Mapping the emerging legal landscape for neuroprostheses: Human interests and legal resources

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Introduction

We are now within a rapidly advancing wave of innovation in neurotechnology integrated with artificial intelligence. Among the innovations are neuroprosthetic devices such as adaptive
deep brain stimulation systems that detect brain states and adjust stimulation of the brain according to those states, and mind-controlled robotic limbs. These systems blur the boundaries between the body and mind of the person and the hardware and software of the device. In addition, the device represents a novel point of access to the body and mind of the person, with the collection of streams of neural data otherwise generally inaccessible and a potential route – if networked - for inadvertent disruption or malicious hacking.

In anticipation of the possible consequences of these kinds of technologies, some have called for the recognition of novel human rights or the expansion of existing legal rights to address the impact of advancing neurotechnology on fundamental human interests in liberty, privacy, and mental integrity (Yuste et al, 2017; Sommaggio et al, 2017; Ienca & Andorno, 2017). These recent calls for the recognition of neurorights is a natural development in the age of neuroethics, neurolaw, neuromarketing, neuroaesthetics and other neuro-terms. The rapid evolution of technologies that allow for the investigation and intervention into brain function, as well as the integration of artificial intelligence, explain the level of interest, excitement and concern.

This chapter is agnostic on whether it is necessary or advisable to recognize novel neurorights, as opposed to applying existing long-standing human rights or other laws to situations involving novel neurotechnologies. Existing laws have a certain flexibility when framed generally and can incorporate novel situations as they arise, and there is a risk of “rights inflation” with the attendant devaluation of the idea of a human right when they unduly proliferate (Council of Europe, 2017). At the same time, international declarations often play an educational or hortatory role, highlighting and signalling consensus on issues of concern and encouraging anticipatory precaution even in the absence of strong legal impact.

In this chapter, we take a step backward from the specific question of the advisability of novel neurorights to ask a prior question about the types of interests human beings develop in relation to prostheses in general and neuroprostheses in particular, and the legal concepts and categories available to recognize and respond to those interests. We propose a map of these human interests as well as a legal ontology of concepts and categories. The purpose of doing this is to understand better the existing range of legal resources that are available to meet the challenges posed by the current development of neurotechnologies and their integration with artificial intelligence.

Ultimately, we propose that before pursuing novel laws, we should first ask what are the best legal tools to respond to the particular human interests affected by neuroprostheses. These might include interpretations of existing constitutional rights, modified criminal or civil code provisions, more carefully tailored privacy legislation, or adaptations of common law rules. We draw on Western legal traditions in this study, recognizing that other cultures and traditions may see the human interests and legal resources at issue differently.

1. The types of human interests in prostheses
There is a vast range of prostheses available and in development. The types of interests that humans may have in these devices is accordingly also variable and complex. Here we adopt the standard dictionary definition of prosthesis: an artificial replacement for a part of the body (Oxford English Dictionary, n.d.). It might be better to speak of replacing or supplementing a function of a body part using a device, as prostheses do not always replace body parts but instead restore or modulate bodily functions (e.g. cochlear implants, deep brain stimulation). Furthermore, with the contemporary technological developments, prostheses enhance these functions and even add new functions previously not possible, such as the introduction of new senses like magnetic implants, allowing a person to feel magnetic fields and attach metallic objects to him or herself.

Human interests are given formal recognition and protection through laws, which at the same time balances those interests against those of others, by using a legal toolkit of different types of rules and remedies. In order to think more about the manner in which the law should address human interests in prostheses, we propose a typology of these interests. The potential interests identified here relate to (1) physical integration and harm of removal, (2) phenomenological integration and the harm of disruption, (3) reliance interests and survival, (4) reliance interests and human functioning, (5) social interests and (6) informational interests. We close this section with a summary of how these potential interests are implicated in neuroprostheses.

1.1 Physical integration and the harm of removal

Prostheses vary in their degree of physical connection to the body (implanted, inserted, wearable), and the ease with which they can be attached and disconnected (Campbell et al, 2007).

Those that are implanted vary in location and in the degree to which they become biologically integrated, and therefore in the degree of risk and damage involved in removing them. For example, bone grows into metal joint replacements or dental implants (osseointegration) (Zaid et al, 2019) so that some bone damage occurs with explantation (Roy et al, 2020). The electrodes inserted into the brain for deep brain stimulation may not be integrated biologically in the same way and this therapy is commonly described as reversible, but its removal requires neurosurgery and all of its associated risks (Pugh, 2019).

The degree of risk and injury entailed by the removal of a prosthesis furnishes an important human interest in the prosthesis, and reflects the basic interest in bodily integrity and security. The degree of physical integration is a distinct interest from reliance on the device because of its function. For example, implanted devices vary in the importance of the functional reliance and a person’s life may depend upon an implanted cardiac pacemaker, while breast implants play a psychological or cosmetic purpose. In addition, some devices that have modest levels of physical integration (e.g. insulin pumps) can involve a high reliance interest.

1.2 Phenomenological Integration and the harm of disruption
Phenomenologically, some objects can be experienced as a part or extension of the body. A classic example is Merleau-Ponty’s (1962) blind man and his stick.

The blind man’s stick has ceased to be an object for him, and is no longer perceived for itself; its point has become an area of sensitivity, extending the scope and active radius of touch, and providing a parallel to sight. In the exploration of things, the length of the stick does not enter expressly as a middle term: the blind man is rather aware of it through the position of objects than of the position of objects through it. The position of things is immediately given through the extent of the reach that carries him to it, which comprises, besides the arm’s reach, the stick’s range of action. (p. 127)

After long-term use, a blind man feels that the cane is an extension of his senses, the tip of his body that helps him navigate, his hands, his eyes: the means of how he experiences the outer world. It is no more a wooden stick, but organic, even invisible. It becomes transparent (Thompson & Stapleton, 2009). Indeed, this transparency can be seen as a design objective for prosthetic technologies.

Psychological and neurological research has continued to explore the sense of one’s own body, or “body ownership,” which is a fundamental aspect of self-consciousness that is reflected neurologically. For example, neural networks containing maps of the body and peripersonal space can be significantly modified through tool use (Maravita & Iriki, 2004; Maravita et al, 2003).

There is a classical distinction drawn in neurology and psychology between the “body schema” and the “body image,” respectively representing the unconscious and conscious aspects of a continuously updated map of the body shape and posture in space (Maravita & Iriki, 2004; Constantini & Haggard, 2007). The body schema refers to an ongoing, unconscious integration of proprioceptive and other sensory signals about the body surface and external space in a way relevant to bodily actions (Maravita & Iriki, 2004). External objects can be incorporated into the body schema, which plays an important role in the use of tools by humans (Carlson et al, 2010). The body image, on the other hand, is the conscious idea or mental representation of one’s own body (Constantini & Haggard, 2007; Adame et al, 1991; Schilder, 1935). It comprises body-specific perceptions, mental representations, beliefs, attitudes and emotions (Constantini & Haggard, 2007; Cash & Brown, 1987; Gardner & Moncrieff, 1988; Powers et al, 1987).

