Original article

Are Predictive Brain Implants an indispensable feature of autonomy?

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Abstract

Novel predictive and advisory brain implants have been tested with significant success for the first time in a human clinical trial. These implantable brain devices are programmed to predict brain activity patterns before specific outcomes occur and provide information to help patients to respond to the upcoming neuronal events that are forecast. Being guided by predictive and advisory information provided through an invasive brain technology offers enormous potential to benefit individuals by increasing control on upcoming symptoms, enhancing decision-making and quality of life. However, these potential benefits do not come free of ethical concerns. What role, if any, do predictive and advisory functionalities play in either impairing or reinstating a patient's capacity to exercise her/his autonomy? There currently is a gap in our knowledge concerning the consequences of these functionalities on patients' postoperative life, in particular how it might impact patients' decision-making as free and autonomous agent. This paper addresses this gap by exploring whether predictive and advisory brain implants are an indispensable feature of autonomy. In order to address this gap in knowledge, the first part of this manuscript explores ethical concerns regarding who is "in control" when patients are experiencing postoperative feelings of "loss of control". Section two examines what could be morally wrong with having predictive and advisory brain system "in control". The third section reports findings resulting from a study we conducted with patients implanted with these novel brain devices. Our conclusion discusses how these findings are evidence that, rather than being a threat, predictive and advisory brain devices are an indispensable feature of autonomy.

Key words: autonomy, advisory system, control, brain implants, epistemic authority, predictive brain devices.

Introduction

Cochlear implants and Deep Brain Stimulation (DBS) devices are the most commonly used implantable brain technologies in the world. Worldwide, around 325 000 people have been implanted with cochlear implants and 100 000 people have received DBS implants [1]. While the former treat patients suffering from auditory impairment, the latter consists of electrodes discharging continuous electric stimulation in the brain. DBS devices have been used successfully to alleviate symptoms arising from neurologic and psychiatric conditions. New DBS technologies are now undergoing clinical trials. This new technology records electrical signals in specific areas of the brain so that this can improve a patient's livelihood through the use of sensing and adjustable stimulation technology [2]. With a rapidly aging population, the number of patients requiring new treatments, such as implantable devices, will increase drastically in the next 20 years.

At the same time, the first human clinical trial using a more advanced and novel generation of brain technology – namely a predictive and advisory system – has been completed with substantial success. It is this predictive and advisory function that raises new ethical issues. Predictive brain technologies involve the permanent implantation of a device designed to forecast specific neuronal events. This device then translates raw neuronal data into information that a patient can access immediately in order to help them prevent an otherwise unforeseen neuronal event.

For instance, the world's first in-human clinical trial using these technologies has successfully shown that such technologies can predict epileptic seizures using an advisory system [3, 4]. In brief, continuous electroencephalography recordings are made directly from a patient's brain activity while an algorithm analyses the captured data. It then advises a patient via visual or audible information in order to show the likelihood of a seizure. The patient, in turn, may prepare for, or perhaps even prevent, the oncoming seizure by taking anti-seizure medications.

Because these novel predictive and advisory devices can forecast upcoming brain activities, and their correlated outcomes, they offer great potential benefit to patients by increasing control over upcoming symptoms. Every time information is provided that anticipates a neuronal event, patients are offered prescriptive measures to be undertaken. In other words, by informing the patient in advance, devices are capable of influencing a patient's decision-making on how the patient *should* act in order to avoid specific neuronal events.

Despite these obvious benefits, advisory and predictive devices are not without ethical concern, especially because they may disrupt or interfere with a patient's ability to exercise her/his autonomy. Can a patient's capacity to exercise her/his autonomy be at risk of postoperative iatrogenic harm? In other words, to what extent does a patient's decision-making become compromised by advisory functionalities? When, if at all, do novel predictive and advisory implants result in an erosion of a patient's autonomy?

The purpose of this manuscript is to preliminarily explore in what respect predictive and advisory brain devices are related to a patient's capacity to exercise her/his autonomy. In section one, we examine who is "in control" when patients are experiencing feelings of "loss of control" following implantation of invasive brain technologies. Section two examines what could be morally wrong with putting advisory systems "in control". The third section sheds light on these concerns by examining findings from a study we conducted with patients involved in the first human trial testing these predictive and advisory brain implants. Our conclusion discusses whether these findings are initial evidence that predictive and advisory brain devices are in fact an indispensable feature of autonomy rather than being a threat to autonomy.

