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On The Verge of the Hybrid Mind

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ABSTRACT:
Recent advances in neurotechnology allow for an increasingly tight integration of the human brain and mind with artificial cognitive systems, blending persons with technologies and creating an assemblage that we call a hybrid mind. In some ways the mind has always been a hybrid, emerging from the interaction of biology, culture (including technological artifacts) and the natural environment. However, with the emergence of neurotechnologies enabling bidirectional flows of information between the brain and AI-enabled devices, integrated into mutually adaptive assemblages, we have arrived at a point where the specific examination of this new instantiation of the hybrid mind is essential. Among the critical questions raised by this development are the effects of these devices on the user's perception of the self, and on the user's experience of their own mental contents. Questions arise related to the boundaries of the mind and body and whether the hardware and software that are functionally integrated with the body and mind are to be viewed as parts of the person or separate artifacts subject to different legal treatment. Other questions relate to how to attribute responsibility for actions taken as a result of the operations of a hybrid mind, as well as how to settle questions of the privacy and security of information generated and retained within a hybrid mind.

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A hybrid is the blend or combination of different elements into a novel entity. The term is commonly used in biology where it refers to the offspring of different varieties of plants or animals (including humans, many of whose genomes contain Neanderthal or Denisovan DNA). It also refers to technological artifacts with dual properties like cars that combine electrical and petrochemical motors. Moreover, the term hybrid is used to speak of blends of biological with technological entities, and this includes the combination of human beings with complex artifacts that begin to merge individual bodies with machines. This sense of hybridity and some of its recent manifestations are the focus of this paper. More precisely, we wish to address the trajectoryof such mergers as they are about to expand to the human brain and the human mind, and as they increasingly involve technologies making use of elements of artificial intelligence (AI). This creates physical admixtures of humans and technological artifacts which blend organic and artificial intelligence. Technological developments have reached an interesting stage on the verge of creating hybrid minds.

This remarkable development is a further milestone in human-machine interaction and merits reflection. Some ethical and legal considerations are laid out in the final section. We wish to note that this paper does not address possible developments at further points on the trajectory such as uploading the mind to digital networks or the creation of general artificial intelligence, which enjoy some attention in public media and ethical debates, but are largely speculative at the moment. We wish to draw attention to more near term developments; in fact, we will show that simple forms of hybrid minds already exist in experimental neurological and psychiatric treatments. Already at this nascent stage, hybrid minds raise a range of intriguing questions, and answers may affect the further trajectory of the field.

FROM HYBRID BODIES ...

This development emerges from a long history. Such is human nature that we have long invented and used technologies that have profoundly shaped our own evolution as a species over millennia (Zink & Liebermann, 2016; Durham, 1991). Through remote and recent history, the use of various types of bodily prostheses to restore lost or damaged parts and functions can be traced. The trajectory is one of increasing sophistication and integration between the biological substrate and technological artifacts; from simple prosthetics for soldiers in the First World War to sophisticated current versions which may even partially restore tactile feelings; from eyeglasses to implanted lenses in cataract surgery and further to retinal implants. Insulin pumps, the artificial pancreas, heart or implanted cardiac pacemakers offer further examples of hybrid bodies.

Hybrid bodies raise interesting questions about the extent to which humans are limited by their biological nature, and whether they should be limited in this way. One of the imaginaries of this debate is the cyborg, i.e., an entity composed of organic and technological components. It revives and modernizes hybrids of human and animal bodies found in mythological figures such as the Centaur as well as in prehistoric art (Boric, 2007). As the cyborg is often imagined as less vulnerable and sometimes more capable than ordinary humans, it contrasts with the images of deficiencies and disabilities typically associated with bodily prosthetics. It has therefore resonated with artists wishing to transcend the boundaries of the body. Bodies are conceived not as enclosed structures but as modifiable platforms to which devices can be attached and functions added or subtracted, without firm or essential borders (Stelarc, 2009).

The cyborg also resonated with feminist authors seeking to overcome the confines of stereotypical roles ascribed on the basis of biological bodies. As Donna Haraway wrote in 1985: "By the late twentieth century, our time, a mythic time, we are all chimeras, theorized and fabricated hybrids of machine and organism. In short, we are cyborgs" (2009, 292). To her, the cyborg emerges from the breakdown of three boundaries: Between humans and animals, humans and machines, and physical and mental. And she called for "pleasure in the confusion of boundaries and responsibility in their construction" (ital. in original, p.229). These far-ranging re-conceptions of the human body were ahead of their time, but may slowly find traction. Many people live with (simple) technologies implanted in their bodies and have become, without necessarily realizing it, everyday cyborgs (Quigley & Ayihongbe, 2018). Some conceive the prosthetic extensions of their bodies as parts of themselves and demand their recognition as such. For instance, the Cyborg Foundation, cofounded by the artist Neil Harbisson who invented the eyeborg, a device that enables him to hear colours, calls for morphological freedom - the freedom to change and modify one's body (Cyborg Foundation 2021). Such calls may foreshadow political struggles about the boundaries of human bodies.

