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***Slaying the Chimera: a Complementarity
Approach to the Extended Mind Thesis***

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Abstract

Much of the literature directed at the Extended Mind Thesis (EMT) has revolved around parity issues, focussing on the problem of how to individuate the functional roles and on the relevance of these roles for the production of human intelligent behaviour. Proponents of EMT have famously claimed that we shouldn't take the location of a process as a reliable indicator of the mechanisms that support our cognitive behaviour. This functionalist understanding of cognition has however been challenged by opponents of EMT [such as Rupert (2009); Adams & Aizawa (2009)], who have claimed that differences between internal, biological processes and putatively extended ones not only exist but are actually crucial to undermine the idea that inner and outer are functionally equivalent. This debate about how to individuate the functional roles has led to a treacherous stand-off, in which proponents of EMT have been trapped under the persistent accusation of causal/constitution conflation. My strategy for responding to this charge is to look precisely at those functional differences highlighted by critics of EMT. I reckon that extended cognitive systems are endowed with quite different properties from systems that are "brain bound" and argue that it is precisely these differences that allow human minds to transcend their biological limitations. I thus defend a complementarity version of the extended mind, according to which externally located resources and internal biological elements make a different but complementary contribution to bringing about intelligent behaviour [Sutton (2010)]. My defence of complementarity is based on both the phylogeny and the ontogeny of cognitive systems. I initially explore the interrelation between brain and cognitive development from a neuroconstructivist perspective [Quartz & Sejnowski (1997); Mareshal et al. (2007)] and then argue that our brains do not have fixed functional architectures but are sculpted and given form by the activities we repeatedly engage in. As a result of repeated engagements in socio-cultural tasks, relevant brain pathways undergo substantial rewiring. Development thus scaffolds our brains, which become geared into working in symbiotic partnership with external resources. [Kiverstein & Farina (2011)]. On these grounds, I call into question any tendency to interpret the human biological nature as fixed and endogenously pre-

determined and side with proponents of DST [Oyama (2000); Griffiths & Gray (2001)] and ontogenetic niche construction [Stotz (2010)] in arguing that we should think of natural selection as operating on whole developmental systems composed of living organisms in culturally enriched niches. [Wheeler & Clark(2008)].

Complementarity defences of EMT argue that many of the kinds of cognition humans excel at can only be accomplished by brains working together with a body that directly manipulates and acts on the world [Rowlands (2010); Menary (2007)]. I take Sensory Substitution Devices (SSDs henceforth) as my empirical case study. SSDs exploit the remarkable plasticity of our brains and with training supply a novel perceptual modality that compensates for loss or impaired sensory channel. I argue that the coupling with these devices triggers a new mode of phenomenal access to the world, something I propose to label as a kind of “artificial synaesthesia [Ward & Meijer (2010)]. This new mode of access to the world transforms our cognitive skills and gives rise to augmented processes of deep bio-technological symbiosis. SSDs therefore become mind enhancing tools [Clark (2003)] and a perfect case study for Complementarity. Having shown the relevance of SSDs for EMT, I then take up the possibility that these devices don’t just relocate the boundaries of cognition but may also stretch the bounds of perceptual awareness. I explore the possibility that perceivers using SSDs count as extended cognitive systems and therefore argue that the experiences they enjoy should be counted as extended conscious experiences.[Kiverstein & Farina, (forthcoming)]. SSDs are quite often said to involve some form of incorporation.[Clark (2008)]. Rupert has challenged this idea and its relevance for EMT on the grounds of his embedded approach. Particularly, he has explained tool-use in terms of the causal interaction between the subject and its detached tool. In the final chapter of my dissertation I critically look at his objections and argue that all his arguments fail to apply to SSDs. In SSD perception in fact the tool becomes geared to work in symbiotic partnership with the active subject and then get factored into its’ body schema so that both of them come to form a single system of cognitive analysis.

Declaration

I do hereby declare that I am the sole author of this thesis and that the work contained within is my own, except where explicitly stated otherwise. I also declare that this work has not been submitted for any other degree or professional qualification.

I understand that my thesis may be made electronically available to the public.

