NEUROMARKETING APPLICATIONS OF NEUROPROSTHETIC DEVICES: AN ASSESSMENT OF NEURAL IMPLANTS' CAPACITIES FOR GATHERING DATA AND INFLUENCING BEHAVIOR

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ABSTRACT

Neuromarketing utilizes innovative technologies to accomplish two key tasks: 1) gathering data about the ways in which human beings' cognitive processes can be influenced by particular stimuli; and 2) creating and delivering stimuli to influence the behavior of potential consumers. In this text, we argue that rather than utilizing specialized systems such as EEG and fMRI equipment (for data gathering) and web-based microtargeting platforms (for influencing behavior), it will increasingly be possible for neuromarketing practitioners to perform both tasks by accessing and exploiting neuroprosthetic devices already possessed by members of society. We first present an overview of neuromarketing and neuroprosthetic devices. A two-dimensional conceptual framework is then developed that can be used to identify the technological and biocybernetic capacities of different types of neuroprosthetic devices for performing neuromarketing-related functions. One axis of the framework delineates the main functional types of sensory, motor, and cognitive neural implants; the other describes the key neuromarketing activities of gathering data on consumers' cognitive activity and influencing their behavior. This framework is then utilized to identify potential neuromarketing applications for a diverse range of existing and anticipated neuroprosthetic technologies. It is hoped that this analysis of the capacities of neuroprosthetic devices to be utilized in neuromarketing-related roles can: 1) lay a foundation for subsequent analyses of whether such potential applications are desirable or inappropriate from ethical, legal, and operational perspectives; and 2) help information security professionals develop effective mechanisms for protecting neuroprosthetic devices against inappropriate or undesired neuromarketing techniques while safeguarding legitimate neuromarketing activities.

Keywords*:* *neuromarketing; neuroprosthetics; neural implants; consumer behavior; marketing; biocybernetics; neurocybernetics; brain-computer interfaces (BCIs); information security; privacy*

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INTRODUCTION

Ongoing developments in the field of neuromarketing are being made possible by innovative applications of various technologies. For example, neuromarketing researchers and practitioners rely on instruments such as EEG and fMRI equipment to gather data about the ways in which potential consumers respond on a subconscious or unconscious level to the contents of advertisements or other stimuli. Once such insights have been developed, websites, email, and social media platforms and other technologies utilizing microtargeting approaches can be applied to deliver personalized advertising messages that are shaped to maximize their appeal to an individual recipient.

In this text, we argue that the emerging technologies of sensory, cognitive, and motor neuroprosthetics are creating powerful new tools that can potentially be used by neuromarketing professionals both for gathering data about the cognitive activity of potential consumers and for influencing their behavior. Rather than immediately developing an ethical, legal, or business analysis of the case for or against utilizing neuroprosthetic devices in such neuromarketing-related roles, our focus in this text is on the conceptually prior task of formulating a comprehensive framework for analyzing the technological and biocybernetic capacities of neuroprosthetic devices to be employed in such roles.

It is hoped that this conceptual framework can inform further investigations of the propriety and desirability of neuroprosthetically facilitated neuromarketing approaches from ethical, legal, and business perspectives. Such a framework can also facilitate the work of information security (InfoSec) professionals in two ways. First, InfoSec personnel must develop effective mechanisms for protecting neuroprosthetic devices against external actors' deployment of neuromarketing techniques that are considered unwelcome by the users of such devices or which are inherently unethical or illegal. Second, InfoSec personnel must ensure that those forms of neuromarketing conducted by means of neural implants that are acceptable to and authorized by the devices' users are performed in a way that suitably protects the confidentiality, integrity, and availability of information belonging to all of the stakeholders involved in those activities. Developing and employing frameworks such as the one described in this text will become especially important as the number of human beings who possess neural implants continues to grow: while such devices are currently employed primarily to treat particular medical conditions, it is anticipated that their increasing use for purposes of human augmentation and elective enhancement will continuously expand the portion of society that utilizes such technology. Moreover, due to the kinds of enhanced capacities that neuroprosthetic devices may grant and the great expense, surgical risks, and other obstacles involved with the acquisition of such devices, the groups of people who possess neuroprosthetic implants for medical or augmentative purposes may tend to disproportionately manifest particular cognitive, biological, professional, or

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socioeconomic characteristics (such as holding senior-level positions in business or government or possessing above-average levels of wealth) that make them especially attractive targets for particular kinds of neuromarketing. It is thus important to understand the full spectrum of ways in which neural implants might be employed for neuromarketing purposes.