... TO HYBRID MINDS

Hybrid minds are a continuation of the hybridization of the biological body and technology with respect to the mind. Like other parts of the body and their functions, the human brain and the mental functions it enables can be explored, altered and supported technologically, raising the possibility of generating minds that emerge from an increasingly complex and tight integration of biology and technology. As with bodily functions, humans have long sought to manipulate their minds, although technologies to do so have been relatively limited until recently. However, today's neuroprosthetics and other neurotechnologies directly engage with the brain; they may even be implanted in the brain, and target bodily as well as mental functions. A particularly good example is deep brain stimulation (DBS), in which electrodes implanted within the brain deliver targeted electric stimulation to alleviate symptoms of neurological conditions like Parkinson's disease. DBS is now also being investigated to address symptoms of psychiatric conditions like depression or obsessive -compulsive disorder (OCD). A further step - and the one with which we are primarily concerned here - incorporates artificial cognitive systems within neurotechnologies, so that, for example, the parameters of the stimulation are set by the AI. This would give rise to a hybrid mind in a comprehensive sense. We shall take a closer look at three examples and their implications in a moment.

MULTIPLE HYBRIDITY OF THE MIND

Before moving on to discuss examples of the hybrid mind, as we use the term, we wish to note some different senses in which the human mind is conceived as a hybrid. For example, it has been described as a hybrid of biology and culture, or genetics and environment. Hybridity here refers to the complex interplay of biological (and innate) predispositions and experiences in the genesis of minds. In a different sense, people who grew up in two different cultures are described as having hybrid minds as they have internalized different mindsets. Some phenomenologists, moreover, describe the mind as a hybrid because it consists of both inner (cerebral and phenomenological) and outer processes (bodily movements). They view expressive actions such as smiling as constitutive parts of the mental process because some mental states can be changed through such actions – smile and you feel better (Krueger, 2012).

This relates to the influential Extended Mind Thesis, the claim that human thought does not take place solely within the skull but may instead extend to the external world (Clark & Chalmers, 1998). This thesis is based on the idea that, for instance, composing a text in writing or calculating on a piece of paper is not merely a repetition of an internal mental operation, it is thinking or calculating. Cognitive processes recruit and manipulate things and features of the environment for the performance of a cognitive task; they take place in and outside of the skull, and indeed they "promiscuously criss-cross the boundaries of brain, body, and world" (Clark, 2008, p. 149). This ability to transgress the boundaries of the skull, to form "mergers and coalitions" with cognitive artifacts, grounds the hybridity of the mind.

The further intriguing claim associated with the Extended Mind Thesis is that hybridity is a natural feature of the human mind. Andy Clark, one of its pioneers, writes (2002, p22):

"For we are, and long have been, bio-technological symbionts: reasoning and thinking systems spread across biological matter and the delicately codetermined gossamers of our socio-technological nest. This tendency towards bio-technological hybridisation is not an especially modern development. On the contrary, it is an aspect of our humanity which is as basic and ancient as the use of speech, and which has been extending its territory ever since."

According to this view and the various senses of hybrid mind laid out previously, one can say:
The mind is, and may always have been, a hybrid.
Furthermore, the term hybrid intelligence has recently emerged to describe combinations of human and machine intelligence (Dellermann et al., 2019). The two operate differently; computers exceed humans in some operations such as pattern recognition, but are weak in others where they are outperformed by children (Lake et al., 2017). Hybrid intelligence seeks ways to combine the strengths of both forms to improve performance. This requires a division of labour between the different forms of intelligence so that both work on the part of the problems for which they are best suited.

Finally, the idea of a hybrid mind can be addressed from the way in which the ordinary use of tools shapes human brains and minds. It is one of the fundamental insights from neuroscience that the human brain changes continuously and can be highly plastic even after full maturation around the age of 26 (Sowell et al., 2006). A number of mechanisms from the cellular to the systems level allow for extensive neuroplasticity, which forms the basis for life-long learning and transformation. Studies show that interactions with tools such as musical instruments or the smartphones that direct us through the complex traffic of London City can have a profound impact on the organization of the brain.

THREE EXAMPLES OF *HYBRID MINDS*

In this section, we offer examples that illustrate the trajectory toward the specific form of AI-brain hybrid mind in which we are particularly interested: A hybrid of the organic human brain and mind that is functionally integrated with neurotechnologies and involves AI. Or in other words, systems that involve the bidirectional exchange of information between a biological brain and an artificial cognitive system, and in which there are processes of mutual adaptation between the user and the technology. In what follows, we will call this a hybrid mind.