Who is *in control* when patients are experiencing postoperative feelings of *loss of control?*

To understand how predictive and advisory brain implants may induce postoperative iatrogenic harms, we first need to compare these novel invasive technologies with other type of implantable brain devices. Knowledge gained through previous DBS clinical trials may help to understand many phenomena that some patients might experience while being implanted with predictive and advisory devices. Although generally safe, there is an increasing number of reports of DBS patients suffering from postoperative iatrogenic harms. Most of these postoperative iatrogenic harms are associated with hypersexuality, hypomania, and addictive behaviors [5–8]. These side-effects to the "self" have been framed in terms of postoperative self-estrangement, especially when patients experience feelings of powerlessness or *loss of control* over some impulses [9, 10]. The most concerning cases of postoperative self-estrangements associated with feelings of powerlessness and loss of control are those linked to suicide attempts [9–11]. Patients experiencing a diminution in their sense of control, or those suffering from feelings of powerlessness, are more likely to commit suicide. Although these cases of loss of control are very concerning, and call for revising some of the eligibility criteria for the recruitment of patients [11], they nonetheless remain rare cases.[1] We need to recognise these factors in order to understand how postoperative feelings of loss of control are critical for patients implanted with brain devices. It is also necessary to comprehend the unique and novel character of predictive and advisory brain devices compared to DBS devices.

The major difference between DBS devices and advisory implants is that the latter do not "stimulate" the brain, but rather predict specific brain activities. Predictive and advisory functionalities offer the prospect of instigating or prescribing a course of action to the implanted individual. This is not possible with DBS implants alone. Take, for example, the case of a patient who is suffering from epilepsy. If the device alerts a patient that X is about to occur (an epileptic seizure), then the device also prescribes a course of action Y (do something about it, e.g. taking anti-seizure medication), which the patient is expected to initiate, in order to prevent X from happening. By informing a patient in advance, devices are capable of influencing a patient's decision-making on how the patient *should* act in order to avoid specific neuronal events. In that respect, an advisory system may be seen as some sort of prescriptive authority with a capacity to instigate certain courses of actions. Without any other relevant and reliable available evidence to base a decision upon, an individual may not have any other choice but to blindly trust the displayed forecast.

By predicting upcoming neurological events, devices have substantial power to make individuals engage in particular courses of action. Are devices imposing or forcing prescriptive decisions to act through prediction? Given their ability to predict, advisory device may be said to be in an authoritative position over an individual patient. Are individuals losing control over how they should act? To what extent do these devices have coercive power over a patient's decision making? That is, when displaying information to individuals, an advisory system plays an epistemically authoritative role in informing individuals, but at the same time how must we understand advisory system instructing a patient on how they should act?[2]

1 To our knowledge, no neurobiological studies claim that postoperative feeling of loss of control can be predicted solely on the basis of DBS itself. Before linking any type of brain implants to postoperative suicidal attempt, many rigorous studies would need to be conducted. Nobody is accepting *post hoc ergo propter hoc*. For instance, with DBS, postoperative self-alteration or self-change may be induced directly through electric stimulation; or through the fact that patients diminish or stop using their usual medication; or through the use of new drugs; or because they are suffering from neurodegenerative disease which inevitably changes their personality (with or without treatment); or because they are suffering from micro lesions, or because of some important social environment fluctuations, etc.; or it may be the result of some of these, or the consequence of all these together, or other factors entirely.

2 To what extent do advisory systems play a moral authoritative role? In other words, by instructing patient how they should act do advisory devices play a form of moral authority? Some could argue that when a device prescribes a course of action to a patient it also introduces a sense of moral duty to undertake that action. That is, patients may have a duty of care towards themselves and consequently not following the device's instructions would violate one's own duty of care. Some could see a sort of normative prescription within this duty of care – more precisely a prescription toward *the*

Some could argue that individuals are obliged to always act in accordance with reliable available evidence. When all the evidence is taken into account, if advisory information is an individual's only reliable evidence capable of playing an epistemic and informative role, anyone who decides contrary to that reliable available evidence would be putting herself/himself at risk. They would thereby be choosing a potentially harmful alternative (e.g. an epileptic seizure) against the device's recommendations. In a context where there is an exclusive and sole source of relevant evidence, this source can be seen as device's authoritative standpoint.