An illusion of body ownership called the Rubber Hand Illusion arises when a person watches a rubber hand that is stimulated synchronously with his own unseen hand, causing the rubber hand to feel as if it is the person’s own hand. Further studies on the Rubber Hand Illusion also suggest that the feeling of body ownership can extend to prostheses (Thompson & Stapleton, 2009; Tsakiris et al, 2006). The exact degree of human flexibility in incorporation of external objects into the body schema is uncertain (Tsakiris & Haggard, 2005; Constantini & Haggard, 2007) although some experiments suggest considerable flexibility if the conditions are right (Ma & Hommel, 2015). Based on their experiments on body ownership and the
incorporation of external objects using a virtual balloon and square changing in size and color in synchrony with movements of the subjects’ real hands, Ma and Hommel (2015) concluded that, 

people seem to be relatively liberal in accepting all sorts of objects to become part of their body, if they can control relevant features and the behavior of these objects, and in particular if the objects seem physically connected to their body. In other words, people perceive as their body everything that expresses their intentions, including things within reach that move ‘as they wish’ (p. 85).

De Vignemont (2010) proposes that an object should be considered embodied if some properties of the object are processed in the same way as the properties of one’s body. Relying on studies with the Rubber Hand Illusion, tools and virtual reality, she distinguishes three categories of measures of embodiment: spatial measures, motor measures and affective measures. Spatial measures of embodiment are most commonly discussed, and refer to the processing of the object spatially as if it fell within one’s body space. Motor measures of embodiment are more often discussed in studies of tools and virtual reality, and have to do with the sense that one’s body directly obeys one’s will. This is distinct from the sense of control over an object that is not embodied. Affective measures of embodiment refer to the behavioural and physiological responses of self-preservation to the threat of injury, and if one reacts to threats to or injury of an object in the same way as one reacts when a part of the body is threatened or hurt, then it is affectively embodied. For example, participants in virtual reality experiments show a similar affective reaction to vertigo when they see their virtual avatar at a stressful virtual height (de Vignemont, 2010, citing Meehan et al, 2005). The three measures of embodiment are not always correlated. An embodied tool – a spoon used to stir boiling soup – does not meet the affective criterion (de Vignemont, 2010). Ultimately, de Vignemont (2010) notes that the degree, type and mechanisms of embodiment can be highly variable (pp. 85-86).

For our purposes here, we propose that there is a human interest in objects that are phenomenologically integrated with the body, even if they are not physically integrated. The extent of that phenomenological interest likely depends upon the degree of brain reorganization provoked by the use of prosthesis and the extent to which the removal of the prosthesis would be disturbing. It will also depend on the type of embodiment. Perhaps objects that are affectively embodied such that physiological and emotional threat responses are provoked when the object is threatened should receive particular protection. Justifications for that protection are the idea that psychological well-being should be protected from harm and also that interferences likely to generate retaliation should be discouraged.

1.3 Reliance Interests and survival

Another important form of human interest in prostheses has to do with reliance or dependence, whether or not it is physically or phenomenologically integrated or not. The degree and type of reliance may differ according to the prosthesis. At the most extreme, a prosthesis may be essential to the continued survival of the person so that the person can be said to have a
“survival interest” in the prosthesis. These might be implanted, like a cardiac pacemaker, or external like a ventilator.

During the COVID-19 pandemic, discussions about ventilator triage policies raised great concern among people with disabilities who feared that not only would they be deprioritized for access to ventilators if they became ill, but that if they were already using them, these might be removed and given to another patient. This issue arose during the earlier preparation by the New York Department of Health of Ventilator Allocation Guidelines to be used in the event of a severe influenza pandemic. Joseph J. Fins, a member of the task force that wrote the guidelines explained how the group discussed the identification of the pool of ventilators that would be subject to allocation. In particular the question was whether a person who used a ventilator due to a chronic disability might lose the ventilator to the collective (Fins, 2020). He recounted how the disability scholar and bioethicist Adrienne Asch drew a distinction between a ventilator in chronic use to maintain the health of a person with a pre-existing lung condition and a ventilator used in response to an acute pandemic.

Asch argued that the chronic ventilator was part and parcel of that person. As such it was not subject to being commandeered in a crisis. It was theirs, not the collective’s. However, if that same person was admitted to the hospital and needed to make a claim on a more sophisticated ventilator because of a new severe illness, then they would be subject to the same assessment as everyone else (Fins, 2020).

These concerns have been articulated in the context of COVID-19 triage as well. Alice Wong of the Disability Visibility Project, was quoted more recently:

My vent is part of my body — I cannot be without it for more than an hour at the most due to my neuromuscular disability. For clinicians to take my vent away from me would be an assault on my personhood and lead to my death (Ne’eman, 2020).

A neuroprosthesis such as a spinal cord stimulator to address chronic pain may also be life-saving given the association between chronic pain and suicide (Racine, 2018). As a woman with chronic pain for whom this therapy was helpful put it: “If I did not have that nerve stimulator in my back, I would have committed suicide a long time ago” (Weiss, 2018).

Some emerging cognitive prostheses suggest that a psychological form of the survival interest may lie in prostheses that support personal identity-constituting aspects of the mind. For example, hippocampal memory prosthetics are being explored for use to improve memory formation in Alzheimer’s patients (Hampson et al, 2018). Memory is essential for psychological continuity of the person as it binds together the temporal stages of the same person. John Locke defended consciousness and memory as the criteria for personal identity: to be one and the same person is to have the memories of events that befell the earlier person.

As far as [a] consciousness can be extended backwards to any past action or thought, so far reaches the identity of that person; it is the same self now as it was then; and it is by
the same self with this present one that now reflects on it, that that action was done (Locke, 1813, II.XXVII.9, p.313).

Our way of knowing that we are one and same over time seems to rely on memory. It is a person’s past memories that convince him that he persists in time. It is not necessary that one remember all the events that one has experienced, but what is needed is continuity of memory, a chain of “memory-connected person-stages.” Understood in this sense, a memory-supporting prosthetic becomes indispensable for the survival of the person.

1.4 Reliance interests and human functioning

Clearly, a survival interest in the prosthesis represents perhaps the strongest possible reliance interest, because without it both physical and psychological continuity of the person are at risk. A lesser, but still potentially substantial, form of reliance would exist where a person relies upon the prosthesis to replace or restore an important physical or mental function – a “functional interest.” The strength of these functional interests will lie upon a continuum related to the importance of the particular function to the person’s well-being. Prostheses may address mobility impairments. They may restore or improve deficits in sensory perception, as with cochlear implants, hearing aids, retinal implants (Ayton et al, 2020), contact lenses and eyeglasses.

An example of prosthesis serving a primarily mobility-related functional interest comes from the story of Mr. Collins, a physically disabled veteran whose “fully functional powered mobility assistance device” or MAD was damaged in transit by an airline company (Glenn, 2012). The MAD was an advanced technology, quite different from an ordinary wheelchair, which Collins could not use. The airline agreed to fix the “wheelchair” promptly, but it was not until nearly a year later that it was eventually replaced. During this time Collins was confined to his home and essentially bedridden, suffering decubitus ulcers and having to hire helpers to run errands. In the ensuing debate over appropriate compensation, the airline maintained that this was a baggage claim incident so that Collins was not entitled to compensatory damages, and that damages were minimal as the device was fully replaced. His lawyer explained how the MAD was more than just a manual wheelchair, but “operated as an extension of Mr. Collins’ body, functioning as his lower limbs and lower torso muscles,” and that since the MAD was an extension of Mr. Collins, harming the MAD constituted bodily harm to Mr. Collins. The adjuster ultimately offered a higher sum, which was acceptable to the client. The story of the MAD illustrates how the functional importance of the device was invoked to argue for a preferred legal outcome.

