Neural Privacy, Personhood and Agency with Brain-To-Brain Interfacing

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Abstract

Sci-fi movies have often romanticized the ability to influence or command objects at a distance with nothing but our thoughts and no direct contact. Much like turning imagination into potential reality scientists and researchers are informing us, that reading brain data and using it to command distanced applications and/or objects is not just possible but also being employed by various institutions, think tanks, industries and military sectors. This paper discusses whether such technologies be brought to the platter for mankind at all or not, considering the side effects and problems such technologies invite to the ethico-legal and ethico-technical domains in context of personhood, agency, sense of self, right to self-determination, and questions the urgency of requirement of political and legal institutions to act and lay down frameworks for regulation of the same.

Keywords - *BCI, BTBI, Neuroethics, Neurotheft, Neuroimprisonment*

I. INTRODUCTION

With the advent of scientific and engineering marvels of the 21st centurey, the question often sparks in sociological debates, are we technologically heading forward but consciouslly heading backwards? Neuroscientists and Neuropsychologists have often employed the hit and trial methods to study the human brain in depths, however, with the exponentially faster advancement of technologies, its merely surprising that we are heading to a point where we can entirely outcast any external device (like smartphones) for accessing remote information and directly communicate with each other's brains in an almost telepathic manner.

Brain-Computer Interfacing (explained in later sections) has been in existence for more than a decade, at the time of writing, and seems to be only lately another victim of populism. Whilst the idea of directly communicating with each other's minds without any middle-tech, it raises essential questions on the grounds of ethics, personal legal rights and consent behind the commercial use of such tech.

Extracted information (using an fMRI) when coupled with advanced artificially intelligent deep neural networks [1] are able to learn and decode images from the brain [11]. These algorithms work surprisingly well, so much so that they could create images of dreams of the patient quite well if not entirely accurately. Whilst such scientific breakthroughs do bring a new ray of hope for those who suffer paraly-

[1]Deep/Artificial Neural Networks is an engineering concept inspired from neurons in human brain. Such networks essentially take inputs and produce appropriate outputs after being engineered to learn the relationships between both [12].

ses or from down syndrome, probing into human mind also raise equal number of questions about how ethical such machines may not be.

II. Literature Review

Researchers at University of Washington turned eyes worldwide whence they announced **BrainNet**, a novel BBI (Brain-To-Brain Interface) or B2B (also, Brain-To-Brain Interface) which covers the faults and fallacies of previous B2B designs. BrainNet's first design is capable of connecting over three human brains, with two acting as the *Senders* and one as the *Receiver*. The senders observe the task and transmit their information to the receiver [13]. The design not just transmits information but is also capable of deciding which sender should be trusted more after learning from their transmissions overtime. In testing environments, BrainNet was able to rule out or de-prioritize the sender whose information was deliberately corrupted or manipulated by the researchers.

Elon Musk, a seasoned inventor, also didn't fall short from dropping praise over future possibilities of having *an internet of brains*. His acquisition of the company Neuralink [2] confirmed his aspirations with the technology. One of Neuralink's primary inventions is **neural lace** which is a digital layer made by incorporating silicon particles to go inside the brain and spread out. Neural lace, in turn, allows the users to interact with the brain by reading or imaging the neural data, or provoking electrical stimulations inside the brain [14].

Primary objective of neural lace is to help in curing neural diseases, however, it could also potentially enable users to control external digital devices like cellphones or cursors on direction of signals from the brain.

Neural lace may, however, not be required to be implanted manually in the brain through surgeries, rather can be injected into the blood stream and is able to find its way to the brain and set itself up.

[2]Neuralink develops high bandwith BCI systems - www.neuralink.com/

Virtual Reality (VR) as a frontier has not just opened doors to a gaming utopia, rather can also act as companions for BCI devices, helping to yield higher accuracy results in neurotherapy and studies of neurosciences. Researchers use VR headgear to study and improve BCI. Current standard BCI have allows users to move signatory positions like handling steering wheels or change position of wheelchairs. However, greater challenges need to be bypassed to interpret words, sentences and perform credible neuroinformatic analysis [15].