Implanted individuals have no control over a device's authoritative standpoint while choosing to act in accordance with its predictions. This is where some form of loss of control over decisions influenced by advisory devices may become a threat to autonomy. The question is: to what extent is decisional autonomy preserved when patients have no other evidence than the device's authoritative standpoint to guide their choice on upcoming brain activities that require an immediate action?

This lead us to suggest that an individual's decision could be argued to be in control of a device's authoritative standpoint when there is no source of evidence other than the evidence produced by the authoritative standpoint itself.[3] The question we need to answer now is what could be morally wrong with having predictive brain devices in control of an individual's decisions.

What could be morally wrong with putting an advisory system *in control?*

A traditional way of seeing personal autonomy is to conceive it intimately linked to the notion of personal freedom. It is largely believed that freedom of choice guarantees autonomy because freedom is rooted within mechanisms an agent has ownership over. In that sense, some have argued that agents are fundamentally the original cause of their decision [12, 13]. This type of *agent-cause* approach guarantees that one possesses the kind of internal causal power to decide what to do. That is, the instigation of their decision ultimately and sufficiently relies within them, and not in external factors. But if this traditional uncaused-agent-cause is true, how external predictive brain implants could impact autonomy?

As Mele suggests, one way to understand autonomy is in terms of control [14]. According to this account, autonomous decisions require that an individual exercises control over their decisions, rather than exclusively being justified by a particular idea of uncaused-agent-cause or freedom of action. In that respect, autonomy encompasses self-control or being a self-controlled individual. However, is this conception of autonomy sufficient for understanding how decisions are supposed to be made? Can we say that such a decision is a truly autonomous one? These questions matter because they involve important ethical concerns. The core ethical issue is whether a technologically self-controlled individual could experience a sense of autonomy while being fully under the influence of predictive and advisory functionalities. If it is the case, as we have established in the previous section, that the implanted individual has no control over a device's authoritative standpoint while choosing to act in accordance with its predictions, then this would represent a threat to the individual's autonomy. We normally view it as important to preserve an individual's autonomy wherever possible, hence such a development would constitute an ethical problem. In terms of predictive and advisory brain implant devices, the question is whether it is morally right to have programmed brain devices in control of some decisions that consequently limit autonomous control.[4]

In many fields, including medicine, it has been established that some computer programs are more reliable than the best human decision-makers available (e.g. airport traffic control; medical robotics). Consequently, in many expert areas, it has been rational to transfer decision-making responsibility from humans to machines [15]. Having an algorithm in control of vital decision-making allows for the reliable avoidance of human error.

The concern with advisory brain system is whether it is overall in the best interest of implanted individuals to have less decisional control if it means that significant risks of harm are avoided or it is better to have a higher chance of risk of harm but more decisional autonomy. It might be better for individuals trying to look at other available evidence or phenomenon to guide their choice rather than solely relying on the advisory indicator.

good life (i.e. a desire to alleviate one's own suffering). However here, an important distinction needs to be made: such prescription could be seen as, A) an external injunction (the device being something other than the individual); and B) an internal injunction (compatible with one's consent to alleviate one's suffering). Regarding B, it seems it would enhance one's consent or desire to increase one's quality of life. In that respect, it would be difficult to think of a moral authority *per se,* because one's own consent would be compatible with the authority. Thanks to the anonymous reviewer who pointed at this issue.

3 Predictive and advisory devices are an excellent example of epistemic authority because they inform us of events that an individual has no potential to confirm until it occurs. A similar, and hypothetical example would be, for instance, if you are currently packing your suitcase to leave earth to visit the otherwise unpopulated planet Charlotte, and you receive a forecast from a device about the weather on Charlotte, you likely have no other evidence than the available forecast itself to decide whether the forecast is reliable. For example, you cannot look out the window to determine whether you will continue with your trip. Nor can you contact someone on the planet to ask them in advance. You can only rely on the data from the device.

4 We must stress that executing these advisory prescriptions represents some decisions and not all decisions.

Unlike technologies that display information about upcoming environmental states, such as GPS or satellite forecasts, predictive and advisory brain devices inform us of future neuronal states. This distinction is fundamental for understanding the risk of harm associated with decisions that need to be taken immediately after prediction. Implanted individuals have no control over prediction, moreover, they have no power to verify predicted information until it occurs, which is not the case with technology guiding individuals on actual and upcoming environmental changes.