In addition to replacing or enhancing a mobility or sensory function, prostheses may serve a mental or psychological function. Admittedly the distinction being drawn here between physical and mental functions is dualistic, and reflects the limits of current knowledge about how the mind relates to the body. However, we follow this prevalent mode of thinking here because it is reflected in legal thinking.
Prostheses may serve a mental function in at least two different ways. First, they may work by altering the mental (cognitive, affective or behavioural) properties of the person. Second, they may serve a primarily psychological purpose even if they do so indirectly by, for example, restoring lost physical body parts. Examples of the latter are prostheses used for cosmetic purposes, like a prosthetic eye, which aims to restore the self-image of the person, even if it does not restore the function of the lost body part. And of course, a prosthesis may do both – it may support both physical function and help to restore a compromised body image (Desmond et al, 2012; Murray, 2004 citing Pereira et al. 1996).

An example of the first type of prosthesis intended to address mental functions is deep brain stimulation (DBS), in which implanted electrodes stimulate targeted pieces of brain tissue to alleviate neurological conditions like Parkinson’s disease. DBS is increasingly being explored for a broad range of psychiatric and behavioural problems including depression, OCD, eating disorders, aggression and addiction (Fitzgerald & Segrave, 2015). Depending upon the severity of the symptoms and the efficacy of the treatment, the degree of reliance upon the mental prosthesis will vary. It may in fact be lifesaving in the case of suicidal depression that is lifted by DBS, as illustrated in the vivid account presented in a 2019 episode of the podcast Invisibilia of a young woman who received DBS for debilitating to OCD and depression (NPR, Invisibilia, 2019).

The extended mind hypothesis of Clark and Chalmers (1998) offers another context in which to explore how a person may rely upon prostheses to serve a mental function. We do not discuss the critiques and responses provoked by the extended mind hypothesis here, but raise it for what it might mean normatively about the possible human interests in objects supporting cognitive functions. This hypothesis holds that cognition always takes place through coupled cognitive systems including the human organism and things external to the body, and so the mind should not be considered as limited to the contents of the skull. In later discussion of what it would take for an external thing to be part of a person’s cognitive system, Clark proposed additional criteria that have come to be known as the “trust and glue” criteria that require the external thing to be reliably available, typically invoked and quasi-automatically trusted. As Clark (2006) puts it, these are “equipment (like the carpenter’s hammer) with which we are so familiar and fluent that we do not think about it in use, but rather rely on it to mediate our encounters with a still-wider world.”

Clark and Chalmers (1998) raised the normative consequences of their idea at its launch:

There are obvious consequences for philosophical views of the mind and for the methodology of research in cognitive science, but there will also be effects in the moral and social domains. It may be for example, that in some cases interfering with someone’s environment will have the same moral significance as interfering with their person (p.18).

The idea is clear that by virtue of the reliance on external objects as part of mental functions, a person should, in some cases, be protected against interference with those objects. The circumstances in which this should be the case are less clear, given the potential competing interests of others. Sterelny (2010) critiques the extended mind idea, suggesting that the
examples that motivate it are better understood as instances in which we have modified and become dependent upon our environments.

Many of the examples that motivate the extended mind picture can be seen as special cases of niche construction, cases in which human competences depend intimately on the environment being scaffolded to support adaptive decision making. [...] We have engineered our gustatory niche; we have transformed both our food sources and the process of eating itself. Our under-powered jaws, short gut, small teeth and mouth fit our niche because we eat soft, rich and easily digested food. Our digestive system is environmentally scaffolded. But is my soup pot, my food processor and my fine collection of choppers part of my digestive system? As far as I know, no one has defended an extended stomach hypothesis, treating routine kitchen equipment as part of an agent’s digestive system; indeed “extended stomach” and “extended digestion” on Google Scholar return some very strange hits (pp.466-468).

For our purposes, it may not matter too much whether the extended mind hypothesis offers the best conceptualization of the mind, or its critics are correct. In either case, we may have interests in objects in the environment because of our reliance upon them for important mental functions. This may justify a demand for protection, but it does not necessarily follow that it is necessary to conceptualize those objects as part of the person in order to do so. It may be adequate to treat them as important pieces of property.

The distinction between therapy and enhancement is also relevant to this discussion of functional reliance interests in prostheses, given the tendency to recognize greater legal rights to therapy than to enhancements. For example, the UN Convention on the Rights of Persons with Disabilities obliges signatories to support access to devices and assistive technologies suitable for persons with disabilities (UN CRPD, 2008). A similar governmental obligation to support technological enhancements for those without disabilities has not been recognized. The distinction between therapy and enhancement is contested, obscure, and shifting, but one influential division is the line between what is considered normal or “species-typical” (Boorse, 1975; Savulescu et al, 2011). Therapy restores functions to “normal” levels while enhancements move functions “beyond normal”. This distinction is imperfect even if one accepts it as the appropriate one to draw, as a prosthesis may go beyond species-typicality and so be both therapeutic and enhancing. Oscar Pistorius’ Cheetahs - prosthetic limbs which were more efficient than natural limbs – became the subject of dispute when he sought to compete in the Olympic Games (Corrigan et al, 2010). Or the therapy may provide a substitute ability that is not species-typical. For example, Neil Harbisson’s antenna gave him access to a sonic version of colour despite being colour blind (Jeffries, 2014).

In any event, many would dispute the normative significance of the therapy – enhancement distinction. Welfarists tie enhancement to well-being, and could see both therapy and enhancement as “subclasses of enhancement” because they both “increase the chances of a person to lead a good life” (Bracanović, 2016 as cited in van Houwelingen, 2018; see also Savulescu et al, 2011). Transhumanists and proponents of cyborg rights argue for individual
liberty to integrate and use technologies that transcend “species-typical” functions, essentially stating a broad functional interest in prostheses that need not be limited to those supporting the standard type or degree of human functions (MacKinnon, 2017; Balkan, n.d). These arguments sometimes go further than asserting liberty interests in the use of technology to a range of positive rights claims (Clarke, 2010; Transhumanist Bill of Rights, 2018), or to a reconceptualization of the boundaries of the human being:

The relationship of a human being to digital technology is that of an organism to its organs. The digital organs of a human being can reside both within (implants) and without (explants) their biological borders. Therefore, we recognize that, [...] The boundaries of human beings in the digital age extend beyond their biological boundaries to encompass the greater boundary of their cyborg selves and include the digital organs by which they extend themselves (Balkan, n.d).

We do not try to resolve the issue of the normative importance of different types of functional interests in prostheses here. Instead, we suggest that the degree of legal protection recognized to protect these functional interests in prosthetic technologies is likely to vary according to the importance of the function served by the prosthesis (an importance which will vary by society and over time), as well as according to the weight of any countervailing interests or policy reasons that would justify limiting that legal protection.

1.5 Social Interests

We propose another set of human interests in prostheses having to do with the way a prosthesis may be significant to social identity and relationships. The terminology is not meant to suggest that the types of interests based on physical or phenomenological integration or reliance do not also have social dimensions, but that these constitute a different form of interest that need not be associated with integration or functional reliance.

By social interest, we have in mind a form of social psychological function, where the use of a particular object is important for social relations or social identity. The example, cited above, of the prosthetic eye shows that an object may serve a psychological interest in bodily self-image, but it might also serve to increase social confidence and smooth social interactions. The use of certain clothes or body modifications (e.g tattoos) can function as social messages signifying group membership (Ramachandran, 2017). Some of these objects are fungible, so that if a culturally specific piece of clothing is lost or destroyed it can be easily replaced by another version. Others – like a wedding ring – are unique.