Perceived electrical responses from the brain are trained on deep convulational neural networks to **reconstruct faces** [16]. fMRI (explained later in detail) is used to project the faces reconstructed after deep adversarial neural decoding. Latent features are linearly tranformed to signal responses from the brain and then inverted with nonlinear transformation from the perceived response back to latent features. Technology is gradually becoming state -of-the-art in reconstructing perceived faces.

In other cases fMRI systems are being employed to reconstruct complete streams of images (or entire videos) observed or remembered by patients [18], in turn decoding the objects of videos remembered by patients [17] and eventually decide whether the patients are lying [19].

To avoid uncalled for sensationalism, this paper ignores imaginative and unconnected future issues with low possibility of happening, like the potential threats to consent and identity in case of unsolicited imaging someone's dreams on a digital screen.

Study and research in the areas of concious association and memory incorporates the Non-Primary BCI arena. While focussing on sensing functions and motory detection incorporates the Primary BCI arena. Whilst scientific community is rising to the potential ethical implications of Primary, defense sectors worldwide, public and private both, are quietly elevating military funding on Non-Primary BCI research. While certain applications of military research in this area is positive for mental health of military personnel [20], other potential usage of remotely using weaponized robotic systems does raise ethical concerns.

III. Technologies and Methods Review

Amongst many technologies, machines, algorithms and concepts which warrant the capability to scientist/engineer to peek into someone's brain there's one technology which often stands out and is adhered to, almost religiously, as the standard way to accomplish the task: **Brain-Computer Interface**. BCI Systems essentially act as an intermediary technology to permit human (or other) minds interact with digital computing environments. BCI techniques are broadly classified into two categories [1]:

1. Invasive
2. Non-Invasive

Former one generally involves implanting certain digital components inside the brain - like chips. These implants in turn allow the engineers to receive commands from a remote BCI system outside and return recorded data appropriately. Latter technique involves using physical wearable device which can be removed and are only accessed upon the will of the patient.

In this paper, we'll only briefly cover the non-invasive techniques, since they are currently industry standard.

i. Electroencephalography

One of the most common non-invasive BCI techniques is **Electroencephalography (EEG)** [3]. For neuro-scientists and neuro-engineers the brain computer interface (BCI) opens the horizons of a new and exciting universe of next generation technologies. For aspiring researchers and tech-enthusiasts, DIY (do it yourself) self-assembling BCI devices are also readily available on the internet or the nearby radioshack. Coupled with the capabilites of wifi and li-fi, the potential to send signals from a user's brain to a remote device which if programmed to decode and receive the signals and then produce actions associated to the received signals, is unprecentended. The physiotherapy industry and pyschology research groups and institutions strongly advocate the technology due to high-accuracy remedies to patient's problems.

The operational logic behind reading the brain data lies with a specific signal called **P300 Signals** [5]. Whenever we suddenly strike focus on a certain object or thought, our neural activity gives rise to the P300 signal amongst others. For an example at hand, if you are browsing the menu for ice creams and suddenly you see your favourite ice cream, the P300 signal sparks roughly 300 miliseconds after the event. Similarly, if you are solving a Multiple Choice Questionare (MCQ) and suddenly see the correct option for the answer, P300 is spiked. And detecting this signal, with a certain threshold value, gives us the capability to send commands to remote devices. Softwares and engines can be trained to detect this signal and send pre-programmed commands to remote devices.

ii. Transcranial Magnetic Stimulation

Another non-invasive brain probing technique goes by the abbreviation **TMS**. In a rather even more intriguing manner than the BCI, TMS works by using a pulsed magnetic field to create current flow in the brain, thereby exciting certain areas of the brain specificially [3]. For example, if the motor cortex is *TMS-ed* then it may twitch certain muscles or block certain movements. Or, TMS-ing the occipital cortex may produce scotomas. Previous researches have shown that TMS is also partially successfull in altering the functionality of the human brain even after halting the stimulation. Therefore, it displays strong potential for neurotherapy and hence, has been an attractive contemporary tool of new-age neuroscientists or neuropsychologists.