CONNECTING BRAINS TO COMPUTERS VIA BCI

A key element of these hybrids is the connection between human brains and computers. The idea of such direct connections is not new; the Belgian-American engineer Jacques Vidal coined the term brain-computer interface (BCI) nearly half a century ago. But until recently, only a handful of scientists worked on them. Today, BCIs are indispensable tools in science and medicine to advance our understanding of the brain and to improve quality of life in severe paralysis. Rapid technological evolution characterized by miniaturization, increased computational power, sensor integration, and wireless communication has catalysed the development of a new generation of neural interfaces that promise to offer much higher bandwidth for information exchange. While for many decades BCI systems were confined to well-controlled laboratory environments, such systems are now about to enter everyday life environments (Soekadar et al. 2016; Clausen et al. 2017).

The first BCIs were conceptualized as unidirectional tools that detect electric, magnetic or metabolic brain activity and translate it into signals to control digital devices. Users typically receive feedback about the effects of the BCI through their visual, auditory, or proprioceptive senses. For example, severely paralyzed or locked-in patients who cannot move their bodies may use a BCI to communicate. They can select letters on a screen by modulating their brain activity, which is detected via electroencephalography (EEG) (Birbaumer et al., 1999). With repeated use, their performance in selecting letters increases. Here, the BCI creates a novel form of output of signals from the Central Nervous System (Wolpaw & Wolpaw, 2012). This output can also be used to control assistive devices such as wheelchairs or exoskeletons. It has been applied for restoration of movement, e.g. in stroke or spinal cord injury (Soekadar et al., 2015). Based on operant conditioning of neural cell assemblies' activity, users achieved the ability to execute complex movements through robotic devices or exoskeletons (Hochberg et al., 2012; Collinger et al., 2012; Ajiboye et al., 2017).

ENTER ARTIFICIAL INTELLIGENCE

Reliable classification of neural activity is challenging, however, even more so when brain signals are recorded from outside the skull. Not only is the neural signal attenuated due to the distance of the brain to the sensor, but also muscle artifacts and environmental electromagnetic fields impede reliable recordings. Therefore, building on advances in machine learning, BCIs were successfully coupled with actuators enhanced with AI to supplement insufficient brain activity-based control commands. The intention of the user or the goal of a desired movement is decoded from brain activity, but the AI component calculates the optimal solution to execute the movement or to achieve the goal, and delivers the necessary control commands to the actuator, e.g. robot or exoskeleton.

• ***Case 1: Hybrid Body with a Robotic Arm***

In a recent study, we equipped a wheelchair with a context sensitive, vision-guided robotic system that could detect and precisely locate objects of daily living, such as a water bottle on a table (Crea et al., 2018). We coupled this system with a non-invasive brain/neural interface based on electroencephalography and electrooculography (EEG/EOG). When the intention to grasp the bottle was detected from the user's brain, a robotic arm would reach out to the bottle and securely grasp it. Depending on other brain/neural signals, the robotic arm would lift the bottle and eventually move it to the user's mouth with high precision to allow for drinking. So in this application, the user and the AI work together to control the robotic actuator. Beyond this example, enhancing brain/neural machine interaction with AI has proven to be very effective, particularly to compensate for the limited bandwidth of neural interfaces, and it is very likely that such approaches will increasingly be used in a variety of assistive applications.

Depending on details about their connection and interplay, one may say that such applications can create hybrid bodies - of the human body and the robotic arm - controlled by a simple form of a hybrid mind. It shows some interesting features of mutual adaptation. Controlling a device via a BCI is often hard and exhausting; users have to train to create brain signals that the device detects, often by trial and error (Kögel et al. 2020). Thus, the user adapts some form of brain activity to the demands of the technology, and vice versa, the BCI learns to correctly detect - and sometimes predict - states of the user (Bublitz et al 2019). This is often achieved by machine learning algorithms. Moreover, there is long-term adaptivity at the neural level. For instance, it was shown that repeated use of an exoskeleton to mobilize a paralyzed limb is associated not only with improved control, but can also trigger functional and structural neuroplasticity in the user's brains that is linked to neural recovery. In other words, regular use of a BCI system impacts the organization and function of the brain. More generally, one may say that in such tightly integrated, mutually adaptive systems, boundaries between the operator and the tool begin to blur.

- ***Case 2: Intervening into the brain***

A more sophisticated example of a BCI is capable of electrically stimulating the brain to provide artificial haptic feedback when controlling a prosthetic arm. In a study at the Johns Hopkins Department of Physical Medicine and Rehabilitation, a 51 year old male who survived a high cervical spinal cord injury that left him paralyzed from his shoulders downward was implanted with six microelectrode arrays in the sensory and motor areas of his brain. The microelectrode arrays were used both for recording his brain activity and for stimulating his brain electrically. After some training sessions, the patient was able to control two prosthetic hands, for example, to eat with a fork and knife. To restore the sensation of touch, the prosthetic fingers were equipped with touch sensors. When touched, electric stimulation was delivered to the sensory cortex allowing him to discriminate individual fingers with 100% accuracy.