The topic of hair and wigs illustrates the possible social significance of prostheses. A recent English case addressed the coerced cutting of a woman’s hair:

In my judgment, whether it is alive beneath the surface of the skin or dead tissue above the surface of the skin, the hair is an attribute and part of the human body. It is intrinsic to each individual and to the identity of each individual. [...] an individual’s hair is relevant
to his or her autonomy. Some regard it as their crowning glory. Admirers may so regard it in the object of their affections. Even if, medically and scientifically speaking, the hair above the surface of the scalp is no more than dead tissue, it remains part of the body and is attached to it. While it is so attached, in my judgment it falls within the meaning of "bodily" in the phrase "actual bodily harm". It is concerned with the body of the individual victim (DPP v. Smith, 2006, cited in Bennett, 2019).

Much more can be said about the social significance of hair, hair-coverings, wigs and the law. Hair-coverings are used by some Muslim and Orthodox Jewish women for religious reasons and also as markers of social and cultural identity (Howard, 2017). With respect to the Muslim veil, the law has become involved in some jurisdictions, requiring it to be worn in some places and banning it in others (Howard, 2017), pointing to the social significance of this object. The use of specific clothing and wigs when in the presence of others is important to identity and dignity in non-religious contexts as well, such as in cases involving the treatment of transgender prisoners during the jail intake process (Pryor v. SF City and County, 2013; Shaw v. District of Columbia, 2013). Discriminatory treatment involving “appearance-related items” such as wigs or clothing is addressed in the police department policies pertaining to the “Processing and Housing of Transgender Arrestees” cited in the 2013 Shaw case. These policies make it clear that the same rules are to be applied with respect to “appearance-related items” to transgender and non-transgender people, and further items are not to be removed unless they present a safety hazard or constitute criminal evidence:

Restrictions on the wearing of appearance-related items must be consistent with restrictions on the wearing of similar items for non-transgender individuals. Appearance-related items, including, but not limited to, prosthetics, clothes of the presenting gender, wigs, or make-up should not be confiscated or removed from transgender individuals unless such items present a safety hazard or are needed for evidentiary reasons (MPD Transgender Order cited in Shaw v. District of Columbia, 2013).

Admittedly, hair, veils and wigs are not precisely what we would have in mind when thinking of prostheses, even if they do show how social identity may become involved in the use of an external object. An example that is perhaps more obviously about a prosthesis is the cochlear implant. This is an implanted neuroprostheses that stimulates the cochlear nerve and may address severe hearing loss. A considerable social debate has arisen over the use of cochlear implants in children, with the suggestion that it constitutes “ethnocide” of Deaf community (Sparrow, 2010). From the perspective of some critics, these neuroprostheses threaten a minority linguistic culture that faces considerable challenges, and their use also makes an important social cultural choice for young children.

1.6 Informational Interests

We also propose a form of informational interest in prostheses. We have in mind here the manner in which a prosthesis may serve as an “access point” to the person by making information about the person accessible to other people. Certain advanced prostheses are able
to collect and store physiological data, and others are connected to the Internet to facilitate remote medical oversight. Medtronic’s new deep brain stimulation device Percept, delivers therapeutic stimulation to the brain and gathers ongoing data about brain activity. The company explains that the Percept device will feature “BrainSense technology designed to capture brain signals (local field potentials, or LFP) using the implanted DBS lead. These signals can be recorded simultaneously while delivering therapeutic stimulation, inside and outside the clinic” (Medtronic, 2021).

It is certainly true that more and more personal information is being made accessible about people’s behaviour by virtue of increasing technologies of surveillance and communication, as well as more powerful data processing and cheaper data storage. Telematics devices given to insured drivers track and record driving behaviour. The term “digital exhaust” refers to the “trackable or storable actions, choices, and preferences that we generate as we go about our daily lives” (McFedries, 2013). This rich stream of behavioural data permits others to draw inferences about our identities and personal characteristics. The medical use of this digital exhaust is called “digital phenotyping” and refers to the idea that digital footprints on social media and other digital devices and platforms can be used to measure and predict health – particularly mental health (Montag et al. 2020). Thus the fact that prostheses may also contribute to this collection of information might seem to be no more than a small incremental addition. Nevertheless, there are key differences – prostheses may directly record kinds of physiological data not revealed in digital exhaust, and furthermore, only the information of users of the prostheses will be exposed. To the extent that prostheses are used by people who are already vulnerable due to functional impairments, the greater informational exposure of already vulnerable groups may cause concern. Concern is building that networked devices and prostheses might not just represent a store of information about the person, but might also represent an access portal through which harm can be done by hacking prosthetic devices (Matwyshyn, 2019).

Another class of possible informational interest has to do with software incorporated within prostheses. The ability of the user to access and modify that software, and conversely the continued rights of the maker of that software, raise questions about self-ownership and self-determination.

1.7 Summarizing the human interests in neuroprostheses

To conclude with this section, we propose a range of possible types of human interests in prostheses, some of which seem particularly important for neuroprostheses.

Various existing types of neuroprostheses such as implanted chips for brain-computer interfaces, DBS, cochlear or retinal implants, or spinal cord stimulators all involve surgically implanted components, and so raise the risk of physical harm associated with removal or damage. On the other hand, a brain-computer interface that works through electroencephalography (EEG) at the surface of the scalp will not raise this type of interest.
One can imagine that neuroprostheses might become phenomenologically embodied, if their use becomes sufficiently effortless and immediate to become transparent (Heersmink, 2013). Some, like the cochlear implant, may meet these criteria. Hallberg and Ringdahl’s qualitative study (2004) of the experiences of 17 adult patients largely addressed the user’s interpretations of the experience, but some observations point to phenomenological experiences: “After varying periods of time, sounds became more familiar and a natural part of the ‘taken-for-granted’ environmental background sounds” (p. 120).

Neuroprostheses also likely raise a range of reliance interests. Survival of the physical person may be supported via alleviation of suffering that poses a risk of suicide and the psychological person may be supported through memory prostheses. A multitude of functional reliance interests are also possible, given the range of motor, sensory, and cognitive functions that neuroprostheses may serve.

Finally, interpersonal interests flowing from the influence of the neuroprostheses on social relations and as a point of access to the person are also clearly raised by devices of advancing complexity that can collect, store and transmit physiological data, or that are networked and permit a novel point of access to the body and mind via the neuroprostheses.

2. How does the law approach prostheses?

Human beings exist and survive through the use of objects – both animate and inanimate – and methods or techniques of acting or thinking that help us to meet our needs. Through these means of existence, human beings acting in social communities have shaped themselves and their environments over millennia. Laws and legal systems – techniques themselves – arose to order human behaviour in ways conducive to that continued co-existence and survival (although the Anthropocene suggests questions about their ultimate efficacy in doing so). Given the centrality of objects, tools and techniques to human existence, it is no surprise that human beings have a deep interest in them, as well as in the impact of their use by others.