Before our two-dimensional framework is presented, it will be helpful to briefly review the nature of neuromarketing and neuroprosthetic devices.

AN OVERVIEW OF NEUROMARKETING

The concept of 'neuromarketing' has been defined in various ways. Some definitions seek to position neuromarketing primarily as an academic discipline that analyzes consumer behavior through the lens of neuroscience. Lee et al. (2007, p. 200) emphasize the academic aspect, arguing that "neuromarketing as a field of study can simply be defined as the application of neuroscientific methods to analyze and understand human behaviour in relation to markets and marketing exchanges." Other definitions position neuromarketing primarily as a business practice; for example, for Fisher et al. (2010), neuromarketing can be "defined as marketing designed on the basis of neuroscience research […]." Still other definitions span both spheres, positioning neuromarketing as the applied branch of the academic field of 'consumer neuroscience' (Fisher et al., 2010).

In both its academic and applied forms, neuromarketing seeks to help businesses and other organizations understand how particular stimuli (such as the words or images used in TV advertisements or the background music played in retail stores) influence potential consumers' behavior; however, it does this not by asking individuals for their conscious reaction to stimuli but by directly monitoring biological activity in the brain or other organs in order to detect subconscious or unconscious cognitive responses that the individuals themselves cannot clearly describe or do not even realize that they are manifesting (Fisher et al., 2010). Such research might, for example, measure how consumers' 'willingness to pay' (WTP) for different products and services is influenced by the presentation of different stimuli (Ariely and Berns, 2010). In order to gather such data, neuromarketing utilizes technologies such as electroencephalography (EEG), magnetoencephalography (MEG), functional magnetic resonance imaging (fMRI), Galvanic skin response (GSR), electrocardiography (EKG), electromyography (EMG), and eye tracking to detect responses to stimuli (Fisher et al., 2010; Lee et al., 2007; Morin, 2011; Ariely and Berns, 2010).

Applied forms of neuromarketing utilize the knowledge obtained by means of such technologies in order to craft designs for products and packaging, advertising messages, website content, and other goods, communications, or stimuli that are formulated to maximize the positive response on the part of

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potential consumers. Although accounts in the popular media sometimes focus on the perceived danger that neuromarketing techniques might allow businesses or other organizations to illicitly manipulate the brain and coerce consumers into taking actions against their own will, when used ethically neuromarketing practices can play a positive role in matching consumers with the goods and services that they most truly desire (Ariely and Berns, 2010). Neuromarketing techniques can be applied effectively in such diverse areas as the development of TV advertisements for food products, the architectural design of new buildings, and the management of political campaigns (Ariely and Berns, 2010).

AN OVERVIEW OF NEUROPROSTHETIC DEVICES

Neuroprosthetic devices are pieces of technology that are directly integrated into the human body's neural circuitry (Gladden, 2015b, p. 20; Gladden, 2016; Lebedev, 2014). At present, such neuroprostheses are typically invasive devices designed to be surgically implanted in the body of their human host (often, though not always, within the brain itself); while non-invasive technologies such as EEG and fMRI equipment may be utilized as brain-computer interface (BCI) technologies in a broader sense, they are not generally considered to be neuroprostheses insofar as they are not "integrated into the neural circuitry" of their human subject in a direct and long-term manner. While future technological advances may yield a growing range of non-invasive neuroprostheses that can be incorporated into an individual's neural circuitry without physically entering the brain, for purposes of this text the phrases 'neuroprosthetic device' and 'neural implant' can be considered roughly synonymous. Neuroprostheses should not be confused with passive RFID tags or other kinds of implantable devices that may provide valuable information relating to their host's physical location or movements but which – because they are not integrated into a host's neural circuitry – do not directly gather information about or influence a host's cognitive activity.

