Locked-in Syndrome, BCI, and a Confusion about Embodied, Embedded, Extended, and Enacted Cognition[*]

1. Introduction

In a recent contribution to this journal [1] Andrew Fenton and Sheri Alpert (F&A) have argued that the so-called "extended mind hypothesis" (for reasons that will become apparent in section 2, I prefer the label "extended cognition," EXC)[1] allows us to understand why Brain Computer Interfaces (BCIs) have the potential to change the self of patients suffering from Locked-in syndrome (LIS) by extending their minds beyond their bodies. I do not quarrel with the claim "that BCI technology has the potential to change the lives of … individuals with LIS in some fundamental ways" by "aiding willing individuals in re-engaging with their physical and social worlds" (p. 120) [1]. Nor do I have any qualms about the ethical issues raised by F&A (e.g., whether society has a responsibility to aid LIS patients in such re-engagement). Moreover, I happily endorse EXC [7]. What I deny is that EXC can shed any light on the theoretical, or philosophical, underpinnings of BCIs as a tool for enabling communication with, or bodily action by, patients with LIS: BCIs are not a case of cognitive extension in the sense advocated by EXC.

---

[*] The paper is original and ownership is possessed by the author; it is neither published nor under consideration for publication elsewhere.

[1] For the classic statement of EM see [2]. Other labels for EM include "active externalism" [2], "wide computationalism" [3], "vehicle externalism" [4], "locational externalism" [5] or "environmentalism" [6].

F&A's claim to the contrary is the result of a confusion about some related, but significantly different, approaches to cognition that all fall under the heading of "situated cognition" [8]. Once this confusion is resolved, it is obvious that (1) BCIs are not a case of cognitive extension, and (2) the research program that has the implications F&F attribute to EXC is in fact a position called "*enacted cognition*."[2]

Section 2 briefly recaps some information about LIS and BCIs. Section 3 offers a short taxonomy of various situated approaches to cognition, highlighting (some of) their important commonalities and differences, which, I hope, dissolves some of the confusions surrounding them. Section 4 shows why EXC is unsuitable as a model of BCI enhancements of LIS patients' capacity to interact with their surroundings. Section 5 argues that the situated approach with obvious bearings on the sort of questions that were driving F&A is the idea that cognition is *enacted*.

2. LIS and BCI

LIS is a rare neurological disorder. It is often caused by a primary vascular or traumatic injury to the brain stem (normally corresponding to a ventral pons lesion due to an obstruction of the basilar artery; p. 571 [9]), but it can be due to late stage amyoptrophic lateral sclerosis (ALS), a degenerative motor neuron disease. LIS is characterized by upper motor neuron quadriplegia (the

[2] I should stress that the confusion is not to blame on F&A. The situated approach to cognition is a relatively recent development with a variety of subtly different strands (see section 2) whose key tenets, theoretical and terminological commitments, and interrelationships and interdependencies are still in happy disarray, which leads to confusion even among the researchers working in the field [8].

loss of use of all limbs, including both sensation and voluntary control), paralysis of lower cranial nerves resulting in the inability to swallow, bilateral paresis of horizontal gaze and anarthria (loss of articulate speech) [10, 11]. The voluntary motor paralysis prevents LIS patients from communicating by either word or body movement. Only vertical eye movements and/or movements of the eye lid (blinking) are usually preserved (see below). Nevertheless, consciousness, memory, awareness of the own self and environment are typically said to be unimpaired [12, 13, 14]. LIS has been classified into three categories [15]: (1) *Classic LIS* (quadriplegia, anarthria, preserved consciousness and vertical eye movement); (2) *Incomplete LIS* (*Classic LIS* with remnants of voluntary movement other than vertical eye movement); (3) *Total LIS* (total immobility, including eye movements and blinking, accompanied by full consciousness awareness and cognitive function). LIS patients are "locked-in" in the sense that while their conscious mental life and cognitive functioning is fully preserved, they have no, or little, way of communicating their desires, needs, thoughts, memories, and experiences to outside observers.

BCIs promise to improve the quality of life of LIS patients and to restore part of their autonomy by opening up new channels of communication and allowing them at least some control over their environment. BCIs make use of the plasticity of the brain; they create new output pathways by assigning to cortical neurons the function ordinarily played by spinal motor neurons in the production of motor actions [16]. The activity of these cortical neurons is recorded (either invasive by electrodes or non-invasive by EEG) and then used to generate, *via* computer, behavioral output without the use of the patient's muscles, for instance moving a cursor over a screen, selecting icons on the screen, write emails, controlling a robotic arm, or steering a

wheelchair [17].[3] BCIs thus allow LIS patients (1) to exert some degree of *voluntary control* over external props in order (2) to *act* by using these props instead of their muscles, and (3) to *communicate*, *via* these actions, with other people.

According to F&A, BCIs have much more sweeping consequences: BCIs have not only the potential to change the daily lifes of LIS patients, they "also have the potential to change the individual users themselves" (p. 124), to "change who these patients are" (p. 127), by enabling them to "extend in a shared action space" (p. 129), just as they did before the onset of their disease [1]. In order to understand F&A's remarks, a digression into the various research programs in situated cognition is required.