The law uses a variety of categories – a legal ontology – that distinguishes aspects of the legal person or subject, as well as a range of tangible and intangible things or objects. This classification is important, as different legal rules and concepts apply to each category. For example, legal rights and duties are held by or imposed upon legal persons; only objects may be treated as property. Furthermore, the degrees of legal protection against harm that are given to the bodily integrity of persons, to psychological aspects of persons, and to property typically differ (see e.g. Quigley & Ayihongbe, 2018). The particular rules may vary within these categories. Legal persons contain sub-categories, and the sub-category of natural human persons is assigned different rights and duties than other entities with more limited legal personhood (e.g. corporations). The same can be said of things, where different rules apply to various classes of inanimate or animate things (e.g. animal welfare rules), tangible or intangible things (e.g. intellectual property, debt instruments like mortgages, insurance policies), and so on.
Successive waves of technological innovation have always posed challenges to legal systems because they create new human capabilities and also threats and risks, often with important effects on the users of the technologies, other people, and society. Sometimes these technological innovations have profoundly challenged the then existing laws, and required innovation in legal categories and concepts to adequately recognize and address the relevant human interests, and the interpersonal balancing of competing interests. One example of a technologically-induced change in the fundamental concepts of the law is the development of the concept of brain death as a direct result of the invention of mechanical ventilation (Machado, 2007).

Challenges arise for the law where an entity appears to cross between these various categories and sub-categories, or appears to be a hybrid between them. In these cases, there might be confusion about the applicable rules, particularly if they point to inconsistent results. As an example, the natural human body would normally be viewed as governed by rules that recognize and strongly protect rights to bodily integrity as well as its non-alienability (i.e. it cannot be owned or transferred as property). However, parts of that body, such as DNA, cells, tissues, organs, hair etc. can be detached, leading to questions about whether they continue to be governed by the full range of rules related to the natural human body, or instead acquire attributes of property that can be transferred to and owned by others. Furthermore, the importance of detached parts of the body may lie not in their physical manifestation but instead in their information content (i.e. a cheek swab taken by the police is not as important for its removal of skin cells as it is for the DNA informational content). Here, questions about the nature of the rules to apply to that information content arise; to what extent does that information remain “of the person” so as to attract protection from acquisition, use or dissemination by others. For example, does the constitutional protection against unreasonable search and seizure prevent the state from taking buccal swabs to obtain DNA along with fingerprinting and photographing a person arrested for probable cause to hold for a serious offense (see e.g. Maryland v. King, 2013)? In a further example, should genetic privacy laws prohibit insurers from using DNA sequences in determining insurability and setting premiums (Genetic Information Nondiscrimination Act of 2008)?

In addition to uncertainty about how to classify a part of the body, one can also imagine cases in which several categories seem simultaneously applicable – a hybrid legal entity – where several sets of legal rules and principles could apply and inconsistencies would need to be resolved. For example, an implantable radiofrequency ID (RFID) chip could be viewed simultaneously as body, property and repository of information, with the last perhaps having the most significance. These chips, often used to identify pets, can and are also implanted in human beings to identify them for the purpose of linking to important information (e.g. medical history, allergies), or the purpose of performing actions (e.g. making payments, unlocking doors) (Gasson, 2010).

In this section, we offer an overview of the legal categorization of persons, bodies, tangible and intangible objects, and personal information, in order to review the options
available for categorizing prostheses and recognizing the range of human interests in prostheses. As related above, the claim that a prosthesis is part of the body is often made. In some cases, this appears to be a metaphysical claim about the boundaries of the body, and in others it is meant to suggest that the prosthesis should be treated as if it were part of the natural body – attracting the same strong level of protection given to bodily integrity.

2.1 Law’s Persons and Things

As a starting point, the Western legal perspective is primarily anthropocentric. The human person is the central subject, surrounded by animate and inanimate things or objects – flora, fauna, movable and immovable objects (Grear, 2015). This division, i.e. summa divisio, was articulated by the Roman jurisconsult Gaius in his *Institutes*: “Now, all the law that we make use of pertains either to persons or to things or to actions” (Trahan, 2008 p.9; Reiter, 2008; Deming, 2001). Similarly, the later *Institutes* of Justinian state that "[a]ll of our law is related either to persons or to things or to actions" (Kelley, 1979, p.626) and the person-thing divide is presently reflected in the laws of both civil law and common law countries (Reiter, 2008, p. 190; Kurki, 2017). This dominant juridical architecture structures the legal apprehension of the world, and forms the foundation for the fundamental legal categories of the legal person and property (Pottage, 2004; Rose, 1984).

The set of legal persons is not strictly congruent with the set of human persons, and, furthermore, who or what exactly counts as a legal person has changed over time. At one point, whole classes of human beings, such as women, children and slaves were excluded from legal personhood (Gaakeer, 2016). Today, all human beings are legal persons, and non-human objects and abstractions such as rivers and corporations have limited forms of legal personhood (Bryson et al, 2017; Solaiman, 2017).

The law clearly recognizes and differentiates between physical and psychological interests of human persons. It imposes liability for a variety of actions causing physical harm (e.g. homicide, battery), emotional or psychological harm (e.g. threats, tortious infliction of psychiatric harm, harassment, invasion of privacy) and psycho-social harm (e.g. defamation).

The legal person, as a subject or holder of legal rights, is able to hold things or objects as property. The historically shifting concepts of persons and property is illustrated by Aristotle (Reeves’ translation, 1998): “Some tools are inanimate... and some are animate. The ship captain’s rudder, for example, is an inanimate tool, but his lookout is an animate one; for where crafts are concerned every assistant is classed as a tool. So a piece of property is a tool for maintaining life [...] a slave is a piece of animate property of a sort; and all assistants are like tools for using tools.” (Aristotle, 1998 trans. Reeves, 1253b27–33)

Over time, the law recognized new categories of things that could be held as property, namely creative works of authorship subject to copyright, and patents in new and useful inventions. These property rights in artistic creations and useful inventions can be transferred to others, like many other kinds of property.
The law also recognizes personal interests in intangible things that are not property. For example, privacy laws provide protection against the collection, use and disposition of personal information (i.e. information about an identifiable individual) by others. Moral rights subsist along with copyright in works of authorship, but reflect the author’s personality rights as opposed to property rights and so may be waived but not transferred to others. They include the right of attribution to the author as well as right to the integrity of the work (see e.g. Copyright Act, 1985).

We turn now to consider the key legal categories relevant to advanced neuroprostheses: the body, the physical object, and intangible components (personal information and software).

2.2 Objects as parts of the human body

Various external objects come to be incorporated within human bodies. Some of this is so familiar as to be invisible, such as the ingestion and biological incorporation of food, air and water, all of which lose their separate status and merge with the body. Similarly, transplanted tissues like blood or vital organs lose their separate status and become part of the body even if the biological incorporation in the case of organs is not perfect and requires the suppression of the immune response. If we turn to non-biological physical objects, we can discern a broad range of artifacts used by human beings that vary in their physical proximity to the body, as well as their importance to human existence as physical, psychological and social beings.

The legal approach to this range of objects varies, in recognition of the differing relationships represented along this continuum of proximity and importance. The psychological, social, and legal importance of physical distance is illustrated by theories such as proxemics, which is the social scientific study of the human use of space and its causes and effects on social relationships. Cultural anthropologist Hall (1966) described the interpersonal distances of persons as follows according to their proximity to other persons: (1) intimate space, (2) personal space, (3) social space, and (4) public space. Neuropsychology also describes personal space in terms of nested spheres based on proximity from the body: (1) percutaneous space (2) peripersonal space and (3) extrapersonal space (Elias & Saucier, 2006).