Such adaptive or closed-loop brain stimulation paradigms (i.e., when stimulation parameters are adapted to internal or external triggers) also play an increasing role in treating brain disorders that are associated with disease-specific alterations of brain activity, such as epilepsy or Parkinson's disease. Since 2013, more than 1700 patients with intractable epilepsy have been implanted with such a closed-loop, brain-responsive neurostimulation system. Based on the presence or absence of patient specific patterns of brain activity that precede a major epileptic seizure, a deep brain stimulator (DBS) that blocks seizure activity is either turned on or off. For instance, such a system was also implanted in a 31 year old woman who had suffered up to 8 seizures a day since she was 3 years old. Because her seizures originated in the motor cortex, surgical removal of the epileptic brain tissue was not an option. This could have led to severe paralysis of her body. In 2008, she was one of the first to receive a closed-loop stimulator to block her seizures. Initially, the stimulator reduced the intensity but not frequency of seizures, but the replacement in 2013 of the device led to the complete abatement of seizures. In theory, such an approach could be applied in any brain disorder for which a disease-specific biomarker has been identified.

In these applications, the BCI not only reads out brain activity, but also intervenes into the brain, e.g. via electric stimulation. It thereby modifies brain states and processes, and often also mental states and processes. The arm prosthesis provides haptic feedback, i.e. the patient feels which prosthetic finger is activated. This feeling is triggered by stimulation of sensory areas in the brain. Thus, parts of the operations of the mind are now taken over by the BCI; the bidirectional BCI becomes integrated with ordinary functioning of the brain and mind. This is a decisive step for hybrid minds. Similar things happen in the prevention of epilepsy, where the artificial system intervenes in the brain to sustain ordinary functioning and suppress the onset of a seizure. Its mental effect is thus preventative. Moreover, it is worth noting that in these closed-loop applications, this brain-machine system operates without additional input from the user. Moreover, the workings of bidirectional BCI often involve machine learning, not only in interpreting brain signals, but also in adjusting the parameters of stimulation - so called adaptive brain stimulation. These are good examples of a hybrid mind: The human brain and mind with functionally integrated technology, operated by machine learning, or - more broadly - AI.

- ***Case 3: Targeting the contents of the mind***

Besides sensory perceptions, like touch, targets of brain interventions could also be other domains of brain function, including the content of thoughts. While this to a large extent has not yet been achieved, there are some remarkable successes. In one case a young man was diagnosed with schizophrenia (Schwippel et al., 2017). He presented with multimodal hallucinatory perceptions that included auditory, visual and haptic qualities. More specifically, he reported perceiving three individuals who would argue with each other and comment on his behaviour. Regularly, they would physically approach and threatenhim leaving him in states of intense anxiety. Because of these experiences, he withdrew from social interactions and suffered from anhedonia, poverty of speech and impaired psychosocial functioning. Neither the EEG nor anatomical brain scans showed abnormalities. Since no psychopharmacological approach had any lasting impact on the hallucinations, electric and magnetic brain stimulation was applied using different stimulation settings. Most settings did not have any effect, but when placing a cathodal electrode over the right dorsolateral prefrontal cortex (DLPFC) and an anodal electrode over the left temporoparietal junction (an area related to multisensory integration) to deliver transcranial direct current stimulation (tDCS) at an intensity of 2mA, the young man reported that the three individuals withdrew from him and remained silent. This effect could be reliably reproduced every time the stimulation was delivered. The man was then given a device that he could use outside the clinic to self-administer the stimulation as needed to "chase away" the people in his delusions.

In this case, electric stimulation of the brain affected the perceptions and experiences of the patient. While this was open-loop as the patient controlled the stimulation, devices in which this is achieved without user participation, as in the DBS against epilepsy, are conceivable. For instance, closed-loop devices which regulate moods are being discussed (Kellmeyer et al., 2016). This device would detect the moods of patients and adjust them via electric stimulation. So part of the affective regulation of the person is carried out by the device, and its workings would likely involve AI.

These examples illustrate the phenomenon of the hybrid mind, a tightly interwoven functional integration of organic brains and mental processes with neurotechnologies and adaptive algorithms. Possible devices and applications range on a spectrum along which they vary in terms of the directness and mode of the interaction with the brain, the timescale of the interactions, the degree of invasiveness or integration, the transparency and predictability of the effects, and so forth. Despite, and perhaps because of these differences, the resulting hybrid mind is an intriguing object of study and reflection, The boundaries between the user and the device blur, to a point where they may be said to blend with each other. At a functional level, it may not be possible to discern the inputs from the BCI or the human brain, especially if there are adaptive feedback loops between them. The inputs of one may be the precondition of the other, so that they jointly bring about specific mental or bodily functions. But even on the bodily level, both become hard to keep separate, when some parts are implanted inside the body, or external parts are necessary elements to move the body (as in exoskeletons).

We think the integration of the device makes it more than an ordinary tool. One would probably miss the distinct aspects of ordinary implants like the pacemaker if one conceived them merely as tools. They may become more, namely technologies that are integrated into the functioning of the body. And the same is true, perhaps to a stronger degree, if technologies are integrated into the human mind and brain. At the same time, we acknowledge that the mind can be described as a hybrid in many other ways. The boundaries between the environment and the person are not as strict as one may intuitively hold. Still, we think this particular instantiation merits special attention, the integration of AI with the human mind is a distinct milestone in the long history of human-machine interaction.

