feminists explore the intrinsic relationship between the natural, the human and the nonhuman, with a particular focus on the question of agency. They explore the "interaction of culture, history, discourse, technology, biology, and the 'environment', without privileging any one of these elements" (Alaimo and Hekman 2008, p. 7).

New materialism arose as a reaction to the representationalist and constructivist movements that overlooked the material and in turn, resulted in postulating dualisms between what was observed and the external reality (Ferrando 2019). New materialism holds that biology is culturally mediated as much as culture is materially constructed. It denounces conventional thinking which perceives matter as inert, passive and static, and proposes to understand it as active and agentic (Ferrando 2019). Barad (2007) introduces an "ontoepistemological" framework, which she labels "agential realism", to demonstrate how humans and nonhumans create the world together. Agential realism criticizes representationalism, the idea that "representations and the objects (subjects, events or states of affairs) they purport to represent are independent of one another" (Barad 2007, p. 28). Representationalism assumes the existence of two independent entities: representations and the entities to be represented. The notion of separation is at the heart of representationalism, and thus, conflicts with feminist epistemologies (Anderson 2020) that denounce dualisms and separations, and work to reinforce connections and entanglements. Accordingly, Barad shifts the questions of descriptions and reality to matters of practices and actions, hence moving from representationalism to performativity.

In Barad's (2007, 2012) agential realism, matter is not a fixed substance, but a dynamic and an intra-active agent. Matter's dynamism is about the engagement with a new understanding of the world where bodies are not simply situated in the world but rather, bodies and the environment are intra-actively co-constituted. Agency in this account is not a capacity that someone or something has. Rather, agency is understood as a matter of intra-acting. Intra-action is also a new way to think about causality. Causality is not interactional, but intra-actional. In contrast with the concept of interaction, which presumes the prior existence of independent entities or relata, intra-action presents a shift in that it signifies "the mutual constitution of objects and agencies of observation within phenomena" (Barad 2007, p. 197). Thus, similar to Haraway's (1991) seminal "Cyborg Manifesto", Barad (2007) challenges dichotomies by incorporating the human and nonhuman, material and discursive, natural and cultural, and stresses that subjects, objects and agencies of observation are entangled and intra-act with one another. It is only through agential intra-actions that the properties and boundaries of the components of any given phenomena become meaningful (Barad 2007).

BBIs allow for direct communication between two brains. Brain–computer interfaces (BCIs), which constitute BBIs, detect neural signals in a brain and translate them to computer commands. The CBI then delivers these commands to another brain (Hildt 2019). This understanding of BBIs presumes linearity since the neural signals are transferred from one brain to a computer program, and then to another brain (Coin et al. 2020). A new materialist lens exposes the narrowness of this understanding of causation, positing that it is only when we think about causation in “linear terms that essentialism can be seen as the inevitable outcome of an attempt to think about the agency of matter or biology” (Frost 2011, p. 71). Therefore, new materialists aim to transform the understanding from “a framework within which the agency of bodies and material objects is understood largely as an effect of power – a unidirectional account of agency – to a framework within which, for example, culture and biology have reciprocal agentive effects upon one another” (Frost 2011, p. 71). This underscores the view that causation is not linear, but is rather conceived as “complex, recursive and multi-linear” (Frost 2011, p. 71).

A second challenge posed by this simple understanding of BBI is that of inertness, where the human brains are perceived as passive actors throughout the transmission process from one brain to another. New materialists challenge the idea that matter is passive and inert, emphasizing that it is active and dynamic (Alaimo and Hekman 2008, p. 75 and p. 135). Barad develops the notion of performativity, which is a “materialist, naturalist, and posthumanist elaboration that allows matter its due as an active participant in the world’s becoming” (Alaimo and Hekman 2008, p. 122).

BBIs can be interpreted to demonstrate the power of agential realism. Agential realism (Barad 2007) permits the understanding of BBI as a material-discursive practice where actors are always already entangled. The relationship between the actors materializes through the continuous intra-actions, and thus challenges the biological determinisms that are used to legitimize gendered norms (Schmitz 2016, p. 141). In other words, BBIs are better conceptualized as intra-active phenomena that are constituted out of the intra-actions of multiple forces, that is, the intra-action of “the discursive, technological, and material”, which produce a new configuration that has agency (Alaimo and Hekman 2008, p. 106). Although communication using BBIs seems linear, this is not the case. In fact, BBIs demonstrate the effect of mutual communication and information exchange on biological formations (Schmitz 2016, p. 151). BBI “rests on two pillars: the capacity to read (or ‘decode’) useful information from neural activity and the capacity to write (or ‘encode’) digital information back into neural activity” (Rao et al. 2014, p. 1). Therefore, BBI is a phenomenon that is constituted as a result of the reciprocal exchange of information between the brain, body, technologies and the environment.