The graduated territoriality of human beings is recognized in the strong legal protection given to the human body and things attached to it, with generally lesser protections given to property. For example, the permissible scope of self-defence, which excuses violence done in protecting one’s person is greater than the permissible scope of defence of property. For instance, it is clear in Canadian criminal law that the defence of property does not justify the intentional killing of a trespasser, but self-defence could do so (see e.g. R. v. Gunning, 2005).

The importance of physical proximity is illustrated by the common law tort of battery, which is the intentional infliction of harmful or offensive bodily contact. No harm need be done for liability to ensue, and indeed unwanted helpful or even life-saving contact would be a battery – a legal wrong. The interesting point, from the perspective of the proximity of objects, is that the tort of battery is also committed when one interferes with anything that a person is carrying,
wearing, or riding upon (see e.g. Linden and Feldthusen, 2006, p.44) In assimilating these objects to the person, the law is acknowledging the psychological incorporation of these objects into the personal sphere, and is both vindicating the person’s perceived boundaries and trying to deter behaviour that is likely to generate self-defensive reactions. This point is made clear in the American Restatement of the Law, Torts 2d:

Since the essence of the plaintiff’s grievance consists in the offense to the dignity involved in the unpermitted and intentional invasion of the inviolability of his person and not in any physical harm done to his body, it is not necessary that the plaintiff’s actual body be disturbed. Unpermitted and intentional contacts with anything so connected with the body as to be customarily regarded as part of the other’s person and therefore as partaking of its inviolability is actionable as an offensive contact with his person. There are some things such as clothing or a cane or, indeed, anything directly grasped by the hand which are so intimately connected with one’s body as to be universally regarded as part of the person. On the other hand, there may be things which are attached to one’s body with a connection so slight that they are not so regarded. The line of distinction is very difficult to draw. It is a thing which is felt rather than one to be defined, since it depends upon an emotional reaction (Restatement (Second) of Torts § 18, 1965).

The consequentialist idea that a law should be designed to deter actions likely to provoke socially disruptive retaliation also has a deontological foundation, namely that there is a sphere of belongings to which each person is entitled and that the violation of that sphere justifies forceful retaliation. The 17th century natural law philosopher, Grotius, explained that in the state of nature prior to the invention of private property in civil society, everyone is free and equal and each individual is entitled to a personal sphere that belongs to him or her: the suum (Mancilla, 2015). But what is included in that suum that we are commanded by natural law to respect? For Grotius, the answer is to be found in human nature: reasonable and sociable creatures retaliate forcefully to the invasion of the suum and we learn “what we cannot do to others without expecting them to strike back” (Mancilla, 2015, p.70). As Mancilla (2015) puts it, the motivational force of this minimal morality is that we do not want to be harmed and so quickly learn to respect the boundary between our own suum and that of others (p. 71).

The suum consists of two classes of things: what is ours by nature, and what becomes ours when we perform the first seizure of an object or occupation of a space (Olivecrona, 1975, p. 112). Among those things that are ours by nature are the elements needed for physical self-preservation - life, body and limbs (vita, corpus, membra) - and, since we are social animals requiring others to subsist, the elements needed for social existence - honour and reputation (honor, fama) (Olivecrona, 1975, p. 113; Olivecrona, 1974, p. 213; Mancilla, 2015 pp. 69, 72). The content of the latter evidently varies more among cultures and over time than the interests in physical self-preservation. At the same time, we live through the use of external things, and our proactive actions of seizing objects and occupying space allow these things to become part of our suum (Mancilla, 2015, p. 75).
By acknowledging our need and dependence on external factors, Grotius's moral theory depicts the human individual not as a mind trapped in a body malgré lui, but rather as an embodied self in permanent and necessary interaction with his environment - so much so that this environment is transformed by his very actions into a constitutive part of him. Owning oneself only makes sense, then, if one can also own what is needed to support oneself (Mancilla, 2015, p. 75).

The combined importance of the physical proximity and functional importance of an object is reflected in French cases cited by Bertrand-Mirkovic (2003). In a case dealing with a dentist who retained a denture for non-payment when the patient attended for other dental treatment, the court distinguished between objects that are not integrated into the person and medical prostheses that become part of the person once put in place. It suggested that the denture was an object as the patient was able to voluntarily remove the denture and eat without it, even if it improved chewing. On appeal, however, the Cour de Cassation overturned the decision, on the basis that the relevant article of the Code of Civil Procedure, which allowed for the seizure for non-payment of objects necessary for handicapped persons did not apply to “objects that are an integral part of the human person” (trans.) (Bertrand-Mirkovic, 2003, fn 1219).

Civilian legal scholars addressing the status of the human body have noted the distinction between objects that are part of the person by nature (“personne par nature”) and those that are part of the person because their purpose or function is to be part of the person (“personne par destination”) (Ducor, 1996; Labbée, 1990). This idea is drawn from Roman real property law, which recognizes mobile objects as part of real estate when it is integrated with it (accessorium sequitur principale). Ducor notes that the common law equivalent is the notion of fixtures to real property (Ducor, 1996, p.207). Citing from Labbée, Ducor suggests that when applied to the human body “this means an artificial prosthesis should also be treated and protected as a body part at the moment it is integrated with the body. In other words, the prosthesis legally ‘disappears’ when it is embodied in the subject or the person” and becomes a “personne par destination” (Ducor, 1996, p. 208; Labbée, 1990, p. 251). He extends the analogy to real property law further, however, observing that Roman property law allows a mobile accessory that is not integrated with real estate to be part of it nonetheless if it is needed by the owner:

As applied to human materials, any device necessary to the functioning of the person would be personne par destination as soon and as long as the owner attaches it to his person. The physical integration with the body would no longer be necessary. Accordingly, all prostheses, whether physically integrated or not, could be personne par destination. This concept extends to many prostheses: removable dentures, artificial limbs, hearing aids, glasses, lenses, crutches, and so forth. Conversely, the prosthesis recovers its former status of object when the person decides to end the assignment of the device. One could change glass frames, for example. This line of reasoning would create, however, problems in borderline cases like wigs, in which a clear definition of what is necessary to the person would be essential (Ducor, 1996, p.208).
Together these varied accounts drawn from different legal cultures suggest that things that are physically proximate and/or functionally essential could be treated as part of the body or at least as part of the person. Additional objects of lesser importance might still attract legal protection but would fall outside the suum.

Margaret Jane Radin’s (1982) personhood theory of property, developed based upon Hegel (1821), adds an additional useful element to understanding the human relationship to objects as reflected in the law of property. She focuses on the psychological incorporation of objects into the person. Radin suggests that people identify themselves with certain forms of property, and that these play an important role in the constitution of their personhood.