[3] EEG gives estimation of electrical activity of the brain measured as voltage at different locations of brain. Signals are usually dynamic in nature and can be studied using different signal processing methods [2].

iii. Brain-To-Brain Interface

By carefully combining both popular non-invasive techniques of EEG and TMS, a new era **Brain-To-Brain Interface (B2B)** can be designed to connect two (or more) brains with each other for direct data/information transfer and interpretation by the other without the need of interacting with any intermediate computer [8] thereby, establing an entire network of direct information flow amongst humans. Eventually ditching external gadgets (devices) to access remote information. B2B or BBI systems essentially act as a combination of neuroimaging and neurostimulation techniques.

One interesting thing to note over here is that, if achieved at a large scale, every brain (person) conencted to such a network will always be at an equal level of access to all the information available in anyone's brain connected to the same network.

Amongst several ideas and designs proposed to achieve B2B by duly combining TMS and EEG, the basic analogy operating behind the scenes looks something like this: If the sender A (Aryan) wishes to send information to the brain of B (Brooklyn) directly from xis own brain, an EEG headgear would record the motory signals from A's brain and cause a simultaneous and appropriate motor response in B's head by triggering a TMS headgear worn by B.

One of the major issues preventing B2B systems from making their debut in the commercial markets is the low speed of data transfer between the 2 (or more) brains. Or we could simply say, that the bandwith is quite low to use such systems on a large scale in a commercial production environment. However, such non-invasive B2B systems still remain quite less problematic to us in terms of ethics as compared to invasice B2B systems.

BrainNet, explained under the literature review, stands as one of the most succesfully invented BTBI device, till date.

iv. functional Magnetic Resonance Imaging

fMRI is another non-invasive technique employed whilst probing the neurobiological substrates behind varying cognitive functions of the human brain. In slightly easier terms, fMRI indirectly gives estimation of activity in the brain. It metabolically measures alterations in the flow of blood and oxygen consumption, which is deemed a direct consequence of underlying neural acitivities. Eventually terming this response signal as Blood-Oxygen Level Dependent (BOLD) Response [9].

Unlike brain probing techniques PET or EEG, fMRI allows us to sample neural activity across the whole brain very quickly (usually within one or two seconds) whilst offering high spatial resolution.

As a result of an upper hand offered by fMRI technique under certain environments, fMRI has also naturally used in mind reading experiments. In one such activity, sex-matched very healthy students were selected from a Japenese University and were indulged in a game with two tasks: an experimental task for reading their minds and another control task. Both tasks were directed to indicate the activated/excited regions of the human brain and exctract insights from the results [10]

IV. Ethical Dimension

The job at hand is to regulate and legalise the ethical and moral aspect of brain interfacing technologies taking the moral and sociological concerns into account. Before advancing to descript the arguments concerning the ethics of brain interfaces, let's first crystallize certain fundamental definitions [4] to solidify our further understanding.

Privacy *- someone's right to keep their personal matters and relationships secret.*

[4] Definitions are adopted directly from Cambridge Dictionary - `https://dictionary.cambridge.org/`

Ethics *- collection of beliefs about what is morally right or wrong.*

Morals *- set standards for what is bad or right behaviour.*

Intellectual Property *- anyone's idea, creation or invention which can and should be protected from being copied/replicated by someone else.*

Certain questions can be raised at an elementary level regarding the ethics and possible violations of ethics behind reading brain data.

i. Question of Neural Privacy

If *thoughts* are counted under *personal matters* then the term *Neural Privacy* can be easily justified and defined. Neural data, declared to withold thoughts, ideas, personal secrets and creations, should be accounted for under the laws of privacy. However, judicial systems of most countries, are still in the infancy stage of drafting laws for neural privacy. In such a scenario, if our psychologist makes us wear an EEG headgear with the aim of reading our brain data for higher accuracy output in consulting sessions by clearer understanding of our thoughts, then which laws binds our psychologist from misusing the data. What exactly permits the employers of Brain interfaces to look into the patient's minds and read their neural data, which could be empirically translated into reading their *thoughts*.