3. Situated Cognition

According to traditional cognitivism (the intellectual core of both the "rules and representation" approach to cognition characteristic of GOFAI and the "distributed representation" approach of connectionism), the mind is a representational symbol processing input/output device whose syntactically driven transformations of symbolic or subsymbolic structures yield semantic features. Most notable about cognitivism is the "insular" view of cognition it embraces: "Cognition is cut off from the world in the sense that cognitive processes operate only on symbolic deliverances from the sense organs. … Because cognition begins and ends with inputs to and outputs from the nervous system, it has no need for interaction with the real world outside it" (p. 339) [18]. Situated approaches to cognition depart from this "brainbound"[4] approach of

[3] See [1], in particular pp. 122–124, for a more details and further references.

[4] It is unclear who coined the term "brainbound," but it is a by now well-entrenched characterization of the opponents of situated approaches to cognition [19, 20].

cognitivism in that they stress the crucial role of an organism's *body* and *environment*. Being interested only in abstract programs for specialized feats of reasoning and inference in narrow domains, they argue, cognitivism fails to do justice to the full breadth of the cognitive. Cognition is something that emerges "online" out of dynamical interactions between embodied cognitive systems and their environments, and not something that is done "offline" by a computational and representational system implemented in the brain. What we must understand is how physically embodied agents achieve sensorimotor control in real-time interactions with the environment. According to situated cognition, it is impossible to understand cognitive systems without taking into account their bodies (acknowledging the essentially *embodied* nature of cognition), their environment (acknowledging the essentially *embedded* nature of cognition), and their dynamical interaction with the environment (acknowledging the essentially *enacted* and possibly *extended* nature of cognition). It is at this point that important differences start to emerge.

Embodied Cognition

According to an *embodied* approach, cognition bears a profound relation to bodily processes in the sense that "the specific details of human embodiment make a special and … ineliminable contribution to our mental states and properties" [21, p. 39]. Since it is largely left unspecified what that special relationship consists in, the term "embodied cognition" serves as a conceptual umbrella under which a range of widely different approaches find shelter [18, 22, 23]. The perhaps weakest, although not at all uninteresting or trivial, way to characterize embodied cognition is to say that cognitive processes are partially *dependent* upon extracranial bodily processes:

Embodied Cognition I (ECI): Cognitive processes are partially *dependent upon extracranial bodily* processes.

What is meant by "dependent" may, of course, be a matter of debate, but two simple examples may convey the key idea. First, consider our body's contribution to our conceptual repertoire. According to George Lakoff and Mark Johnston, all our concepts derive from some basic concepts (e.g., spatial ones like *up*, *down*, *front*, *back* etc.) which stem directly from and are constrained by the type of body human beings possess and the manner in which this type of body interacts with the environment [24]. Second, consider how outfielders manage to catch fly balls. A cognitivist solution would be to take the visual perception of the current position of the ball as the input on the basis of which an internal reasoning system calculates the ball's future trajectory and then triggers an appropriate motor output. In reality, the solution is much simpler: simply run in such a way that the optical image of the ball appears to present a straight-line constant speed trajectory against the visual background [25]. Such examples illustrate one sense in which "the presence of a humanlike mind *depends* quite directly upon the possession of a humanlike body" (p. 43; emphasis AUTHOR) [21].

According to a stronger reading of the embodiment thesis, cognitive processes are not only *dependent* upon bodily processes, but *constituted* by them. The most prominent support for this stronger thesis comes from studies on human vision which show that bodily movements are an essential aspect of vision. For instance, we move our heads to gain information about the relative distances of objects because nearer objects appear to move the most (for more details see below). Such bodily movements, Larry Shapiro argues, are not merely extracranial aids upon which vision *depends*—they are "as much *part* of vision as the detection of disparity or the

calculation of shape from shading" (p. 188), so that "[v]ision for human beings is a process that *includes* features of the human body" (p. 190; both emphases AUTHOR [23].

> *Embodied Cognition II (ECII)*: Cognitive processes are partially *constituted by extracranial bodily* processes.

As far as I am aware, the distinction between ECI and ECII as not yet been paid much attention to, although it has obvious ramifications for the study of cognitive processing. ECII is an ontologically much more demanding and (to many perhaps) much more hazardous explication of the idea that "minds profoundly reflect the bodies in which they are contained" (p. 167) [23] than ECI. According to ECI, cognitive processes are restricted to an organism's brain, although they heavily depend upon its bodily characteristics, whereas according to ECII, cognitive processing leaks out into the organism's body.[5] I am not sure whether the difference is merely a conceptual or a substantive one.[6] Clearly, more research is needed to settle this issue, but for our purposes the foregoing suffices.

Embedded Cognition

[5] F&A seem to have in mind ECII: "[w]hen the self is understood as embodied, the body is *constitutive* of the self" (p. 120; emphasis AUTHOR) [1].

[6] I tend to favor the latter view since some cases of embodiment (Lakoff and Johnston's work on concepts, say, or work on the body's role in catching fly balls) are much harder, if not impossible, to interpret constitutively along the lines of ECII than, say, vision.