Classification of Neuroprostheses by Function

Particular neural implants can be described as *sensory*, *cognitive*, or *motor* neuroprostheses; a neural implant may also combine more than one of these functions in a single device (Lebedev, 2014; Gladden, 2015b).

Sensory neuroprostheses provide sense data to the brain of their human host. Most existing sensory neuroprostheses are utilized for purposes of treating medical conditions; such devices already in use include cochlear implants and artificial retinas (Koops and Leenes, 2012; Gladden, 2015b, pp. 22-24). However, the use of sensory neuroprostheses for purposes of human augmentation and enhancement has already begun on an experimental basis and is expected to grow in the coming years; such

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technologies might, for example, provide a human subject with telescopic or infrared vision or the ability to hear ultrasonic frequencies (Warwick, 2014; Gasson et al., 2012; Merkel et al., 2007).

Cognitive neuroprostheses affect cognitive processes and phenomena internal to the brain of their human host (Gladden, 2015b, pp. 26-27), including imagination (Cosgrove, 2004; Gasson, 2012), emotion (Soussou and Berger, 2008), conscious alertness (Kourany, 2013, pp. 992-93), and the sense of personal identity (Van den Berg, 2012). While it is not possible to precisely edit the contents of memories within a human mind using existing cognitive neuroprosthetic technologies – and may never be possible, if the nature of memory storage within the brain is sufficiently holographic or holistic (Levy, 2010, p. xv) – experimental technologies have, for example, already been developed that can create or erase simple memories in the brains of mice (Ramirez et al., 2013; Han et al., 2009).

Motor neuroprostheses, meanwhile, either detect motor instructions within the brain of their human host and convey them to some external system or generate motor instructions which the brain itself is not able to provide (Lebedev, 2014; Gladden, 2015b, pp. 24-26). Such devices allow their hosts to control robotic prosthetic limbs, motorized wheelchairs, or computers (Donchin and Arbel, 2009); are used to treat conditions such as bladder function disorders, swallowing disorders, and sleep apnea; provide a means of communication for paralyzed patients suffering from ALS, traumatic brain injury, or stroke (Taylor, 2008); and can potentially be used to treat conditions such as epilepsy (Fountas and Smith, 2007), Alzheimer's disease, anxiety disorders, bulimia, and addictions (Ansari et al., 2007) or to allow their users to control external networked systems such as drones or 3D printers (Gladden, 2015a).

Biocybernetic Aspects of Neuroprosthetic Devices

The field of cybernetics offers a transdisciplinary theoretical framework and vocabulary that can translate insights between the diverse range of disciplines that study patterns of communication and control in machines, living organisms, or social systems (Wiener, 1961). In the case of neuroprosthetic devices, such processes of communication and control involve both the devices themselves and the biological organisms in which they are implanted. When neural implants are viewed from a biocybernetic perspective, one considers not only their internal physical components and behaviors but also the ways in which they interact with a host's organism through executing, sharing in, or being affected by processes of communication and control.

While the interaction between a neural implant and human host may be relatively simple and unidirectional (such as when a cochlear implant electrically stimulates the cochlear nerve to present auditory sense data to the mind of its human host), a growing number of neuroprosthetic devices create complex biocybernetic feedback loops that allow their human users to both manipulate some

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external physical or virtual environment and then sense the ways in which that environment has been altered as a result of their actions (Gladden 2015a; Fairclough, 2010; Park et al., 2009).