For instance, weather forecasting has room for verification by satellite prediction. One could always look up to see whether factors such as clouds, wind, rain, etc, are present. In comparison, it would be difficult to cite analogous ways by which an individual might check their own brain activity. Individuals have no independent means of verification and they are relying blindly on the device's predictions. A decision could be seen as fully in control or relying on an advisory system's epistemic authority when the individual is not able to look at other evidence to evaluate the correctness or relevancy of displayed information.

On this account, we can understand that individuals may not be fully *in control* of some decision-making process when implanted advisory brain devices are the sole epistemic authority. Consequently, when algorithms are more competent than any available human expert and are the only evidence available to guide patient, it appears to be morally justified to put some algorithm in control of some decision-making. In that respect, the ethical concern we need to look at is not whether it is morally wrong to have a predictive and advisory algorithm in control of some decision-making, but rather how could it be right not having them? [15]

Taking into account the above, our hypothesis is the following: Not only should predictive and advisory devices be in control of the instigation of some decisions-making processes, but also, when manifesting an exclusive epistemic authoritative role (e.g. sole reliable evidence available) within a context where autonomy is potentially interrupted, advisory functionalities are a *sine qua non* feature that allow patients to exercise their full autonomy.

One way to examine our hypothesis is to look at the phenomenological accounts that explain a patient's experience of these predictive and advisory brain devices. This will help shed light on how predictive technologies may potentially interact with patient autonomy.

Findings from patients involved in first-in-human trial[5]

We conducted semi-structured interviews with patients who volunteered to be implanted with the first experimental advisory brain device capable of predicting epilepsy seizure.[6] Description of the trial's details can be found here [3, 4].

How can advisory prescriptions become an integral part of an individual's autonomous decision-making process? All patients reported that after implantation, they were doubtful and had a sceptical attitude towards the potential veracity of the promised predictions. However, when most patients realised the advisory functionalities were helpful, they quickly started relying on the device. This reliability translated into a reason for adopting these predictions as trustworthy evidence. In the words of one patient: "Well as I got more and more confident, I didn't question it, no. But initially when the algorithm was first put in, then I had very little confidence that it was going to be of any assistance. But then overtime, I got more and more confident and so, yeah, I trusted it." From these observations, we suggest that patients would not have endorsed an advisory system as reliable evidence should it have consistently led to falsehood.

When patients were asked about their subjective experience of being implanted, in particular how they interpreted the information provided by the devices, they reported that they perceived an increased feeling of being in control. For instance, one patient reported: "I felt more in control when I used the device. I could push on and do what I wanted to do." Another patient explained: "It gave me more confidence to do things that I wouldn't necessarily and normally do." On these accounts, predictive brain devices appear to enable patients to expand control beyond the pre-implanted realm: to "push on", "do what I want to do" and "do things that I wouldn't necessarily and normally do". Here patients seem to be describing a sense of autonomy mapped by a newly tailor-made ability to control. From the patient's report, it appears that their decision-making process 'to push' was not felt to constitute an imposition and a compromisation of their autonomy.

5 This study pilot was conducted in accordance to Tasmanian Human Research Ethics Committee regulations. Patient Consent and Minimal Risk Ethics Application Approval, entitled "(H0013883) Implantable Seizure Advisory Brain Devices: Ethical Implications" are conformed to Tasmania Human Research Ethics Committee regulations. Initial ethics approval was obtained in March 2013, and an amendment was approved on November 2014.

6 Semi-structured interviews consisted in following an uninstructive script with a duration average of 45 minutes per patient. 15 patients were implanted with the devices. At the time of writing this manuscript, we were able to interview 4 of them. Open questions such as: "How was it to live with/without the device"; "How did you experience device prediction"; etc. were asked. Following patients answers, we followed up on some key themes or concepts introduced by patients.

One patient explained: "It's a natural consequence [to decide to push]. It was not imposed, no. So it was a natural consequence of the development of the algorithm." It seems that individuals may not fully be in control of some decisional inception, but in fact endorse the devices authority, which, in the end, allowed them to exercise their own autonomy under the cover of cumulative confidence and control.