What has become known as “embedded cognition” is a natural extension of ECI. Like ECI, an embedded approach to cognition stresses the *dependence* of cognitive processes upon extracranial processes. However, in contrast to ECI, the dependence base of cognitive processes is not only extra*cranial*, but also extra*bodily* in the sense that “cognitive processes depend very heavily … on organismically external props and devices and on the structure of the external environment in which cognition takes place” (p. 393) [26].

> *Embedded Cognition (EMC)*: Cognitive processes are partially *dependent upon extrabodily* processes.

Consider again recent research on visual processing [27, 28, 29, 30] that suggests that instead of creating detailed internal representations as the basis for later stage cognitive processing, human subjects extract the relevant information “on the fly” from the world itself which, to use Rodney Brooks’ famous phrase, serves as its own best model [31]. Or consider David Kirsh and Paul Maglio’s research on “epistemic actions” [32] which highlights a similar kind of environmental “offloading” or “outsourcing”: proficient players of the computer game Tetris use button presses to rotate the figures on the screen rather than rotate them mentally because it is cognitively much cheaper.[7] EMC is even more radical than ECI and ECII, since it suggests studying cognition not

[7] Clark expresses this aspect of EMC in what he calls the “007-principle”:

> In general, evolved creatures will neither store nor process information in costly ways when they can use the structure of the environment and their operations upon it as a convenient stand-in for the information processing operations concerned. That is, know only as much as you nee to know to get the job done. (p. 64) [33]

so much by looking at computational processes in the brain and their dependence (causal or constitutive) upon the body, but instead by looking at the way the system uses its environment's structure or structures its environment in order to facilitate intrabodily cognitive processesing.

Extended Cognition

Just as EMC extends ECI's dependence base of cognitive processes from extracranial but still intrabodily processes to extrabodily processes, what has lately been called "*extended cognition*" is a natural corollary of ECII. Like ECII, an extended gloss on cognition stresses that cognitive processes are partially *constituted by* extracranial processes. However, in contrast to ECII, the constituents of cognitive processes are not only extra*cranial*, but also extra*bodily* in the sense that "human cognitive processing literally extends into the environment surrounding the organism, and human cognitive states literally comprise—as wholes do their proper parts—elements in that environment" (p. 393) [26].

> *Extended Cognition (EXC)*: Cognitive processes are partially *constituted by extrabodily* processes.

This is the approach F&A refer to when claiming that the "extended mind theory is … best regarded as an extension of embodied and embedded views of human cognition in that it incorporates the insights of these views while also including certain events or processes outside of an individual's body as constitutive elements in the physical substrate that underlies an individual's cognitive processes" (p. 125) [1]. It is EXC that allegedly allows us to see the

potential of BCIs in a (radically?) new light. Before we turn to this, one final version of the situated approach to cognition deserves mentioning.

Enacted Cognition

It is useful to distinguish what is known as the "enactive approach to visual perception," usually associated with the work of Kevin O'Regan and Alva Noë [28, 29], from a more generic conception of enactivism defended by, among others, Evan Thompson [34].

The enacted approach to visual perception is based on the idea of perceivers as *agents*. Visual perception is conceived of as being essentially dependent upon our ability to *act* on the world, i.e., to actively probe and explore our environment, and on our expectations about how our experiences of an object will change as we move that result from these activities. The key tenet is that visual perception is nothing but (implicit) knowledge of the lawful ways in which movement impacts on sensory stimulation, i.e., nothing but *sensorimotor knowledge* or knowledge of *sensorimotor contingencies*. Consider perceiving a cube:

> As you move with respect to the cube, you learn how its aspect changes as you move—that is, you encounter its visual potential. To encounter its visual potential is to encounter its actual shape. When you experience an object as cubical merely on the basis of its aspect, you do so because you bring to bear, in this experience, your sensorimotor knowledge of the relation between changes in cube aspects and movement. To experience the figure as a cube, on the basis of how it looks, is to understand *how* its look changes as you move. [28, p. 77]

Visual perception, Noë argues, is thus a skillful exploratory activity in which the perceiver draws on her mastery of sensorimotor contingencies.

Of course, the enactive approach to visual perception is only a special case of a more generic enactive approach to consciousness and cognition, albeit a very prominent and highly influential one.[8] Although that more generic approach is still far from being a conceptually, methodologically, and theoretically unified approach, one of its core ideas is that "cognition is grounded in the sense-making activity of autonomous agents—beings that actively generate and sustain themselves, and thereby enact or bring forth their own domains of meaning and value" (p. 23) [35]. The notion of "autonomy" is crucial: what makes living beings cognitive is that they are autonomous, i.e., that they are "internally self-constructive in such a way as to regulate actively their interactions with their environment" (p. 24) [35]. Through these interactions, the cognitive agent transforms the world into a place of salience, meaning, and value (i.e., into an *Umwelt*), and these transformations in turn happen through the agent's activity of "sense making": "Sense-making is the interactional and relational side of autonomy. An autonomous system produces and sustains its own identity in precarious conditions and thereby establishes a perspective from which interactions with the world acquire a normative status" (p. 25) [35]. Cognitive processes are thus not merely happening inside the system (in contrast to ECI; ECI, and EMC), nor are they realized in a straightforward way by processes spanning brain, body, and