WHAT ARE THE IMPLICATIONS OF THE HYBRID MIND?

The hybridization of human beings with their technologies – at the level of the body or the mind – raises a plethora of questions about the impact on individuals' lived experiences and perceptions of themselves, as well as on their interpersonal interactions and on society more generally. Here, we touch upon some of these questions, with particular focus on the integration of AI with the brain to form a hybrid mind.

WHAT IS IT LIKE TO HAVE A HYBRID MIND?

Most people, most of the time, identify with their minds as their own and perceive their thoughts, emotions, desires and actions to emanate in some way from themselves. This is the case even if it is true that under normal circumstances we are often unaware of many of the influences on our thinking and behaviour. We have a long history of living with some kinds of influences on our minds, particularly those that operate via the senses. We also have evolved to understand, to influence and to be influenced by other minds - i.e., natural cognitive systems - such as people and some animals. Against this backdrop, technologies that directly and effectively alter a person's brain activity, and that are capable of monitoring and adapting to brain states that may not be directly perceptible to the person concerned, appear to us to represent a significant change.

This raises a host of possibilities and questions related to how such technologies might affect the person's self-conscious awareness of their mental contents, the extent to which the person identifies with and recognizes the mental contents as their own, and the relationship that the person may come to feel with the device. It seems likely that the answers to these questions will vary according to the type of neurotechnology, its particular effects, and the person in question.

In recent years, there has been increasing discussion of whether, or to what extent, DBS for Parkinson's disease affects a patient's personal identity or sense of self (Gilbert et al. 2017). These subjective feelings are challenging to define precisely and difficult to study, and it can be hard to disentangle whether it is the implantation surgery, brain stimulation, alleviation of underlying disease symptoms, progression of disease or other factors that might contribute to alterations in the sense of self. However, Gilbert and colleagues' interviews with 17 patients revealed in some cases feelings of self-estrangement – the sense of not being oneself anymore. Conversely, some felt that they had been able to regain their true selves, at least partly, as a result of the DBS.

From one perspective, the experience of alienation from oneself appears to be a negative result. But perhaps this feeling of alienation is a good outcome in some cases. We might prefer a person to reject the effects of neurotechnology as alien or inauthentic if those effects cause harm by significantly altering long-standing traits and disrupting important relationships? This possibility seems to be a particular risk for neurotechnologies that alter mood, self-control and behaviour. Again, DBS for Parkinson's disease offers an interesting concrete example. Mosley et al. (2019) conducted an interview study with 10 patients who experienced DBS-induced neuropsychiatric side effects such as elevated mood, disinhibition, compulsivity and loss of empathy. This manifested in irritability, aggressive behaviour, compulsive gambling and spending, dangerous driving, unwise business decisions, and other behavioural problems. These changes might be unwelcome to the patient's friends and family, and maybe would have been rejected by the patient as alarming potential side effects prior to treatment. But, under treatment, the patient might welcome and identify with the changes. In fact, one of the patients developed uncharacteristic and apparently negative changes in behaviour ("coarsening of personality manifest with crude language, irritability and sexualized behaviour") but himself regarded the changes as voluntary and welcome. The challenge here is that neurotechnologies that alter mental functions may also alter a patient's evaluation of the changes. This raises fascinating questions about a person's independence of judgment when merged into a hybrid mind. Would independent judgment require disengagement from the neurotechnology that is modulating perceptions and emotions, or is the judgment of the hybrid mind itself to be given priority?

Without moving too far into dystopian fiction, the impact of pleasurable alterations of mood and behaviour raises the risk of addiction. Synofzik and colleagues (2012) recount the case of a young man treated with DBS for obsessive compulsive disorder who experienced euphoria and wished to continue in that state. His physicians refused to do so due to concerns about compromised decision-making and signs of addictive behaviour. Although accounts of this type are rare and brief, they usefully illustrate the strange problems of identifying whose judgment and experience should count —that of the original person, or that of the hybrid mind. The incorporation of adaptive artificial cognitive systems into the mixture may make this more challenging given the unpredictability of such systems over time.

WHAT IS THE BOUNDARY OF THE PERSON WHO HAS A HYBRID MIND?

Another important question raised by the hybridization of humans with their technologies is how to conceive of the boundaries of the person. The concept of personhood is philosophically complex, and is often debated in relation to whether animals or artificial intelligent agents might have all or some of the properties considered to confer the moral status of personhood. We set aside the question of whether an intelligent artificial agent should or could be a person, and instead focus on a different question. The moral and legal personhood of living human beings is now un-controversially recognized as an international human right (even if boundary cases around birth and death are debated), but what is included in that personhood? A human being has physical and psychological dimensions; but when a technology is used, attached, or integrated within the body or mind, does it merge with and become part of the person or does it remain a separate artifact?