FORMULATING A TWO-DIMENSIONAL FRAMEWORK CAPTURING POTENTIAL NEUROMARKETING APPLICATIONS OF NEUROPROSTHETIC DEVICES

In addition to deploying specialized equipment (such as dedicated fMRI and EEG devices) to gather data about consumers' responses to stimuli and relying on customized tools such as microtargeting websites and TV advertisements to deliver the marketing messages that are developed as a result, we suggest that it will increasingly be possible for neuromarketing professionals to accomplish both tasks by utilizing neuroprosthetic devices that have already been implanted in members of the public for therapeutic or augmentative purposes and which possess direct access to the neural circuitry of their human hosts.

We would argue that such potential applications of neuroprosthetic devices for neuromarketing can be effectively identified and analyzed with the assistance of a two-dimensional conceptual framework that reflects: 1) the different functional types of neuroprosthetic technologies; and 2) the fact that a given technology can be employed either to gather data about consumers' cognitive activity or to influence consumers' behavior.

It should be noted that the conceptual framework presented in this text is intended to capture the full universe of potential neuromarketing applications of neuroprosthetic devices that are expected to become *technologically feasible* during the coming years; it is not, however, claimed that all (or even any) potential applications identified through use of this framework are *ethically meritorious or legally permissible*. Indeed, one of the anticipated uses of the proposed framework is to aid government policymakers, ethicists, neuroprosthetic device manufacturers, InfoSec professionals, and neuromarketing researchers and practitioners to identify new ethical questions and concerns that result from the increasing availability within the general population of implanted neuroprosthetic devices that can be exploited for neuromarketing purposes and to develop more robust legal and regulatory frameworks, industry best practices and ethics guidelines, and InfoSec countermeasures and controls to address such possibilities.

We can now consider each of the framework's axes in more detail.

First Axis: Functional Types of Neuroprosthetic Devices

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One axis of the framework delineates the main functional types of neuroprosthetic devices – namely, 1) sensory, 2) cognitive, and 3) motor neuroprostheses. There is not a separate category for hybrid neuroprosthetic devices that combine multiple types, such as a bidirectional sensorimotor neuroprosthesis in the form of a robotic prosthetic arm that allows a human amputee to both feel the pressure of an object held within the robotic fingers' grasp and to control the fingers' motion through his or her thoughts; such a hybrid device could be analyzed within this framework as though it were a set of separate sensory and motor neuroprostheses.

Second Axis: The Role of Gathering Data or Influencing Behavior

The second axis of our framework describes two critical roles that a particular technological device might play within the practice of neuromarketing: 1) gathering data about potential consumers' cognitive activity; or 2) influencing potential consumers' behavior.

At present, the more widely accepted and employed use of neurotechnologies in neuromarketing is in gathering data about the way in which the brain of a potential consumer responds to different kinds of stimuli (Lee et al., 2007; Fisher et al., 2010; Morin, 2011). For example, neuromarketing research has used EEG and MEG technologies to study how the brain reacts differently to various kinds of advertisements and which types of formats and elements can be employed to optimize the processes of attention, memory, and trust that are needed to cultivate brand recognition and loyalty in consumers who are exposed to such advertisements (Lee et al., 2007, p. 201).

A more controversial role that neurotechnologies might possibly play within the field of neuromarketing is that of influencing or even directly controlling the behavior of consumers. Certainly, the use of technological media such as TV advertisements to influence consumers' actions is a longstanding and widely accepted practice. However, neurotechnologies provide new and potentially vastly more powerful tools for attempting to shape consumers' behavior. Such influence can be created either indirectly (e.g., through the creation of cybernetic sensorimotor feedback loops that incentivize and 'train' consumers to behave in particular ways) or directly, through the immediate artificial stimulation of neurons within the brain. While it is not feasible to directly influence consumers' neural activity without their knowledge or consent employing current technologies like EEG and fMRI (Fisher et al., 2010; Murphy et al., 2008, pp. 297-98), such actions might be possible in the future if consumers' existing neuroprosthetic implants could be accessed and exploited (Bonaci et al., 2015) by neuromarketing practitioners.