The BBI experiment conducted by Rao et al. (2014) emphasizes this point. In this experiment, the BBI communication channel was built using EEG to record brain signals and TMS to stimulate the brain. A non-invasive BBI was applied to participants who were given the roles of senders and receivers in playing a computer game. The brain activity from the sender was recorded using EEG, and the resulting signal was used to control a cursor movement. When the cursor hit the assigned target on the screen, the sender’s computer sent a signal over the Internet to the receiver’s computer. The sender’s and receiver’s computers communicated using hypertext transfer protocol (HTTP). When the receiver’s computer received a command, a magnetic pulse was sent to the receiver’s brain, producing a movement of their right hand placed over a touchpad, triggering a click on the touchpad and resulting in the execution of the request initiated by the sender (Rao et al. 2014, p. 2).

This experiment supports the view that BBIs are an entangled network where the multiple actors intra-act together to create the BBI phenomenon. The components of the computer hardware and software intra-act with the brain and body via the screens, the EEG cap, the servers, and touchpad (Rao et al. 2014, pp. 2–4). That is, there is an intertwinement between the materiality of the participants’ brains and bodies, as well as the inputs from the computer and the creation of certain outputs, which are stimulated through the TMS technology and translated through the EEG. This is also accompanied by the materiality of the touch and the movement of the cursor and the touchpad. This entanglement emphasizes that “the communicative intra-actions between brain, bodies and technical apparatuses are not conceptualized only in one direction” (Schmitz 2016, p. 148). In this way, BBIs can be framed through the dynamics of intra-activity, which disrupts the conventional understanding of linearity.

Similarly, in conceiving BBIs through the framework of agential realism, the brain is understood to be shaped by a multiplicity of external forces rather than an independent actor. The brain here is posited as a co-constituted and dynamic actor that is intra-acting with all others. In their experiment, Rao et al. stress that “imagery is central to the demonstration of brain-to-brain communication, as the movement intention that is initially imagined in the sender’s brain is remotely executed by the receiver’s brain” (Rao et al. 2014, p. 2). This demonstrates that the brain is not shaped solely by external forces, but is an agential force itself that initiates actions by imagining and intending certain movements, which results in sending and executing activities by the sender’s and receiver’s brain, respectively. The brain–body relationship cannot be exclusively characterized by auto-poetic dynamics; rather “the dynamics of brain codes, communication, and information patterns are always open to environmental entanglements” (Schmitz 2016, p. 149). While brain plasticity stresses how the brain and body integrate sensory inputs through learning, agential changes “always intra-act with unconscious and conscious experiences, information from the environment, meaning-making and discursive settings” (Schmitz 2016, p. 149). In this respect, the brain is not an isolated material force, but is the result of the “agential convergence that constitutes behavior and communication” (Schmitz 2016, p. 150).

5.5. Political perspective in neuroethics

Given the widespread neurosexism and essentializing tendencies in neuroscience-inspired cultural debates, we cannot overlook the likelihood of BBIs further intensifying the existing sexism and bias. To counter this possibility, we need to increase the socio-political sensibilities of neuroethicists to address the issues that will be raised by BBIs. As indicated earlier, there is a scarcity of neuroethics scholarship on BBIs due to the research being in its infancy. Therefore, our purpose here is to proactively discuss potential ethical concerns and issue a call for more relevant scholarship. Additionally, we hope to open the door of political neuroethics scholarship to traditions of thought (e.g. critical theory, feminism) that are at the same time less represented and more tuned into social conflicts.

Racine (2010) has identified three perspectives on neuroethics which aim to understand the implications of neurotechnology: namely, knowledge-driven perspective, which emphasizes research; technology-driven perspective, which defines neuroethics based on the technologies it examines, and healthcare-driven perspective, which posits that neuroethics is a subfield of bioethics. Dubljević et al. (2021) introduced a fourth political perspective in neuroethics scholarship, which accounts for the "interplay between the behavioral as well as the brain sciences and the socio-political system" (Dubljević et al. 2021, p. 3). This perspective takes into account the political and social regulations that are required and has the potential to address the challenges that result from introducing new technologies (Dubljević et al. 2021, p. 5). We build on this understanding by applying the political perspective to explore the potential implications and challenges that may stem from the application of BBIs. At the same time, we correct the (up until now) overtly liberal and Rawlsian tone of political neuroethics by incorporating insights from neurofeminism and agential realism.