Technologies which permit us to retrieve neural data raise serious ethical concerns over such tech being employed for malicious activities by nefarious men for **hacking autobiographical information** from target's mind [22]. Commercial industry standard BCI systems do not come with strong enough encryption, rather are deliberately designed with weak encryption to increase the speed of computations on the data. This raises flags over how easily these devices can be hacked against the interest of the particular targets. Real simulations to break the encryptions of such devices have been succesfull [21].

This particular domain which extends cyber hacking to neural data, is what we term **neurotheft or neural-theft**. BCI systems with strong encryptions are yet to be introduced in the commercial sector. They might not arrive soon until at least the bandwith of neural data transfer is increased proportionately. BCI with qunatum encryption or even industry standard ECC mechanism is yet to be studied.

ii. Question of Neural Property

If ideas and creations are protected under the laws of *Intellectual Property*, then the phrase *Neural Property* can also be potentially defined as the neural data which contains your ideas, creations and inventions. Let's assume that we awarded our doctors the permission to read our brain data with some brain interfacing machine, then it implies that our neural data, and by extension, all the ideas and inventions are exposed and stand vulnerable.

Therefore, if we happen to have a new idea or thought during the process/treatment employing a brain interface, and the neural data consisting of our idea or just a shred of our idea is read or recorded, then who rightfully owns that idea, **us or the employer**?

Let's go a step forward and assume that we are under anaesthesia or any drug which has kept us unconconcious, which is a standard practice during such treatments, the employer (doctor, psychologist or scientist) might not even inform us or reveal the new idea to us. Would that be counted as property theft? Or perhaps, **neural theft?** Refer back to "Neural Privacy" - i for more.

iii. Question of Social Inequality

Researchers indulging into brain computer interfacing technologies believe that such an ecosystem, wherein everyone can access information from the brain of any other member connected to the network, would put all the members or participants at an equal level of access to knowledge, resources and by an extension, equal level of intelligence. However, while it may serve an advantage to students by increasing their speed of acquiring skills and accessing information, it could potentially widen the vaccum gap between social inqualities in the area of education considering only a few might be able to afford such devices for a brief initial period of time [6]

iv. Question of Personhood

Personhood could be the essence of us being humans or *persons* taking into account the physical self, metaphysical and the legal self. It refers to what we call *humanity* with a certain character trait [4].

Essentially, being 'us' is the essence of personhood. But the 'self' would include our thoughts, ideas and the mind. In that case, if no one can actually confirm *your thoughts to be your own ONLY* then it violates the context of personhood.

In a brain to brain interface technology, if we are transferring thoughts from *Aryan* to *Brooklyn*, then who gets to be identified and/or associated with that thought/data? Person A i.e. Aryan or Person B i.e. Brooklyn? One possible method for the rights of identification be allocated in a chronological order, implying that if the thought is being transferred from A to B, then A (Aryan) gets the right to be identified with that thought. Or both the subjects are allowed to legally divide equal rights over the thought? Or would B (Brooklyn) get complete rights over the thought and Aryan would be devoid of any, because the thought/data has been transferred to Brooklyn now? Essentially, would transfer of data/thought also transfer the rights immediately?