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TYPE OF NEUROPROSTHESIS	POTENTIAL NEUROMARKETING APPLICATION: Gathering Data on Cognitive Activity	POTENTIAL NEUROMARKETING APPLICATION: Influencing Behavior
Sensory Neuroprosthesis	• Access to sense data received or transmitted by a device may reveal information about its host's focus of attention (e.g., direction of gaze) or biological processes (e.g., the sounds of breathing or heartbeat). • Altered or fabricated sense data may be supplied to the host via the device so that his or her reaction can be observed via the device or other means.	• 'Real' sense data may be replaced with altered or fabricated data intended to elicit a particular automatic biological response (e.g., physical discomfort, increased stress, or drowsiness). • Sense data may be altered or fabricated in order to create certain beliefs in the host's mind and elicit in response some conscious action that the host would not otherwise perform.
Cognitive Neuroprosthesis	• Emotional states, the focus of the host's attention, and the general nature of a host's current thoughts may be discernible, even if not otherwise outwardly detectable. • The contents of existing memories and associations held within the host's mind may be detected (if only in a broad sense).	• A host's mood or emotional state may be altered in order to make particular behaviors more or less likely. • A host's conscious alertness may be increased or decreased. • Existing memories may be altered or new memories created in order to generate a desired conscious or unconscious response from the host when later exposed to specific stimuli.
Motor Neuroprosthesis	• Access to motor instructions received by a device from a host's brain may reveal information about the host's thoughts, volitions, and physical state that is not otherwise detectable. • A device's motor behavior may be altered in a particular way in order to observe the host's response.	• A device may directly stimulate or control action of the eyes (e.g., shifting the host's gaze), heart (altering the heart rate), limbs and digits (reaching toward an object), or other organs. • Behavior of a device (e.g., a motorized wheelchair or robotic limb) may be altered in a way designed to elicit a particular conscious or unconscious response by the host.

Figure 1. *Figure 1. For each of the three types of neuroprosthetic devices (sensory, cognitive, and motor neuroprostheses) it is technologically and biocybernetically conceivable that such a device could be used for the two key neuromarketing roles of gathering data about the cognitive activity of the device's human host or influencing the host's behavior. Examples of such applications are described in this diagram.*

Completing the Framework

When the two axes described above are combined, they yield a matrix of the sort depicted in Figure 1. For each of the six fields within the matrix, a description is shown of ways in which that type of neuroprosthetic device might fill that type of neuromarketing role, based on the device's technological and biocybernetic characteristics.

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TECHNOLOGICAL AND BIOCYBERNETIC ASSESSMENT OF POTENTIAL NEUROMARKETING APPLICATIONS OF NEURAL IMPLANT TYPES

Having formulated this two-dimensional framework, we can now use it to identify capacities possessed by particular types of neuroprosthetic devices that are already in use or whose development is being pursued that can allow them to be employed in the dual neuromarketing roles of gathering data about the cognitive activity of the devices' human hosts or influencing the hosts' behavior. As noted earlier, the analysis of sensory, cognitive, and motor neuroprostheses presented below is not an assessment of the ethical or legal propriety or commercial desirability of utilizing neuroprosthetic devices for such purposes but rather a technological and biocybernetic assessment of the capacity of neural implants to be employed in such ways by an organizational or individual actor who wishes to utilize them in such a manner.

Sensory Neuroprostheses: Assessment of Potential Neuromarketing Applications

The commercial utilization of BCIs to detect covert mental states in the devices' human hosts for purposes of carrying out neuromarketing activities is noted by Brunner et al. (2011) as an emerging application for BCIs. One form that this activity might take is the exploitation of sensory neuroprosthetic devices that are already implanted in human hosts for medical or augmentative purposes in order to gain access to data about the hosts' cognitive processes. From a technological perspective, it is possible to perform such actions either with the knowledge and consent of a device's human host (e.g., if the individual 'opts in' to allowing a marketing firm or other company to have limited access to data contained in his or her sensory neuroprosthesis) or in a surreptitious and likely unlawful manner (e.g., by compromising or replacing the components of an already existing BCI device (Bonaci et al., 2015)). Data received or transmitted by a sensory neuroprosthesis and made available to neuromarketers might reveal information about its host's focus of attention (e.g., by decoding information from an artificial retina to detect the direction of its host's gaze) or biological processes (e.g., by filtering the audio data generated by a cochlear implant to detect its user's heart rate or breathing patterns). Moreover, altered or fabricated sense data representing particular stimuli might be supplied to the host's brain via the sensory neuroprosthesis so that the host's unconscious reaction could be observed using the device itself or another mechanism.