Brain–computer and BBIs do not come into existence in a vacuum. Rather, they are realized in "social, political, and economic settings, discourses and power relations" (Schmitz 2016, p. 152): taxpayers provide funds, which are directed by federal agencies (civilian and military), which are awarded to researchers who conduct experiments on animals and humans and publish their results, which are then taken up by the media and interpreted by the general public. This raises important questions such as who has the power to decide on the content, as well as plan the communication and information processes underlying these multidirectional relationships (Schmitz 2016, p. 152). Therefore, a main objective of the socio-political perspective is to keep the public and policymakers informed and offer ethical guidance (Dubljević et al. 2021, p. 9). BBI is simultaneously a social as well as a political technology that is influenced by the publics' social attitudes and perspectives, as well as science policy. Agential realism, as discussed above, is only one way of conceptualizing the pervasiveness of BBI technologies that impact the human condition. As such, a political neuroethics perspective should be taken up by multiple neuroethicists to provide answers to a set of questions based on divergent (including liberal, socialist and conservative) political views. The first question that such political neuroethics scholarship should answer is:

What are the most legitimate public policies for regulating the development and use of BBIs by healthy adults in a reasonably just, though not perfect, democratic society?

Following Dubljević et al. (2021), we posit that political neuroethics will have to answer four additional questions to ensure that the discussion of BBI technology is realistic and not merely hype:

1) What are the criteria for assessing the relevance of cases of BBI technology to be discussed?

2) What are the relevant policy options for the targeted regulation of BBIs (e.g. of research, manufacture, use)?

3) What are the relevant external considerations for policy options (e.g. international treaties)?

4) What are the foreseeable future challenges that public policy may have to grapple with (e.g. proliferation of racism or sexism via BBIs)?

As a way of grounding the discussion of the neuroethics of BBI, we build on Dubljević et al. (2021) to propose several criteria for the relevance of specific cases. The first is the ability to increase the number of senders and responders in the system to something approximating a social group, even if communication is merely reduced to binary responses. Another criterion is the potential for the uptake of the BBI technology in society. Dubljević et al. (2021) highlight five approaches that need to be considered in regard to public policy: mandatory use, encouraged use, laissez-faire, discouraged use and prohibition. Even though policy considerations (on the national or international level) for the manufacture and use may be premature, given that BBI development is still in its early stages, the regulation of BBI research on humans may need to be considered, and the full range of policy options should be weighed. The potential future challenges of BBI-exacerbated racism and sexism are something that neuroethicists and public policies need to consider before such neurotechnologies are introduced in society.

It has to be noted that questions 3 and 4 cannot be answered from a single perspective. In fact, *liberal*, *socialist* and *conservative* political neuroethics will provide different responses. For instance, classical liberal viewpoints may not be impressed by international treaties, whereas conservative viewpoints may de-emphasize sexism as a problem in BBI technology (and beyond). Rather than lamenting the fact that disagreements about political premises will emerge, neuroethics would serve society best if such disagreements were made explicit and offered to public scrutiny in a democratic dialogue.

5.6. Conclusion

In this chapter, we have taken a neurofeminist approach to discuss BBIs as one of the latest developments in the field of neurotechnology. We applied Karen Barad's agential realism as a framework to BBIs for two reasons. The first reason was to highlight the potentially powerful impact and provide a better understanding of BBIs on the overall human condition that stresses the entanglement of multiple actors, as well as challenges the human–technology dichotomy. Second, agential realism provided an alternate viewpoint to the conventional understanding of the notions of causality and agency, as well as to the (up until now) liberal interpretation of political neuroethics. By employing the concept of intra-actions, we provided a new understanding of BBIs that is not understood as linear, where a single cause precedes one or more effects, but rather as an intertwinement of various actors that do not interact but rather intra-act. Furthermore, and in contrast to the present understanding of neuroplasticity, we reconceptualized the brain not as an independent entity, but as an entangled actor in the hybrid becoming of the BBI phenomenon.

BBI technology is still in the early stages of research, and therefore discussing the prospects of social and ethical challenges during research is urgent. By underscoring the pervasiveness of neurosexism in neuroscience and acknowledging the possibility of BBIs further exacerbating the existing sexist bias, this chapter highlighted the importance of a socio-political perspective that aims to provide ethical guidance and ground the discussion in scientific fact, as opposed to science fiction. This perspective embraces the diversity of political views and hopes to avoid overt conflict by fostering reasonable disagreement.

5.7. References

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