This rather strange question has concrete legal consequences. Legal systems typically apply different rules to persons and to objects. Damage to property is treated differently from damage to the physical body, psychological harms to the mind, or social harms to aspects of personhood like reputation.

Property may be expropriated but physical body parts like kidneys cannot be conscripted. Objects may be treated as property that may be sold, but human bodies cannot (although occasionally, in some places, detached bodily substances or parts may be sold). Legal categorization puzzles arise for both hybrid bodies and minds. Should the hardware component of a device become part of the body once implanted, and immune to repossession for non-payment? Another question: Software is typically not sold outright by its creator, but instead the user is granted a license to use a copy under terms specified in an "end user license agreement". In the case of a software algorithm that contributes to the minds and mental functions of its users – should users be subject to restrictive licenses in relation to that software? It seems an undeniably peculiar legal result to conceive of a situation in which end-users hold a restricted license to a portion of their own minds. It would run against the principle that other people do not have rights over parts of a person.

THE PRIVACY OF THE HYBRID MIND

The hybrid mind may constitute a novel point of access to the mind of a person because it involves the bidirectional exchange of information from the brain to the device and vice versa. Let us consider each of these flows of information in turn.

The hybrid mind may involve a technology that monitors and adapts to the brain states (and possibly to other data about the user, depending upon what is being monitored). It thus constitutes a source of real time information that would not otherwise be available and, if recorded, would offer a store of information about the user's state over time. It is, of course, true that we may be unable to infer very much about a person's mental content from that neurological or other data, but this may change in the future. For example, progress is being made at decoding imagined speech or handwriting from neural activity in order to develop communication neurotechnologies useful for people with severe motor impairments (Martin et al., 2019; Willett et al., 2021). Furthermore, it is possible that the inferences of interest are not necessarily related to complex mental content like thoughts or perceptions. Simpler facts, such as whether a person was asleep or awake at a particular time may be of interest. A recent American case – one involving a hybrid body rather than a hybrid mind – illustrates the point. The case involved the use of data from a man's implanted cardiac pacemaker to convict him of arson (*Ohio v. Compton*, 2016; Maras and Wandt, 2020). His heart rate activity was considered inconsistent with his account of his actions at the time. It is of course possible that the court might not have believed him even without the pacemaker data, but the existence of that data in his case illustrates how novel data streams associated with prostheses may be put to other surprising uses. Various applications at the workplace monitoring vigilance, fatigue or distraction are easily conceivable and would offer streams of information about people. What kind of data might be collected in the context of hybrid mind technology, what inferences about a person's mental states and activities might be enabled, and is it appropriate that users - many of whom may be using these technologies to remedy a medical disability - are exposed to the collection of forms of personal data while others are not? It is worth noting that Medtronic's new DBS device, Percept, enables the stimulation of the brain and the ongoing collection of data about brain activity (Medtronic, 2021). The objective is to improve the therapeutic efficacy by collecting data on an ongoing basis outside the clinic. But, if there is one thing that is "as certain as death and taxes" - to borrow the English saying indicating the epitome of predictability - it is that the collected information will find new uses.

The hybrid mind also involves the flow of information in the other direction – from the device to the brain. Here again, the neurotechnology enables a novel point of access and influence on the user. As prosthetic devices are networked – primarily to enable remote monitoring and adjustment for therapeutic purposes in telemedicine – they become vulnerable to unintended and malicious disruption or manipulation. The world of hybrid bodies offers a good example. Proof of principle attacks on both various implanted devices such as cardiac pacemakers have been reported (McGowan, Sittig & Andel, 2021), and the U.S. Food and Drug Administration (FDA) recently recalled certain insulin pumps due to cybersecurity risks (FDA 2019). The possibility of teleprogramming DBS devices was already being discussed before the COVID-19 pandemic, but may accelerate with the general demonstration during the pandemic of the utility of distance medicine (Lin et al., 2020). The more widespread BCI technology becomes, the higher the likelihood of cybersecurity breaches involving the technologies and the data they process. Research has shown that BCIs are vulnerable to a variety of security risks analogous to any other computer technology such as the Internet of Things, wearables and smartphones (Ienca & Haselager, 2016). Unlike the aforementioned technologies, however, the security vulnerabilities of BCIs extend the domain of cybercrime to the mental space and may therefore have a potentially greater and less detectable influence on the user. This risk, which has been labelled "neurohacking," "brainjacking" or "malicious brain hacking" requires special attention as cybersecurity and privacy-and-security-by-default are currently not a top priority for BCI manufacturers (Ienca & Haselager 2016; Pycroft et al., 2016; Pugh et al., 2018; Ienca & Scheibner, 2020). AI in this domain can be a double edged sword. On the one hand, opaque AI methods may provide malicious hackers with more effective strategies to exploit the security weaknesses of a BCI and thereby exert remote influence over a BCI user; on the other hand, however, AI is being used to boost cybersecurity by enabling faster and more comprehensive threat detection.