Mirko Farina
September 2011

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Introduction

In this dissertation I defend the extended mind thesis (EMT). EMT (henceforth often referred to simply as ‘extended’) is a view about the location of the physical mechanisms of mind and cognition that affirms that mental states and cognitive functions can extend spatiotemporally beyond the skin of the organism with biological and environmentally located elements entering into a partnership that enables flexible thinking and acting. [Farina (2010)]. EMT therefore allows for distributed representations to expand outward from their cranial prison into the environment and for humans to transcend their biological boundaries through dynamical couplings, persistent interweavements and cognitive loops. [Rowlands (2009)]. Although EMT has nowadays acquired a prominent status in the cognitive sciences, its validity still remains controversial as its crucial tenets have fallen far short of effectively settling the dispute with intracranialism.

In the first chapter of this dissertation I sketch a brief overview of the debate surrounding the extended mind as it has unfolded thus far, pinpoint the parity principle and analyse the literature directed at it. In particular, I focus on the problem of how to individuate the functional roles. I review the arguments in favour of and against parity and acknowledge a potential stand-off (generated by the persistent accusation of causal/constitution conflation) in which proponents of parity-style defences of EMT seem to have been trapped. Rather than combating the battle for the extended mind thesis on a purely functionalist turf my strategy to escape from the impasse in which the debate between EMT and the embedded theory (henceforth often referred to simply as ‘embedded’) appears to have fallen is to make a case for EMT from a different route. I set aside parity issues and rather argue that it is precisely the differences between extended systems and systems that are “brain bound” that allow human minds to criss-cross their biological boundaries. I therefore defend a Complementarity version of the extended mind thesis, according to which “*different components of a softly-assembled system can play quite different roles and have different properties while nevertheless combining to make complementary causal contributions that bring about flexible thinking and intelligent behaviour*”. [Clark (1997); Sutton et al. (2010); Kiverstein & Farina (2011); Farina (2011), p.285].

My defence of complementarity is based both on the ontogeny and phylogeny of cognitive systems.

In the second chapter of this thesis, I turn my attention to the ontogeny of cognitive systems and explore the interrelation between brain and cognitive development from a constructivist perspective. [Quartz & Sejnowski (2002); Mareshal et al. (2007)]. Neuroconstructivism characterizes development as a trajectory that is shaped by multiple interacting biological and environmental constraints in which complex representations develop based on earlier and simpler ones. [Westermann et al.(2007)]. This increase in representational complexity is realized through a progressive elaboration of functional cortical structures. These structures are not selected from a constrained juvenile stock but rather emerge in an experience-dependent way. I use the work on neuroconstructivism and the principles of Hebbian learning to explain how externally located resources can become enmeshed into our problem-solving strategies. The human brain is incredibly plastic and this plasticity which extends well into adulthood allows our brains to be shaped by our cultural environment to a much greater extent than any other creature [Merzenich et al. (1978); Huttenlocher (2002)]. Cortical plasticity, I then argue, is a pre-condition for extended cognition enabling human beings to incorporate environmentally located resources into their problem solving routines. Human agents, I maintain, do not have fixed biological natures, but rather come to have the specific nature they do because of the brain's plastic ability to be sculpted by the different but complementarity contributions to which it is post-natally exposed.

The third chapter of my dissertation is concerned with the phylogeny of cognition. I investigate the relationship between developmental systems theory(DST henceforth), niche construction and Neo-Darwinian accounts of natural selection. I call into question any tendency to interpret the human biological nature as fixed and endogenously pre-determined [Griffiths & Stotz (2000)] and side with proponents of DST [Oyama (1999), Griffiths and Gray (2004)] and ontogenetic niche construction [Stotz (2010); West & King (1987)] in arguing that we should think of natural selection as operating on whole developmental systems composed of living organisms in culturally enriched niches. [Odling-Smee et al. (2003); Wheeler & Clark (2008)]. Cognitive processes, I argue, are

dynamically constructed in each generation by means of a persisting reliance on external scaffolding [Sterelny (2010)] and emerge from the continuous, delicate and complementary interactions with the rich matrix of resources available outside the genome [Jablonka & Lamb (2005)]. Against purely genetic understandings of human evolution I thus put forward the idea that we are bio-mechanical ensembles, heterogeneous developmental matrixes in which culture and technology flourish and co-evolve. This is the phylogenetic equivalent of the ontogenetic claim abovementioned that human cognitive functions are shaped, forged and sculpted by the many activities we repeatedly engage in, in the world.