[8] Some enactivists of the more generic kind, I should add, would deny that Noë's celebrated work on visual perception properly counts as "enactivism" (I am indebted to REMOVED for pressing me to stress this point, although I cannot go into the details). On a more personal note, let me add that I fail to see why the phenomenon Noë is concerned with cannot simply be seen as an instance of either EMC or EXC.

world (in contrast to EXC).[9] Rather, cognition is the normative engagement of a system with the world in the course of which the world is brought forth ("enacted") by the coherent activity of a cognizer in its environment (p. 12) [37]:

> *Enacted Cognition (ENC)*: Cognition is the relational process of sense-making that takes place between the system and its environment.[10]

The classification of situated approaches to cognition offered in this section, apart from its intrinsic merit of being a first attempt to explicitly and carefully disentangle the hodgepodge of notions and positions at the core of the current debate, is useful for a discussion of F&A's claim that BCIs can reasonably be regarded as a case of cognitive extension (section 4) and for seeing why in fact ENC is playing the role F&A attribute to EXC.

4. BCIs Are Not a Case of Cognitive Extension

[9] The exact relationship between the enactive approach and EXC is, as so many issues in the debate about situated cognition, so far unsettled. There seems to be an emerging agreement, however, that enactivism and EXC are mutually exclusive, but the reasons offered for this incompatibility vary [35, 36, 37, 38].

[10] Of all the characterizations offered in this section, I am the least sure about the adequacy of this one, but it is adequate enough for the purposes of this paper and, I hope, fair enough to the enactivist.

As indicated in the introduction, F&A claim that EXC "can help us re-see the potential of BCIs, particularly in the lives of individuals with LIS" (p. 120) [1] by showing that BCIs (re-)extend their minds beyond their bodies:

> Functionally integrated BCIs will change, as well as facilitate, cognitive expression. A level of physical or social feedback, hitherto missing from a patient's life, will now effect changes in how they act, the desires they will consider or to which they will respond, or even how they conceptualize their world. It is reasonable to think that such functionally integrated devices will extend a patient's cognitive as well as physical capacities … (p. 127) [1]

I deny that BCIs are a case of cognitive extension in the sense advocated by EXC. To begin with, however, note that F&A's appeal to EXC is inappropriate, or misleading, in two regards, regardless of whether or not BCIs can be seen as an instance of EXC.

First, according to F&A, "extended mind theory can be regarded as a *lens* through which we learn to re-see particular aspects of human cognitive engagement with the relevant physical or social environment" (p. 126; emphasis AUTHOR) [1]. In a footnote, F&A then add that the idea is to "use extended mind theory *heuristically*" in order to avoid "becoming embroiled in metaphysical debates about the nature, or extention, of mind that might threaten to undo any possible philosophical advance arising from a re-seeing of mind as extended" (p. 126n10; emphasis AUTHOR) [1]. This remark is problematic for two reasons. First, to avoid becoming embroiled in metaphysical debates is both against the letter and the spirit of EXC, a position whose sole purpose is to establish exactly a metaphysical extension of mind. EXC is a claim

about the ontological nature of cognitive processes, what the late Susan Hurley has called "vehicle externalism" [4]. The claim is that the material vehicles that realize cognitive processes are (sometimes) spatially distributed over brain, body and world. As such, EXC is a decidedly *ontic* thesis, and not (merely) an *epistemic* thesis about a heuristically fruitful way of understanding cognitive processes. Second, I fail to see how one can sensibly claim that "BCIs extend the minds of individuals with LIS beyond their bodies" (p. 120) [1]—which is, after all, a metaphysical claim, not one about the best way of understanding BCIs— while at the same time trying to take the ontological bite out of EXC.[11]

Second, F&A frequently talk about our *selves* being extended. Note, though, that EXC, as its name already indicates, is a thesis about the vehicles of *cognitive processes*, not *per se* about selves. Although Clark and Chalmers briefly hint at the possibility of extended selves at the end of their original discussion of EXC [2], the debate about EXC has so far been restricted to paradigmatically cognitive abilities like perception, memory, thought, and language. Whether EXC can be extended to selves is still a matter of debate (or rather, is, as of yet, not debated at all).[12] If selves are at issue, the appeal to EXC is thus far from uncontroversial.

---

[11] Note that when F&A say (in the long passage quoted above) that BCIs "will extend a patient's cognitive as well as physical capacities" they seem to use the term "extend" in the sense of "enrich." If that is all that is meant, who would disagree? But then the appeal to EXC is misleading, to say the least.

[12] I predict that the ultimate verdict will be negative. Even the most ardent defenders of EXC deny that *consciousness* extends beyond the organism's boundaries [19, 39], and without extended consciousness no extended self.