WHO IS RESPONSIBLE FOR THE ACTIONS OF PERSONS WITH HYBRID MINDS?

Ideas about capacity, agency and moral responsibility are fundamental to social practices of attributing praise and blame, as well as to legal practices of imposing liability and punishment. These ideas have changed to some extent over time, of course, as human societies have evolved, acquiring increased knowledge, adopting novel technologies, and changing ideologically. However, the integration of artificial intelligence within the hybrid mind is likely to raise challenges to our existing social, ethical and legal ideas and practices in several ways. To the extent that the hybrid mind reduces the user's capacity, for example, by affecting attention, inhibitory control, or other important functions, one would be tempted to regard this as a diminishment in capacity that would reduce blameworthiness, particularly if these effects were unforeseeable. And yet, the incorporation of AI within the hybrid mind may do just that. An adaptive algorithm that is trained to monitor certain aspects of a person's brain state in order to optimize one given function, or to balance trade-offs between several functions, may fail to pick up unintended or unforeseen effects. Existing ethical and legal principles might blame a person for using a device that is unpredictable and risky, particularly in situations where the risk is high. However, the same principles might regard it as reasonable to take a certain amount of risk, particularly if there is a strong medical need. In any event, these are questions that may need to be worked out in relation to responsibility for actions taken by the person with a hybrid mind.

A further question relates to the potential for joint responsibility for actions taken by the person with a hybrid mind. Should the makers and programmers of the devices bear responsibility as might be the case under product liability laws, or should disclaimers of liability (common in software end user license agreements) be legally recognized? Haselager (2013) hypothesised that when BCI control is partly dependent on intelligent algorithmic components, it may become difficult to discern whether the resulting behavioural output was actually performed by the user (Steinert et al. 2019). This difficulty introduces a principle of indeterminacy within the cognitive process that starts from the conception of an action (or intention) to its execution, with consequent uncertainty in the attribution of responsibility to the author of this action. This principle of indeterminacy could call the notion of individual responsibility into question, with potential legal repercussions (Bublitz et al, 2019). In addition, it could generate a sense of alienation in the user, the ethical relevance of which is all the greater in the case of a vulnerable individual such as a neurological patient. For example, imagine a patient suffering from tetraplegia using a BCI which is strongly enhanced by intelligent components for the extraction, decoding and classification of information: how will it be possible to determine which components of the patient's actions are attributable to his volition and which to the AI? This question becomes particularly controversial, as mentioned above, in circumstances where the attribution of responsibility has legal significance, such as in court cases which attempt to address liability and culpability.

WHO HAS ACCESS TO THE TECHNOLOGIES OF THE HYBRID MIND?

An important question related to the use of the technologies of the hybrid mind is the question of distributive justice, or equity in the distribution of the benefits and burdens that come along with their use. The same is true for matters of access - and the permission to use these devices. The United Nations' 2008 Convention on the Rights of Persons with Disabilities (CRPD) declares a state responsibility to support the development of and to facilitate access to assistive devices and technologies for people with disabilities. Probably no state is fully realizing this duty at the moment. And, given the potential costs of many devices, it may take political struggles to provide people with the necessary devices. Richer countries may have a special obligation to provide technological knowledge to other countries.

There are various perspectives on using assistive devices and technologies to respond to disability. The social model of disability regards disability as flowing from social structures and expectations embedded into social practices and the environment (see e.g. Shakespeare, 2006). On this view, the disabling impact of an impairment would be lessened by more accommodating social structures and expectations that take variation in human capacities into account. This approach encourages attempts to acknowledge diversity in human physical or cognitive capacity at the social level, rather than seeking to "fix" or "cure" people with impairments at the individual level. Another critique is suggested by the experience of the cochlear implant – a concrete example of a neuroprosthetic device that creates a hybrid body. When applied early in childhood, this would enable children to develop spoken language. However, some in the deaf community question whether this imposes on the child a choice made by others between two valid cultures – deaf culture and mainstream culture (Crouch 1997). The neurodiversity movement, which rejects the medicalization of attention-deficit and hyperactivity ADHD, bipolar disorder, autism spectrum disorder etc. and regards them as variations of human functioning, would potentially raise similar questions about the clinical deployment of hybrid mind technology. Does this approach imply or entrench views antithetical to neurodiversity? The question is complex, particularly given the variation in individual experience and perspective. Some may welcome hybrid mind technology and others may not.