Most people possess certain objects they feel are almost part of themselves. These objects are closely bound up with personhood because they are part of the way we constitute ourselves as continuing personal entities in the world. They may be as different as people are different, but some common examples might be a wedding ring, a portrait, an heirloom, or a house. One may gauge the strength or significance of someone’s relationship with an object by the kind of pain that would be occasioned by its loss. (p.959)

She identifies a continuum ranging “from a thing indispensable to someone’s being, to a thing wholly interchangeable with money” or from personal or constitutive to fungible (Radin, 1982, pp.986-987; Radin, 1993). Radin notes that the law reflects this gradation in practice, recognizing and treating some property as more important and more stringently protected than other property. An example of how this continuum is reflected in the law is the different valuation of compensation for damage to property. In tort law, the measure of damages for a fungible item is the lesser of its diminution in value, replacement value or cost of repair, whereas the measure of damages for a unique, psychologically valuable item like an heirloom is more likely to be the cost of repair (Cassels, 2015, p.86-88). Similarly, bankruptcy laws require the forfeiture of the bankrupt’s property to compensate creditors, but typically exempt certain classes of property. The statutes of the various Canadian provinces specify the exempted classes of property, which usually include items essential to subsistence but also sometimes property whose value is related primarily to the personhood of the bankrupt: items needed for religious services (e.g. Executions Act, C.C.S.M. c. E160, s. 23(1)(g) (Manitoba)), pets (e.g. Enforcement of Money Judgments Act, SNB 2013, c.23, s. 85(f) (New Brunswick)), items of sentimental value up to a certain dollar value (e.g. Judgment Enforcement Act, SNL 1996 c.J-1.1, S.131(1)(f) (Newfoundland and Labrador)), family papers, family portraits, medals and other decorations (e.g. Code of Civil Procedure, CQLR c.C-25.01 s.694(4) (Quebec)). Objects can be constitutive of collective identity, and not just individual personhood. Culturally sensitive objects are protected under constitutions and international human rights or indigenous rights instruments (e.g. United Nations Declaration on the Rights of Indigenous Peoples, 2007; Native American Graves Protection and Repatriation Act, 1990).

The dimension of time is also a factor reflected in the legal treatment of property interests. This is reflected in Grotius’ concept of the suum, where the first person to occupy a space or to seize an object from the common acquires a greater right to it than others, as well as
in substantive legal doctrines from a wide range of legal systems that prioritize the interests of the party first in time in establishing initial property rights – the “rule of first possession” (Lueck, 1995). Another legal example of the importance of time are the rules that allow the acquisition of legal rights based on continuous possession or occupation of property even without the permission of the legal owner – for example, the rule of adverse possession or “squatter’s rights” (Epstein, 1986). So we can see here that it is not just physical proximity, functional necessity or psychological integration that is recognized as important in the law, but also the length of time during which a person has used or occupied property. Uninterrupted use over time allows for reliance on continued use to develop, as well as the psychological dimensions of attachment and perceived entitlement.

Together, this overview illustrates that there is a mixed spatio-temporal-functional relationship between the human body and objects. The factors of physical proximity, psychological closeness or functional importance of the object lead to different legal categorizations and levels of protection. Some objects are integrated into the body or are treated by law as part of the body particularly when worn or held close to the surface of the body or used to fulfil an essential bodily function. Others may continue to be perceived as external to the body but may still be viewed as lying on a continuum of importance and connection to the person, and the extent of the protection for rights in that object would reflect that.

**2.3 Human body parts as objects**

Having explored the legal understanding of the relationship between the human body and objects, we turn to the opposite question of when the law might view the human body or its parts as objects. As noted above, the legal “objectification” of the entire human body is reflected in the institution of slavery. One of the important legal consequences of being classified as an object as opposed to a legal person or subject, is that an entity is prima facie eligible to be treated as property that can be owned, entailing the rights to exclude others, to use the property and to transfer it. Whether or not human beings or their parts can be treated as objects and/or property has varied over time and place.

Even if human beings can no longer legally be treated as objects or property today, some separate parts of the body can be. Detachment is important to transform the bodily part or substance into something capable of being treated as property, although this detachment alone does not guarantee that it will be treated as property, nor does it make it clear who will own that property.

[The physical detachment of biological materials generates the necessary normative distance between a living individual and separated biological materials. This distance enables separated biological materials to be transformed into things that are, in principle, capable of being the subject of property rights [...] Even though detachment may transform biological materials into things potentially the subject of property rights, it does not follow that property rights are necessarily created on the separation of biological materials. The creation of property rights may depend on circumstances that are different]
from the physical detachment. The work and skill exception, for example, creates property rights following the application of work or skill to separated biological materials. Prior to the application of work or skill, these materials are not ‘property’ but things that are merely capable of being the subject of property rights (Hardcastle, 2007, pp. 127-128).

Heubel (1998) describes a German case in which sperm collected for fertility preservation purposes prior to surgery was discarded by the clinic. The court reasoned that separated bodily parts were property, but if they were intended or “destined to be returned” “to fulfil a function typical of the body” then they continued to “form a functional unity with the body” such that “to interfere with this unity against the wishes of the legal subject is bodily injury.” (p.29). In doing so, the court emphasized the significance of the bodily material for bodily integrity, the person’s right to self-determination and self-realization. When the Court described the nature of the object to be protected by law, it quoted one of the famous commentaries: "The good to be protected [...] is not the matter, but the field of being and determination of the person, which is given material form in the bodily state." (Heubel,1998, p.30)

A kidney may be removed from the human body and given to another person for transplantation. It is an example of a body part that may become a transferrable object, although, in most parts of the world, the person who donates the kidney does not have the full range of legal rights that usually are associated with property (e.g. the right to sell the property for money). While the existence of organ black markets is an undeniable global fact, Iran has instituted a regulated market for kidneys (Ghods & Savaj, 2006). Other “renewable” body parts or substances can be sold for monetary compensation in parts of the world, including hair, blood, breast milk, and gametes (Crawford, 2012). Major legal disputes have arisen, however, over whether biological materials derived from bodies can constitute property, and if so, who owns them (Hardcastle, 2007, p. 125; Moore v Regents of the University of California, 1988, 1990; Greenberg v Miami Children’s Hospital Research Institute, 2003; Washington University v Catalona, 2007).

A further question concerns the status of a prosthesis after explantation. While in the body, it is plausible that it would receive the kinds of legal protections against interference accorded to the body. However, its status when removed from the body or after the death of the person is less certain. It is expected that some types of devices be returned to the manufacturer for quality control and post market surveillance after explantation (Runge et al, 2017; Hutchison & Sparrow, 2016). Runge et al. (2017) suggest that patients, physicians, device manufacturers and insurers could all claim the explanted device. The legal answer seems to vary by jurisdiction. In some locations, an implant remains part of the estate of a deceased person unless there is a specific provision to the contrary (e.g. DHSS 1983, cited in Quigley & Ayihongbe, 2018). For example, the Oklahoma Attorney General was asked to provide a legal opinion in 2009 about whether funeral directors, embalmers and funeral establishments could retain compensation for providing prosthetic devices and implants to recycling companies. The Attorney General concluded that implants and prosthetic devices remaining after cremation are the property of the personal representative of the deceased.
Since the prosthesis recovers its former status of object once the person decides to end the assignment of the service, thus, a strong argument supports the concept that once implants and prosthetic devices are no longer needed or attached to a person’s body, they become property, whether or not they were considered property prior to this separation (Oklahoma Attorney General, 2009).

The question of whether body parts can become objects, and whether those objects are treated like ordinary property, does not directly tell us about the categorization and legal protection of prostheses. However, it serves to illustrate how physical proximity (detachment) and/or bodily functionality and/or intention to use continue to be the important characteristics underlying the status of body parts. This mirrors the analysis above regarding when objects either come to be treated as parts of the body or attract particular protection not granted to ordinary objects.

2.4 Information and Intellectual Property

As discussed above, Grotius’ suum, or that which belonged by natural law to the person included not just elements central to physical existence, but also the social capital of honour and reputation. In addition, other intangibles associated closely with the person have come to be legally recognized, such as personal information or the intellectual creations protected by intellectual property and moral rights. These two dimensions of information and intellectual property take on a new importance due to the increasing computing and telecommunications capabilities of prostheses.