More importantly, however, the major problem with F&A's appeal to EXC is that BCIs are simply not a case of cognitive extension, not at least on any plausible construal of EXC. To see where the problem lies, consider the core idea behind a four step argument for EXC discussed by F&A. The argument goes as follows (pp. 125–126) [1]: First, it is possible to restore cognitive capacities by implanting appropriate devices. Second, once these devices are functionally integrated, they are reasonably regarded as constitutive of the underlying substrate of the relevant cognitive processes. Third, external devices can possibly play a relevantly similar functional role. Fourth, it would be mere prejudice to treat functionally relevantly similar devices differently only because of their location. Therefore, functionally integrated external devices, too, are reasonably regarded as constitutive of the underlying substrate of the relevant cognitive processes. This line of reasoning nicely captures the essentials of a prominent argument in favor of EXC,[13] but it also shows what is wrong with the claim that BCIs are a case of cognitive extension. As the four step formulation above makes clear, the crucial claim is that extrabodily devices are part of what plays the functional role characteristic of *cognitive faculties* or *cognitive processes* (like perception, memory, thought, language etc.) and thus count as constitutive of these faculties or processes. Hence, if BCIs were to be a case of cognitive extension, then the BCI technology (the computer, the EEG, the recording electrodes etc.) would have to realize the

[13] In effect, it is an elaboration of what is called the "parity principle." Clark and Chalmers' original presentation of the parity principle (then not yet so-named) was: "If, as we confront some task, a part of the world functions as a process which, *were it done in the head*, we would have no hesitation in recognizing as part of the cognitive process, then that part of the world *is* (so we claim) part of the cognitive process" (p. 8) [2].

functional role characteristic of a cognitive faculty or process. But what faculty or process could that be?

As explained in section 2, BCIs allow patients (1) to exert some degree of *voluntary control* over external props in order (2) to *act* by using these props instead of their muscles and (3) to *communicate, via* these actions, with other people. With regard to *cognitive* extension, (2) is an obvious non-starter, for moving a robotic arm, a cursor on a screen or a wheelchair are not cognitive processes but bodily movements. (1) is not a good candidate either. Although the ability to voluntarily initiate a bodily movement may be a cognitive faculty or process, that ability is arguably still internal in the LIS patient—after all, the EEG or the computer do not contribute to the initiation of the action. The EEG and the computer of course contribute to the action's *execution*, but that, again, means realizing a (substitute for a) bodily movement, not realizing a cognitive faculty or process. The same holds for (3). Communication is a complex process of information transformation that involves both *cognitive aspects* (forming thoughts, forming the intention to communicate, mentally organizing one's thoughts in a way suitable for subsequent public expression etc.) and *bodily aspects* (writing on a board, typing text into one's email program, moving one's vocal chords etc.). Again, the cognitive aspects are, of course, cognitive, but not extended by BCIs (the EEG and the computer do not contribute to the formation of thoughts or the intention to communicate), and although, say, typing text into one's email program are (in a sense) extended BCI-restored faculties or processes, they are bodily aspects of communication, not cognitive ones.

BCIs do not extend cognition, for the simple reason that the capacities they (at least partially) restore and whose functional role is realized by extrabodily technology instead of intrabodily processes are entirely bodily, not cognitive.[14]

Let me stress that I am only concerned with the inadequacy, or illegitimacy, of the appeal to EXC in the context of LIS and BCIs. I do not want to suggest that F&A are wrong about the impact BCIs can have on the life of LIS patients. Consider, for instance, the following passage:

> From our meager beginnings as infants, our selves develop from, or emerge out of, interactions with our physical and social worlds. Our physically embodied and socially embedded nature shapes who we are … With these observations in mind, we can reasonably anticipate that the relevant BCI will change who these patients are. Functionally integrated BCIs will change, as well as facilitate, cognitive expression. A level of physical or social feedback, hitherto missing from a patient's life, will now effect changes in how they act, the desires they will consider or to which they will respond, or even how they conceptualize their world. (pp. 126–127) [1]

I happily agree. However, the next sentence reads: "It is reasonable to think that such functionally integrated devices will extend a patient's cognitive as well as physical capacities

[14] Incidentally, Niels Birbaumer and colleagues make it patently clear in their work on BCIs that was is restored is bodily, or physiological, processes and not cognitive ones: BCI, they argue, "*replaces nerves and muscles and the movements they produce* with electrophysiological signals and the hardware and software that translate those signals into action" (p. 770; emphasis AUTHOR) [40]. (I owe this quotation to REMOVED.)

…" (p. 127) [1]. I am willing to concede that the patient's physical capacities are extended.[15] But I fail to see what the extended cognitive capacities are supposed to be.

Of course, there is *a* sense in which a LIS patient's cognitive life may be said to be "extended." What I have in mind is something like Martin Heidegger's idea [41] that *Dasein*, i.e., the being of humans, is essentially *being-in-the-world* in the sense that humans are in essence a network of related practices, each of which in turn presupposes a network of related items. A consequence of this Heideggerian picture is that we must eschew "thinking of a human being as a biological entity with biological boundaries of the usual sort" and acknowledge that the "being of humans is simply practices, practices that take place in the instrumental networks that partly realize them" (p. 58) [36]. This sounds like what F&A have in mind in the lengthy passage quoted above and with their claim that individuals are "extended in a shared action space" (p. 129) [1]. But note that on such a view the question whether cognitive processes are extended in any substantial sense is mute, because then *everything* we do (and, in fact, *are*) is extended [35]. This may be true or not, but it has nothing to do with EXC, and therefore the appeal to EXC is inapt in this context.