With the increase in non-clinical uses of BCIs, another ethical challenge will soon be neuroenhancement. While clinical applications of BCIs are aimed at restoring motor or cognitive function in people with physical or cognitive impairments such as stroke survivors, neuroenhancement applications may, in the near future, produce superior performance compared to baseline among healthy individuals. This will make it urgent to discuss which types of enhancement are permissible and under which circumstances. Already today, there is a large ecosystem of private companies that market non-invasive BCI to an ever-increasing number of healthy users for purposes such as self-quantification, cognitive training, neurogaming (the use of brain-controlled video games for recreational or competitive purposes), and polysomnography. And already today, several companies, claim to be able to improve the, mental well-being' and ‚concentration' of cognitively healthy users. In other words they claim they can achieve some forms of neuroenhancement. Moreover, BCIs for motor control already allow not only the amplification of existing capabilities, but even the acquisition of faculties otherwise not present in human beings, such as the telepathic control of robotic devices such as drones and other semi-autonomous vehicles, applications of interest within the transport industry and military sector (Ienca, Jotterand & Elger, 2018). The safety and efficacy of enhancement is not the only important consideration when it comes to hybrid mind technologies used for enhancement purposes. Some have warned that enhancement technologies will be more likely to be available to the wealthy, widening already existing socioeconomic disparities as some people use such technologies on themselves and their children.

THE SOCIAL CONTEXT OF THE HYBRID MIND

It is worth highlighting that, today, intelligent components are not solely being deployed to optimize the functioning of clinical devices. As intelligent algorithms and computing methods become increasingly scalable, easy-to-use, low-cost, and hence pervasively distributed, the challenges raised by the hybrid mind may also apply to consumer neurotechnologies such as those used for gaming, wellness and education (Ienca, Haselager & Emanuel 2018; Wexler & Reiner 2018), or military purposes (Brunyé et al., 2020).

Therefore, it is critical to proactively address the metaphysical, ethical and legal questions raised by the hybrid mind within a broad range of contexts. Consumer neurotechnology applications complicate the challenge of scrutinizing and auditing the algorithms embedded in BCIs, as these algorithms are more likely to be protected under closed software licences and/or to be based on opaque AI methods (see discussions of the black box problem of AI).

Another set of issues relates to the ongoing dependency that users – particularly of medical applications – may develop on manufacturers of devices. Commercial decisions with respect to software upgrades, device interoperability, model discontinuation, bankruptcies, sales and mergers, and so forth could have substantial effects for people whose functioning has become deeply integrated with these devices within hybrid minds or bodies. Users may become dependent for continuing function on their devices, or may even come to view those devices and functions as integral to their personhood. Gilbert et al.'s (2017) study of the experiences of Parkinson's patients with implanted DBS shows how neurotechnologies may also become transparent to the user. Most of the patients he interviewed did not notice the device while it was functioning in the background, and some spoke of it as being "part of me" (although one perceived it as an alien intrusion). To the extent that a person using a neurotechnology has achieved the mental equivalent of embodiment - or seamless mental experiences of the self and the world without intrusive awareness of the contributions of the neurotechnological device - one might say it has become part of the mind. The phenomenological integration of technologies – a design objective that makes them useful – also entails a potential vulnerability to disruption (Basaran Akmazoglu and Chandler, 2021, forthcoming). If the hybrid mind relies upon a technology for the continuity of the self, then its removal would constitute an existential threat to the self (cf. the stories told by Kenneally, 2021). In fact, users of BCIs for research purposes have voiced sadness about the end of the studies, which meant for them that use of BCIs was discontinued (Kögel et al., 2020).

There are also other potential implications of the commercial context for hybrid minds. One of the concerns raised in relation to neurotechnologies is the potential that they create a new avenue of state intrusion or intervention into the lives of citizens. One way that this might occur is through state pressure on commercial manufacturers of AI-enabled neurotechnology, or the sale of a manufacturer that has been relatively independent from governmental interests to one that is more exposed to pressure in an autocratic state where human rights are less firmly protected. While this seems to be a fairly remote risk when hybrid minds are used relatively for clinical applications, the expansion in use in future would make this a more important consideration.

CONCLUSION:

In summary, the prospect of hybridizing the human mind with computing technology is no longer science fiction, but has become a concrete scientific possibility whose prodromal examples are already in the making. The hybrid mind opens promising new opportunities for human-machine interaction in the medical and non-medical domains. At the same time, it raises important conceptual, ethical and legal challenges. First of all, it raises several boundary problems: boundaries of bodies, minds, but also of legal regimes and particular norms. Such boundaries have to be drawn, as long as we want to afford special recognition to persons and their defining characteristics. In other words, to not objectify the person, boundaries between individuals as well as things need to be established. Where they should lie may become a more pressing and more complex topic in the near future. At the moment they are taken for granted, but the boundaries of the person may become a site of political contestation. Political demands by patients, artists, and cyborg activists may well foreshadow these coming debates.

Moreover, hybrid minds - and particularly their non-medical use, do raise general questions about the (limits of) technologization of human life. Some may see this as the intrusion of technology into one of the few domains which was, so far, left out - the human mind. Others may fail to see the novelty and point to the many ways in which our minds have always been hybrids. At some stage, public debate will have to come to a decision on how to confront the merging of humans and machines, and the hybridization of the person. As with most of the technological creations of our curious and inventive species, there will be seductive potential benefits to pursue, and simultaneous potential harms at the level of individuals and societies. What is certain is that there will be fascinating and challenging questions to be answered about the meaning of hybrid minds for individual personhood and for the societies in which we live.

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