From these descriptions we can understand that the predictive and advisory functionalities provide an increased degree of control that allows a patient to act unimpeded by the constant risk of unpredictable seizures. The degree of autonomy experienced here appears to be directly proportional to the degree of control provided by these predictive brain implants. We understand that an individual is in control of their decisions if that patient identifies or endorses the sort of control previous described behind their decision [16]. In light of these observations, the traditional conception of autonomy as uncaused-agent-cause might be difficult to uphold when confronting with these findings because external factors play an essential role in contributing to autonomy. As Mele suggested, feelings of control and authenticity appear to be required to experience a sense of autonomy [14].

These preliminary findings allow us to understand that advisory systems can be a source of reliable evidence that help guide decision-making. We note that patients appear to embrace the advisory functionalities as well as the resulting feelings of control. However, the fact that patients are able to use information to help prevent an otherwise predictable seizure facilitates their sense of autonomy, but more is required to declare advisory systems an indispensable feature of their autonomy. The final section clarifies what is needed here.

Conclusion: Are predictive and advisory functionalities an indispensable feature of autonomy?

Advisory devices inform patients of the likelihood of a seizure and, therefore, implanted individuals might be epistemically justified in deciding to act in X way (e.g. take medication, 'to push', and so on) in accordance with the available information. Nonetheless they might not be all-things-considered justified in deciding X, because it might not be in their best interest. Their best interest might be trying to look at other source of available evidence or phenomenon to guide their decision rather than exclusively relying on the computer's advisory indicator.

However, what are the other sources of information that would be relevant and how could patients confirm (or disconfirm) the reliability of such information? For instance, should individuals pay more attention to their own subjective experience, such as the intuitive phenomenology of self-detecting seizures for instance? How reliable can it be? A high degree of reliability is likely equivalent to having a low degree of reliability in the falsehood of the available evidence. Being epistemically justified to decide X corresponds to a low level of uncertainty and an absence of false certainty in the above evidence. Advisory information may be, in some cases, one source of certainty amongst many others. In most cases, when all things are considered, it might be the only available certain evidence.

Being epistemically justified to decide X is essential in supporting an ethically justified decision: depending on what is reliable at the moment of deciding, it may entail the obligation to act accordingly (epistemic authority). As seen above, individuals who decide to act in a particular way, contrary to the reliable available evidence, are putting themselves at risk of seeing the prediction occurring. They thereby choose a potentially harmful alternative (e.g. epileptic seizure). An absence of reliable evidence limits and undermines autonomy. This observation seems to indicate that, in addition to Mele's conception of autonomy, reliability and epistemic accuracy of available information are criteria for autonomous decisions.

Patients deferring to device predictions are expecting accurate evidence, thereby supplementing the absence of better relevant evidence. Allowing some algorithms determining some decisions could be seen as an ethical requirement in some set of autonomous decision-making processes, especially when advisory prescriptions have reliable content that derive from a sole epistemic authority standpoint and when some neuronal event are disrupting personal autonomy. Given the above, we think there are two types of answer to our hypothesis: a weak and a strong sense in which this constitutes an indispensable feature of autonomy.

Regarding the former sense, in a context where some neuronal events act as a menace to feelings of autonomy, and when all things are considered and no other relevant evidence is available, the predictive and advisory brain devices provide an essential way for patients to retain feelings of control over their own symptoms. According to this weak sense of indispensability, when manifesting an exclusive epistemic authoritative role, not only are advisory systems not a threat to autonomy they also are a *sine qua non* feature that allows patients to maintain and exercise their full autonomy. In these circumstances, the risk of autonomy being disrupted by the encroaching symptoms outweighs any risks associated with executing an advisory prescription. Regarding the latter, the concept of indispensability would be understood in a strong sense when, even if other relevant evidence is available, predictive and advisory devices are a *sine qua non* feature that allow patients to maintain and exercise their full autonomy. We subscribe to the former sense.

We concede this article is a preliminary study. More work is required to fully comprehend ethical concerns associated with this predictive technology [17],[7] as it may share a limited number of concerns with other novel invasive brain technologies or other types of neurointerventions [18–21]. When discussing novel predictive and advisory brain technologies, more is needed to capture faithfully the concept of autonomy; in particular by exploring patients' subjective experience of being implanted [17]. The case of epilepsy is a paradigmatic example supporting the use of predictive and advisory brain devices. Epileptic seizures are unpredictable by nature; seizures are uncontrollable mostly because they offer little or no reliable evidence that they are about to occur. Consequently, seizures disrupt a patient's life in a systematic manner. Seizures are a radical discontinuity that interferes with a patient's subjective experience of enjoying her/his life as autonomous agent. The unpredictability of epileptic seizures is a major part of the resulting impairment. This observation supports the position that unpredictable and uncontrollable events impair a patient's capacity to exercise her/his autonomy. In these circumstances, advisory systems are an indispensable feature of autonomy not because predictions are likely true, but simply because executing advisory prescriptions have a greater expected utility for autonomy than not executing them.