The pacemaker furnishes a good example. Pacemakers are now able to collect and retain physiological data which would not ordinarily be available about the user. The prosthesis as repository of information creates a point of informational access to the person, and this has already led to legal consequences. In the case of Ohio v Ross Compton (2016) a man was found guilty of arson and insurance fraud after a fire at his home. He claimed that he was asleep when his house caught fire, and that he packed some belongings in a suitcase and bags when he awoke, broke the window and threw the bags out before climbing out himself and taking the bags to his car. Police obtained a search warrant for the electronic data stored on his pacemaker, and a cardiologist who reviewed the data found it was “highly improbable” Compton would have been able to do all of the things he claimed. Compton sought to have his pacemaker data excluded as violation of his constitutional rights, and as protected by doctor-patient privilege. These claims were both rejected in March 2019, and Compton’s appeal of this decision was cut short due to his death (Pack, 2020). Here a question arises as to whether a person’s integrated medical device, having become part of the body, can be used to incriminate the person in a criminal proceeding in this way. In another case, the judge admitted the Fitbit data of a victim to be used against a murder suspect (Owens, 2020).

Neuroprostheses like adaptive deep brain stimulation devices also rely upon the collection of physiological data in order to adjust the level of brain stimulation. In principle, this could raise issues of informational access to neural data – who might be entitled to that data,
and for what reasons? Legal scholars are now evaluating the adequacy of existing data privacy laws to address some of these emerging forms of prostheses, such as brain-computer interfaces (e.g. Greenberg, 2019).

As prostheses are connected to the Internet to enable remote medical oversight, they also become vulnerable not just to breaches in the privacy of any stored personal information, but also to inadvertent or malicious damage to the integrity of that information and the functioning of the devices. The cybersecurity of prostheses and the appropriate legal responses are active areas of discussion (e.g. Bonaci et al, 2015; Gladden, 2017; Das et al, 2020), and the FDA recently recalled several insulin pumps due to their potential cybersecurity risks (FDA, 2019). Another possible risk is posed by teleprogramming of deep brain stimulators, a development that was already being discussed prior to the COVID-19 pandemic, but has accelerated as a result of it (Lin et al., 2020; Chirra et al., 2019).

Another important trend in the continued evolution of prostheses is the incorporation of forms of artificial intelligence, which allows the prosthesis to adjust to the user’s needs over time. Examples include the “artificial pancreas” consisting of an insulin pump responsive to an implanted glucose monitoring device (FDA, 2018) or adaptive deep brain stimulation device to deliver stimulation when the onset of an epileptic seizure is detected (e.g. Neuropace, 2021). Artificial intelligence may also be used in shared control systems, as with a “smart wheelchair” that decodes neural signals collected via EEG and supplemented with a variable degree of device autonomy (Deng et al, 2020) and mind-controlled prosthetic limbs using AI algorithms are no more science-fiction (Ortiz-Catalan et al, 2020).

The incorporation of artificial intelligence within complex modern prostheses means that they will consist of both hardware and software, which have tended to be protected by different legal regimes. The object itself is physical property while the software is treated as a form of intellectual property protected by copyright and the use of software is permitted under end-user license agreements (EULAs) limiting what users can do to and with the software (Matwyshyn, 2019; Lee et al, 2020). An issue to clarify as intelligent prostheses continue to evolve is the extent of the legal rights of the user in relation to the software running on his or her prosthesis, considering these are black-boxes governed by EULAs typically unilaterally imposed by the developers (McGowan, 2016), and with possible risks in the case of a cybersecurity breach (Ienca et al, 2016; Camara et al, 2015) or complications linked with upgrades (Lee et al, 2019).

A last, admittedly speculative example, illustrates the possible legal complexities ahead regarding informational content derived from neuroprostheses. It is true that mental contents – ideas – can already be externalized and converted into works attracting both intellectual property rights and moral rights. Bruston (2014) takes this point further, asking whether the visual content decoded directly from the brain – a “mind movie” – could be a copyrightable work of authorship.

2.5 Summarizing the law’s approach to neuroprostheses
In the absence of established case law, we are forced to speculate about how the laws are likely to apply. That being said, a neuroprosthesis appears to fall within multiple legal categories at once. It consists of tangible hardware and intangible software, which itself is becoming increasingly complex and may include elements of artificial intelligence.

When placed within or on the physical body of a person, considerations such as proximity or functional necessity sometimes lead to its being conceptualized as part of the physical body, or at least in a class of objects that attracts higher legal protection than ordinary objects. However, even if it is not conceptualized as part of the body, but remains an external object categorized as property, a sliding scale of protections is in place to recognize the characteristics and importance of differing types of property to the person. For example, courts have found ways to address new concepts by borrowing from established principles of property law like the accessio institution, to determine which human interests merit a higher degree of legal protection.

With the advancing ability to record and store data, and to link bodily devices into an Internet of Bodies ecosystem (Lee et al, 2020), advanced neuroprostheses raise additional issues regarding the status and security of that informational content. While it resides on the physical substrate of the device and is communicated involving wired and wireless telecommunications equipment, the essence is the intangible information and information flows, which will require continued legal analysis to determine if existing intellectual property law, privacy law, and civil and criminal laws applicable to hacking networked devices are adequate.

Conclusion

It is increasingly the case that prosthetic technologies are offering replacements for bodily functions, such that biological body parts and non-biological technologies may come to be more and more interchangeable and the boundaries of the corporeal self more and more fluid.

Legal systems are constantly called upon to address seemingly novel problems as societies and technological capacities evolve. They accordingly adjust existing rules or adopt new ones to achieve the desired legal results. In our view a first step is to identify the central human interests at stake with the adoption of increasingly complex neuroprosthetics. It is necessary to both understand those key interests and the potential threats to those interests in order to begin to select the proper legal tools to respond. Our work here focused on this first step. We addressed the place of these new technologies in the human-object continuum. We then proposed a typology of candidate human interests that are raised by prostheses, including neuroprostheses: (a) physical integration and harm of removal, (b) phenomenological integration and the harm of disruption, (c) reliance interests and survival, (d) reliance interests and human functioning, (e) social interests and (f) informational interests.

In a second step, any countervailing interests must be examined and weighed to determine the type and level of legal recognition and protection to accord to the central human
interests at stake in the use of neuroprostheses. For example, how should the intellectual property interests of the creators of neuroprostheses be managed if they conflict with the desires of users of the neuroprostheses? Should limits be placed on the use of neuroprostheses that generate behavioural side effects that pose a risk to users or to others, or that instead enhance user capacities in competitive contexts to the detriment of the unenhanced? Should society be obligated to make neuroprostheses available and to whom? On what grounds will users’ legal claims be recognized and how will their interests be balanced against those of hardware/software developers and society at large?

Finally, the array of existing legal rules and categories should be examined to determine whether they already adequately address the central interests, or could be adapted to do so. If not, novel concepts may need to be created. However, as discussed, the law is tremendously plastic, as evidenced by the flexibility of the concept of legal personhood, which has expanded to encompass rivers and corporations in order to access the legal consequences that this status permits. Similarly, aspects of neuroprostheses may be legally treated as part of the body where the rules applicable to bodies seem appropriate, or instead left as forms of property, where that, instead, seems to allow for the best tailored legal response.

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