Such questions rather spark sensationalism, therefore, are kept minimum in this paper. However, gradually moving into the future where such ecosystems comprising of connecting brains with each other, philosophy serves as an essential tool provoking intriguing ethical questions like **How does someone define oneself as a person when brains are wired between individuals?** And eventually levelling the field to provide a path to frame the policies for such ecosystems.

A direct ideological target of neurocrimes could be to damage the target's *pyschological integrity and capacity of self-identification.*

v. Question of Agency

Being an agent essentially comprises the power/capability to 'act'. And *agency* is the exercise or manifestation of this power. In layman terms, your power to take decisions without the influence of any external power accounts for your *agency* [23]. This philosophy comes under direct scrutiny whence dealing with brain interface technologies. Imagine the use case which employes such a tech, either BCI or BTBI, what is the gaurantee that your **free will** or **agency** to control yourself is protected or un-influenced while operating such a device?

In real life testing environments, subjects were asked to produce movements in virtual arms on screens to design certain gestures. The subjects believed that the gestures were being designed due to the concentration by subjects to command BCI for the same. However, the subjects were later revealed that the virtual arms were pre-programmed to move in those gestures and the subjects had no control whatsoever on it, rendering every sense of agency of the subjects to be questioned [24].

Where do we draw the thin fine line to measure this freedom? How exactly can we measure or account for the inability to control one-self while on a treatment which employes brain interface devices. Such philosophical questions spark serious concerns about the question of agency in the brain-computing ecosystems, especially in the ethico-legal domain.

vi. Question of Consent

Absence of policies or proper international regulations over brain-computing interfacing environments leverages certain degree of legal freedom to people with malicious intentions from keeping their patients informed about reasonable expectations and potential risks associated with probing into their brains for downloading or at least accessing their neural data.

Even though all the potential risks of indluging in brain-computing interfacing technologies might be revealed to the subjects, the **absolute right to withdraw** must be respected at all times [25]. Practices of Consent in the view of BCI ecosystems, however, can be enhanced and safely spread out on the planet with open sourced sharing of all the collected data on potential and verified risks associated with area.

vii. Question of Neuroimprisonment

In a dystopianly ideal situation wherein a malicious attacker is able to gain uninterupted access to target's brain data and is able to coerce the device (implanted or wearable) to produce stimulations in the brain to wishfully insert or withdraw data, be it memories or individual electrical signals, the inability of the patient to act on xis own and categorically refuse to inhibit the impulse/signal is what we term as **Neuroimprisonment**. Its the inability to control your own body under a condition when someone else has access to your brain. Such neurotheft accelerated to a level which handicaps the ability to take decisions on your own, undermines sense of self-identification, disregards consent, agency and moral responsibility of damages produced to the target, may sound a distanced worrisome idea, however, it can seldom be ignored considering the infancy stage we are at in designing and improving BCI.

V. Conclusion

Considering the aforementioned questions and issues discussed to be of utmost concern in the ethico-legal domain in accordance with the BCI and BTBI ecosystems, case can be made that as researchers and the extended scientific community moves to develop such technologies, the idea of respecting identity, morale, ethics and the wholesome personality of human subjects (and customers of this technology in the near future) must be maintained and brought to limelight and discussed openly with agencies beyond the sphere of science, especially the ones in governance and human rights.

While BCI environments invite the possibilities of ultimate non-consensual use to coerce thought or behavior, such technologies might not be posing a large scale serious threat to ethical systems as of the date of writing this paper considering its still in its infancy stage of design and development, however, the potential threats which it invites with itself for the human race in the future, must not be ignored. **Awareness of the crowd** in such an environment as one of the many verticals of safe evolution of BCI and BTBI systems should never be discouraged or ignored.

A certain major conclusion, out of many small ones, generated from the paper stands clear that national governments and international agencies need to table the ethicotechnical issues underlying these fast evolving technologies and attempt to establish a consortium or concrete policies over carefull regulation of the same environments and/or legal and technical protection from neurologically related crimes, like neurotheft, amongst others.

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