Finally, suppose there were indeed some distinctively cognitive capacity or process that BCIs could restore. Even then the appeal to EXC is superfluous in order to make the point that is dearest to F&A, viz., that BCIs may dramatically affect the autonomy of the individual who receives the intervention. In order to establish that, it is entirely sufficient to show that cognitive processes (or "selves") are partially dependent upon or constituted by extracranial bodily

[15] Except perhaps for the fact that I suspect that what F&A mean by "extension" of physical capacities is again (see note 11) more an "enrichment" than the sort of metaphysical vehicle extension characteristic of EXC.

processes (ECI, ECII) or partially dependent upon extrabodily processes (EMC). If cognitive processes are embodied or embedded in this sense, then a patient's inability of voluntary bodily control and her inability to offload or outsource cognitive work that goes along with this inability may seriously affect her cognitive life (supposing, still, that a distinctively cognitive, as opposed to merely bodily, capacity or process is restored). EXC with its heavy duty metaphysics is not needed for that. EXC would not even be a particularly helpful "lens," since ECI, ECII and in particular EMC would do just as well to see how valuable BCIs may be to LIS patients.

I want to close by showing that for the purpose of assessing LIS and the potential vices and virtues of BCIs the by far most potent situated approach to cognition is ENC—unfortunately the only position F&A do not mention at all.

5. LIS, BCI, and ENC

Since ENC's focus on the essentially active nature of visual perception in particular and cognition in general has already been stressed in section 3, it should come as no surprise that the adequate "lens" through which to view LIS and BCIs is ENC. Recall that for Noë, for instance, the visual system is not a merely passive recipient of sensory input from the world. Rather, vision is a *skillful exploratory activity* in which the perceiver is constantly moving his eyes, head and body, picking up information from the world "on the fly" if and when it is needed. In the absence of agency (in the innocuous sense of the ability for bodily movement), therefore, there can, apparently, be no visual perception. In a similar vein, advocates of ENC in the more generic sense with their claim that cognition is "*sense-making in the interactive domain*" (p. 15) [37], i.e., a normative engagement of a system with the world, are committed to the view that in the absence of agency there can be no cognition. Since LIS makes any such skillful exploration of

and sense making interaction with the environment impossible, and since BCIs at least partially restore the capacity for exploration and interaction, the relevance of ENC to the kinds of questions F&A are concerned with is obvious. In particular the bearing of F&A's discussion of the potential of BCIs to restore or enhance a patient's *autonomy*, by which they mean the "capacity of an individual to freely acquire or develop values or interests and then act in accordance with them in contexts that are minimally coercive" (p. 128) [1], on the enactivists' idea that "what makes living organisms cognitive beings is that they embody or realize a certain kind of autonomy" (p. 24) [35] is as plain as day.

ENC may be taken to question the widespread assumption that LIS leaves consciousness and cognitive capacities like visual perception, memory or awareness of the own self and the environment unimpaired. If visual perception indeed depends upon the perceiver's possessing sensorimotor skills then in the absence of such skills one should expect that visual perception *is* going to be impaired.[16] Yet, this pessimistic conclusion may be too quick. One must distinguish between the weaker claim that visual perception requires the *possession* of sensorimotor skills and the much stronger claim that it requires the *exercise* of such skills. Since LIS patients may continue possess *knowledge* of sensorimotor skills even once they are unable to exercise them by actively probing the environment, the weaker claim not have pessimistic consequences for LIS patients (assuming the knowledge of sensorimotor skills does not slowly "fade away" once the patient is locked-in). However, although Noë himself is far from clear on this point, he at least sometimes endorses the stronger reading, for instance when he says that perception is "constituted by our possession *and* exercise if bodily skills" (p. 25) [28] or when O'Regan and

[16] At least in stationary settings where not only the perceiver does not move relative to the objects seen, but the objects do not move relative to the perceiver either.

he argue that vision "is a mode of skillful encounter with the environment, requiring knowledge of sensorimotor contingencies and also the ability to make use of that knowledge for the purpose of guiding action, thought, and (in humans) language use" (pp. 959–960) [29].[17] If the strong reading is correct, one would predict impairments of visual perception in LIS patients. Hence, the enactive approach to visual perception receives support if such impairments are found, and it is undermined to the extent that no such impairments are found. If visual perception is initially unimpaired and then progressively becomes worse, this may support the weaker reading in combination with the speculation that LIS patients' knowledge of sensorimotor skills will slowly "fade away" once they are no longer able to actively exercise them.