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Zusammenfassung

Sind prädiktive Hirnimplantate ein unverzichtbares Merkmal der Autonomie?

Neuartige vorausschauende und beratende Hirnimplantate wurden zum ersten Mal erfolgreich in einer klinischen Studie mit Menschen getestet. Diese Hirnimplantate sind so programmiert, dass sie Gehirnaktivitäten vorhersagen, bevor spezifische Ergebnisse auftreten. Darüber hinaus stellen die Hirnimplantate Informationen zur Verfügung, die den Patienten helfen, auf die kommenden neuronalen Ereignisse zu reagieren. Die vorausschauenden und beratenden Informationen durch eine invasive Gehirn-Technologie bieten ein enormes Potenzial, Personen zu helfen, aufkommende Symptome zu kontrollieren und ihre Selbstbestimmung und Lebensqualität zu verbessern. Jedoch gibt es trotz dieser potenziellen Vorteile auch ethische Bedenken. Welche Rolle, wenn überhaupt, spielen die vorausschauenden und beratenden Funktionen in Bezug auf entweder Behinderung oder Ermächtigung zu einer echten Ausübung der Patientenautonomie? Noch wissen wir nichts über die Folgen dieser Funktionalitäten auf das postoperative Leben der Patienten, insbesondere die Auswirkung auf ihre Entscheidungsfähigkeit als freie und autonome Subjekte. Der Aufsatz befasst sich mit dieser «Wissenslücke» und untersucht, ob vorausschauende und beratende Gehirnimplantate ein unverzichtbares Merkmal der Autonomie sind. Der erste Teil dieses Aufsatzes bezieht sich auf die Frage, wer «die Kontrolle» hat, wenn Patienten postoperative Gefühle von «Kontrollverlust» erleben. Der zweite Teil untersucht, was moralisch falsch daran sein könnte, ein prädiktives Beratungssystem des Gehirns «unter Kontrolle» zu haben. Der dritte Abschnitt referiert die Ergebnisse einer Studie, die wir bei Patienten mit diesen neuartigen Hirnimplantaten durchgeführt haben. Unsere Schlussfolgerung ist, dass vorausschauende und beratende Hirnimplantate nicht eine Bedrohung, sondern ein unverzichtbares Merkmal der Autonomie sind.

Résumé

Nouveaux implants cérébraux prédictifs: un outil indispensable pour l'autonomie?

Le premier essai clinique humain testant de nouveaux implants cérébraux prédictifs et consultatifs a été couronné de succès. Programmés pour prédire l'activité cérébrale associée à certains symptômes, ces implants cérébraux alertent également les patients qui, grâce à l'information délivrée par ces dispositifs, sont guidés dans leurs choix et les décisions qu'ils doivent prendre pour contrôler leurs symptômes. Ainsi, cette technologie améliore la qualité de vie des patients en leur donnant un certain contrôle sur leurs symptômes. Toutefois, cette nouvelle technologie invasive cérébrale n'est pas sans soulever des questions éthiques. En particulier, il s'agit de se demander dans quelle mesure ces dispositifs prédictifs et consultatifs peuvent compromettre la capacité d'un patient à exercer son autonomie. Quelles sont en effet les conséquences de ces dispositifs sur la manière dont le patient prend ses décisions? C'est la question que pose cet article. La première section examine la question de savoir qui est «sous contrôle», vu que certains patients implantés éprouvent des sentiments postopératoires de «perte de contrôle». La deuxième section explore pourquoi il est éthiquement acceptable d'avoir de tels dispositifs «en contrôle». La troisième section présente des résultats issus d'une étude menée chez des patients implantés avec ces nouveaux dispositifs. La conclusion analyse ces résultats et explique que, plutôt que d'être une menace, de tels dispositifs cérébraux sont un élément indispensable de l'autonomie.

7 There is a large repertoire of issues to investigate here. This includes questions of resource allocation and how an epistemic authoritative standpoint may induce a relational shift from autonomy to heteronomy.

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