It is also technologically possible for various kinds of sensory neuroprostheses to be used legitimately or illicitly to influence the behavior of their human hosts. Daigle (2010, p. 40) notes that manipulation of the sensory signals reaching the brain can be used as a means of influencing or controlling the brain's behavior; for example, by hacking the artificial retinal implants of a human host and providing him or her with fabricated visual information that creates a particular (mistaken) belief about the host's

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environment or physical state, the host could be induced to enact certain conscious physical responses that he or she would not otherwise perform. (For example, a host who is artificially made to feel thirsty or to falsely perceive that all of the other patrons of a restaurant are greatly enjoying their beverages might himself or herself choose to order a drink.)

Bublitz (2011, pp. 111-12) distinguishes between 'indirect' and 'direct' interventions in an individual's cognitive processes: *indirect interventions* include the presentation of stimuli to sensory organs (e.g., in the form of music, spoken language, or TV advertisements) that are processed by the brain along with all other external environmental stimuli, while *direct interventions* include techniques such as deep brain stimulation (DBS) and transcranial magnetic stimulation (TMS) that use technological means to artificially and directly stimulate neurons within the brain. According to that schema, the use of sensory neuroprosthetics to influence a host's behavior will typically constitute 'indirect' interventions, while 'direct' interventions might be performed more readily, for example, through the manipulation of cognitive neuroprosthetics.

Cognitive Neuroprostheses: Assessment of Potential Neuromarketing Applications

There are numerous ways in which already-implanted cognitive neuroprostheses could potentially be utilized by neuromarketers to gather data about the cognitive activity of their human hosts. Through access to data contained in such devices, a host's emotional states, the focus of a host's attention, and the general nature of a host's current thoughts may be discernible, even if they are not otherwise outwardly detectable. While it might not be theoretically possible for a neuroprosthetic device to identify complex semantic content of specific memories, it may be possible for a cognitive neuroprosthesis to determine on the basis of neural signals that, for example, its human host is listening to a particular piece of music (Horgan, 2004). Even generalized access to the contents of cognitive processes might help accomplish neuromarketing goal such as that of identifying "the relationship between smells and colors of food products" (Lee et al., 2007, p. 200).

Influencing a host's behavior through the use of an implanted cognitive neuroprosthetic device is also quite feasible. For example, deep brain stimulation can be employed to alter a user's moods (Bublitz, 2011, p. 116). Kohno et al. (2009) and Bublitz (2011, pp. 97-98) explicitly consider the possibility that hackers might illicitly access neural implants that have been installed in human hosts for legitimate therapeutic purposes such as DBS and use them to influence their hosts' thoughts, moods, and emotions in order to directly shape their behaviors as consumers – i.e., for purposes of neuromarketing. Analyzing the mind-altering effects of DBS that have already been demonstrated, Rowland et al. (2013) similarly raise the question of whether brain-machine interface devices might be used for 'cognitive

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control.' It is also known that transcranial magnetic stimulation can affect the formation of volitions (Bublitz, 2011, p. 116). TMS devices induce an electric current in neurons in order to facilitate or inhibit synaptic activity; such tools have been used by researchers to temporarily take particular brain regions 'offline,' thereby allowing researchers to determine how the brain's performance of specific tasks is affected by impairing the functioning of those regions (Ariely and Berns, 2010). Having gained such knowledge through their use, the same or similar technologies could potentially be employed to elicit or block particular kinds of cognitive activity. It has also been shown that commercially available BCI technologies can already be used to develop 'brain spyware' or 'BCI-enabled malicious applications' which, for example, can electrically stimulate the brain to impede users' responses when they are lying (Bonaci et al., 2015, p. 35; Luber et al., 2009).