More generally, if ENC is accepted as a generic paradigm, one should predict not only impairments in visual perception, but also that consciousness and cognition *tout court* are going to be affected.[18] If consciousness crucially depends, as Francisco Varela and Thompson put it,

---

[17] At other times, however, Noë suggests that the exercise of sensorimotor abilities is required only during the learning phase: "only through self-movement can one test and so learn the relevant patterns of sensorimotor dependence" (p. 13) [28].

[18] There is a relatively straightforward route from the perception restricted enactive thesis to the generic one. Based on Hurley's so-called "shared-circuits model" [42] (according to which higher cognitive processes such as imitation, mindreading, counterfactual thinking and deliberation may have originated in sensorimotor control processes) Nivedita Gangopadyhay and Julian Kiverstein have recently argued that "the sensorimotor behaviour which couples a perceiver to her environment cannot be separated from the perceiver's cognitive abilities because subpersonal mechanisms of sensorimotor coupling enable personal-level cognitive abilities" (p. 71) [43].

"on the manner in which brain dynamics are embedded in the somatic and environmental context of the animal's life … [so] that there may be no such thing as a minimal internal neural correlate whose intrinsic properties are sufficient to produce conscious experience" (p. 425) [44], then the prediction must be that given the lack of such an embedding in LIS patients, there will be no consciousness. Neither will there cognition if ENC's claim that "cognition is grounded on the sense-making activity of autonomous agents—beings that actively generate and sustain themselves, and thereby enact or bring forth their own domains of meaning and value" (p. 23) [35] is correct. Again, ENC will be vindicated to the extent that impairments in the conscious or cognitive life of LIS patients are found, and it will be undermined to the extent that no such impairments are found—provided, of course, that the studies that test the cognitive capacities take into account what ENC says about cognition. That no cognitive impairments are found in LIS patients counts against ENC only if the notion of the "cognitive" underlying the experimental tests is the same as the notion appealed to by the enactivist. Moreover, the choice of which cognitive capacities to test may make a difference—a fact that may go unnoticed unless situated approaches to cognition, and in particular ENC, are taken into account. A recent study by Caroline Schnakers and colleagues, for instance, has investigated short- and long-term memory, attention, executive functioning, phonological and semantic processing, and verbal intelligence in LIS patients—all of which are more or less the sort of "offline" cognitive capacities at the focus of classical cognitivism. It may be instructive to investigate how LIS patients fare with regard to cognitive capacities like mindreading or counterfactual reasoning which, according to at least some authors in the field, have clear roots in sensorimotor behavior (see note 18).

For these reasons, among others, it is crucial to be as clear as possible about the details of the various approaches to cognition that are currently discussed, and to convey them as clearly as possible to those doing empirical research on cognitive impairments in LIS patients, to those trying to develop BCIs, and, last but by no means least, to those working with LIS patients on a day-to-day basis. F&A have done us a great service by bringing these issues to our attention, and I hope this paper has continued their job by clearing up some of the conceptual confusions and by inspiring further research, including interdisciplinary research crossing the boundaries between the philosophy of cognition, neuroscience and ethics, on the potentials and pitfalls of situated approaches to cognition *vis-à-vis* LIS and BCI.

Acknowledgements

I'm indebted to REMOVED. She has brought F&A's paper to my attention, and were it not for her, I probably would never have thought about LIS and its potential implications for EXC and ENC.

References

[1] Fenton, Andrew, and Sheri Alpert. 2008. Extending our view on using BCIs for locked-in syndrome. *Neuroethics* 1: 119–132.

[2] Clark, Andy, and David Chalmers. 1998. The extended mind. *Analysis* 58: 7–19.

[3] Wilson, Robert. 1994. Wide computationalism. *Mind* 103: 351–372.

[4] Hurley, Susan. 1998. *Consciousness in action*. Cambridge, MA: Harvard University Press.

[5] Wilson, Robert. 2004. *Boundaries of the mind*. Cambridge: Cambridge University Press.

[6] Rowlands, Mark. 1999. *The body in mind: understanding cognitive processes*. Cambridge: Cambridge University Press.

[7] AUTHOR; removed for anonymous review.

[8] Robbins, Philip, and Murat Aydede. 2008. A short primer on situated cognition. In *The Cambridge handbook of situated cognition*, ed. Philip Robbins and Murat Aydede, 3–11. Cambridge: Cambridge University Press.

[9] León-Carrión, José, Philippe van Eeckhout, María Del Rosario Domínguez-Morales, and Francisco Javier Pérez-Santamaría. 2002. The locked-in syndrome: a syndrome looking for a therapy. *Brain Injury* 16: 571–582.

[10] Smith, Eimear, and Mark Delargy. 2005. Locked-in syndrome. *British Medical Journal* 330: 406–409.

[11] Haig, Andrew, Richard Katz, and Vinod Sahgal. 1987. Mortality and complications of the locked-in syndrome. *Archives of Physical Medicine & Rehabilitation* 68: 24–27.

[12] León-Carrión, José, Philippe van Eeckhout, and María Del Rosario Domínguez-Morales. 2002. The locked-in syndrome: a syndrome looking for a therapy. *Brain Injury* 16: 555–569.

[13] Chisholm, Nick, and Grant Gillett. 2005. The patient's journey: Living with locked-in syndrome. *British Medical Journal* 331: 94–97.

[14] Schnakers Caroline, Steve Majerus, Serge Goldman, Melanie Boly, Philippe Van Eeckhout, Stephane Gay, Frederick Pellas, Valerie Bartsch, Philippe Peigneux, Gustave Moonen, and Stephen Laureys. 2008. Cognitive function in the locked-in syndrome. *Journal of Neurology* 255: 323–330.

[15] Bauer, Gerhard, Franz Gerstenbrand, and Erik Rumpl. 1979. Varieties of locked-in syndrome. *Journal of Neurology* 221: 77–91.

[16] Wolpaw, Jonathan. 2007. Brain-computer interfaces as new brain output pathways. *Journal of Physiology* 5793: 613–619.

[17] National Institute of Biomedical Imaging and Bioengineering (NIBIB). 2006. Brain-computer interfaces come home: November 28, 2006. http://www.nibib.nih.gov/HealthEdu/eAdvances/28Nov06. Accessed 30 July 2009.

[18] Shapiro, Larry. 2007. The embodied cognition research programme. *Philosophy Compass* 2: 338–346.

[19] Clark, Andy. 2008. *Supersizing the mind: embodiment, action, and cognitive extension*. Oxford: Oxford University Press.

[20] Adams, Fred, and Kenneth Aizawa. 2008. *The bounds of cognition*. Malden, MA: Blackwell.

[21] Clark, Andy. 2008. Pressing the flesh: a tension in the study of the embodied, embedded mind? *Philosophy and Phenomenological Research* 76: 37–59.

[22] Wilson, Margaret. 2002. Six views of embodied cognition. *Psychonomic Bulletin and Review* 9: 625–636.

[23] Shapiro, Larry. 2004. *The mind incarnate*. Cambridge, MA: MIT Press.

[24] Lakoff, George, and Mark Johnston. 1999. *Philosophy in the flesh: the embodied mind and its challenge to western thought*. New York, NY: Basic Books.

[25] McBeath, Mike, Dennis Shaffer, and Mary Kaiser. 1995. How baseball outfielders determine where to run to catch fly balls. *Science* 268: 569–573.

[26] Rupert, Robert. 2004. Challenges to the hypothesis of extended cognition. *Journal of Philosophy* 101: 389–428.

[27] O'Reagan, Kevin. 1992. Solving the "real" mysteries of visual perception: the world as an outside memory. *Canadian Journal of Psychology* 46: 461–488.

[28] Noë, Alva. 2004. *Action in perception*. Cambridge, MA: MIT Press.

[29] O'Regan, Kevin, and Alva Noë. 2001. A sensorimotor account of vision and visual consciousness. *Behavioral and Brain Sciences* 24: 939–960.

[30] Ballard, Dana, Mary Hayhoe, Polly Pook, and Rajesh Rao. 1997. Deictic codes for the embodiment of cognition. *Behavioral and Brain Sciences* 20: 723–767.

[31] Brooks, Rodney. 1991. Intelligence without representation. *Artificial Intelligence* 47: 139–159.

[32] Kirsh, David, and Paul Maglio. 1994. On distinguishing epistemic from pragmatic action. *Cognitive Science* 18: 513–549.

[33] Clark, Andy. 1989. *Microcognition: philosophy, cognitive science, and parallel distributed processing*. Cambridge, MA: MIT Press.

[34] Thompson, Evan. 2007. *Mind in life: biology, phenomenology, and the sciences of the mind*. Cambridge, MA: Harvard University Press.

[35] Thompson, Evan, and Mog Stapleton. 2009. Making sense of sense-making: reflections on enactive and extended mind theories. *Topoi* 28: 23–30.

[36] Rowlands, Mark. 2009. Enactivism and the extended mind. *Topoi* 28: 53–62.

[37] Di Paolo, Ezequiel. 2009. Extended life. *Topoi* 28: 9–21.

[38] Wheeler, Mike. *in press*. Minds, things, and materiality. In *The cognitive life of things: recasting the boundaries of the mind*, ed. Lambros Malafouris and Colin Renfew. Cambridge: McDonald Institute Monographs.

[39] Clark, Andy. *under review*. Spreading the joy: why the machinery of consciousness is (probably) still in the head.

[40] Wolpaw, Jonathan, Niels Birbaumer, Dennis McFarland, Gert Pfurtscheller, and Theresa Vaughan. 2002. Brain-computer interfaces for communication and control. *Clinical Neurophysiology* 113: 767–791.

[41] Heidegger, Martin. 1926. *Being and time*. New York, NY: SUNY Press 1996.

[42] Hurley, Susan. 2008. The shared circuits model: how control, mirroring and simulation can enable imitation and mindreading. *Behavioral and Brain Sciences* 31: 1–58.

[43] Gangopadyay, Nivedita, and Julian Kiverstein. 2009. Enactivism and the unity of perception and action. Topoi 28: 63–73.

[44] Varela, Francisco, and Evan Thompson. 2001. Radical embodiment, neural dynamics and consciousness. *Trends in Cognitive Science* 5: 418–425.