Moreover, if neuroprosthetic implants can store memories – thus serving as a sort of 'supplemental memory' to the storage capacity of the brain's natural biological neural network (Daigle, 2010, p. 37; Gladden, 2015b, pp. 148-49) – then any mechanism that can manipulate or alter the contents of such devices could be used to influence future behaviors that are dependent on or affected by such memories. Noting researchers' assessment of DARPA's ongoing $40 million Restoring Active Memory (RAM) and Systems-Based Neurotechnology for Emerging Therapies (SUBNET) programs to develop next-generation implantable neuroprosthetics for treating memory and cognitive disorders, Talan (2014, pp. 9-10) cites "a growing concern that the manipulation of brain networks" by means of such devices "could be used as a form of mind control." Similarly, Krishnan (2014, p. 10) notes the possibility that an actor might compromise an implanted neural device in order to influence or control the behavior of its human host; he distinguishes the application of such 'mind hacking' to exercise short-term control over its host's body versus using it to effect a permanent 'rewiring' of the host's memories or behavior (Krishnan, 2014, p. 10).

Motor Neuroprostheses: Assessment of Potential Neuromarketing Applications

There are various means by which conventional motor neuroprostheses already implanted in human hosts could potentially be utilized by neuromarketers to gather data about the cognitive activity of those hosts. For example, access to motor instructions received by a device from a host's brain may reveal information about the host's thoughts, volitions, and physical state that is not otherwise detectable (Gladden, 2015b, pp. 24-26). It may also be possible to disrupt, control, or otherwise alter a device's motor behavior in a particular way in order to observe the host's response to that unexpected stimulus.

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A motor neuroprosthetic device could also be used to directly stimulate or control action of the eyes (e.g., shifting the host's gaze to a particular object), heart (e.g., artificially increasing or decreasing the heart rate), limbs and digits (e.g., extending an arm to reach for an object), or other organs. The behavior of a device such as a motorized wheelchair or robotic limb might also be altered in a way that is designed to elicit some desired conscious or unconscious response by the device's human user. Already, tens of thousands of people worldwide possess implanted neuroprosthetic devices used for deep brain stimulation, which is employed primarily to treat Parkinson's disease and other movement disorders but which has also been found to generate mood changes in patients (Daigle, 2010, pp. 35-36; Van den Berg, 2012); such neuroprostheses could potentially be used to alter the moods of their human hosts in a way that would make certain consumer activities more or less likely at a given point in time.

CONCLUSION

As we have seen, the kinds of neuroprosthetic devices that are utilized by a growing segment of the population for the treatment of medical conditions or for purposes of human enhancement constitute powerful new tools that can conceivably be used for the two key neuromarketing tasks of gathering data about the ways in which potential consumers' cognitive processes react to particular stimuli and delivering stimuli that can influence consumers' behavior in a desired fashion. While general questions have already been posed by ethicists and others regarding the use of neuroprosthetic devices to gather information about the cognitive activity of their human hosts – either surreptitiously or with the hosts' consent – and to influence the hosts' behavior, such issues have not yet been comprehensively explored from the perspective of the technological and biocybernetic capacity of neuroprosthetic devices to be employed for such purposes within the field of neuromarketing. The conceptual framework proposed in this text represents one approach to developing such a framework; it is hoped that it can aid scholars and practitioners in identifying and exploring the practical, legal, and ethical issues that arise if neuroprosthetic devices that have been implanted in human hosts for other purposes are accessed and utilized by neuromarketing professionals for neuromarketing-related ends. Moreover, it is hoped that the schema presented in this text can assist InfoSec professionals in developing robust security practices and mechanisms both to safeguard the users of neuroprosthetic devices against undesired and illicit forms of neuromarketing and to ensure that legitimate forms of neuromarketing conducted by means of neural implants are carried out in a way that appropriately protects the confidentiality, integrity, and availability of the information of all stakeholders who participate in such activities.

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