In the fourth chapter of this thesis, I tackle another crucial aspect of Complementarity defences of EMT, the idea of manipulation and therefore discuss Sensory Substitution Devices (SSDs henceforth) to explore the empirical ramifications of Complementarity. I argue that SSDs are a perfect example of cognitive and perceptual transformation [Kiverstein, Farina & Clark (forthcoming)] and that through the coupling with them the visually impaired subject acquires, via cortical plasticity, a new form of perceiving and experiencing; a cross-modal union of senses in which the proximal input (either tactile or auditory) is accompanied by some new sensory (quasi-visual) mode of access to the distal one. In agreement with Ward and Meijer (2010), I propose to call this new form of phenomenal access to the world artificial synaesthesia and argue that it becomes available to the visually impaired user only after substantial training with the device. Since the continuous coupling with these devices leads the impaired subject to experience this new form of perceiving, something she wouldn't otherwise get if she was to rely exclusively on her own brain, I claim that SSDs become mind enhancing tools. SSDs systematically transform the sensory experience of the visually impaired and provide access to novel, hybrid, variant and unfamiliar forms of perceptual sensorimotor interaction with the environment. For this reason I take them to count as shiny examples of Complementarity.

Having shown that SSDs count as mind enhancing tools and constitute a strong form of cognitive and perceptual enhancement, at least for the visually impaired, I then take up the possibility that these devices don't just relocate the boundaries of cognition and perception, but may also stretch the bounds of phenomenal awareness. In the fifth chapter

of this dissertation I therefore explore the possibility that SSDs can count as cases in which the conscious mind extends. Although I am quite sympathetic with this idea and even though I have elsewhere argued that SSDs experience qualifies as a case of extended perceptual awareness [Kiverstein and Farina (forthcoming)]; I conclude this chapter with an objection (raised by David Chalmers in private correspondence) that shows negatively that we can't (probably) yet make an argument for extended consciousness, at least based purely on plasticity and integration.

In the sixth and final chapter of this thesis, rather than responding to the Chalmers' objection and tackling the question of whether integration and plasticity are sufficient to establish extended consciousness, I look at attempts that argue that incorporation is not enough even for extended cognition. I therefore address Rupert's criticism of EMT, further discuss SSDs as cases of cognitive and perceptual supplementation and argue that even if integration and plasticity don't yet establish a knockdown argument against bounded, intracranialist accounts of consciousness, incorporation (most likely) allows me to postulate the existence of extended cognition.

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Chapter 1

1.1 Setting up the Scene

I begin by quickly reviewing the so-called situated movement in the cognitive sciences. Unlike individualistic conceptions of mind and cognition that give a solipsistic account of the mental properties of an organism [Fodor (1980)], the situated movement suggests that thinking and learning are deeply rooted in physical and social contexts and that knowing is inseparable from doing. The situated programme therefore describes cognition as naturally tied to action, context, and culture [Brown, Collins, & Duguid, (1989)] and explains it “*as a relation involving an agent in a situation, rather than as an activity in an individual’s mind*” [Greeno (1989), p.135]. In this chapter, I link this understanding of cognition to externalist accounts of the mind in the cognitive sciences (section 1). In particular, I focus on the idea of cognitive extension. In section 2, I introduce the extended mind thesis (EMT) as “*an ontic thesis of partial and contingent composition of some mental processes*” [Rowlands (2009),p.54] and describe its central tenets. I then distinguish three areas (natural, technological and socio-cultural) within which extended cognition can occur. [Wilson & Clark (2009)]. I argue that extended cognition emerges in one of these three dimensions or a combination of them, when any feature (either natural, technological or socio-cultural) that any agent uses for functional purposes, becomes so finely tuned, so well integrated into the agent’s cognitive repertoire that it allows for a brain, body and world boundary crossing architecture.

Having introduced EMT, in section 3 I turn my attention to the main business of this chapter, which is to look at the stalemate in which the debate between extended and embedded has fallen. Much of the literature directed at EMT¹ has revolved around parity issues, focussing on the problem of how to individuate the functional roles and on the relevance of these roles for the production of human intelligent behaviour. Proponents of EMT have famously claimed that we shouldn’t take the location of a process as a reliable

¹ See [Adams & Aizawa (2008)]; [Adams (2010)]; [Clark (2008), (2010a), (2010b)]; [Menary (2007), (2010)]; [Rowlands (2010)]; [Rupert (2004), (2009), (2010)]; [Sprevak (2009)]; [Sutton (2002), (2010)]; [Walter (2010)]; [Weiskopf (2010a), (2010b)]; [Wheeler (2010, (forthcoming)], Sutton et al. (2010), to name a few].

indicator of the mechanisms that support our cognitive behaviour. This functionalist understanding of cognition has however been questioned and strongly challenged by many opponents of EMT [Rupert (2009); Adams and Aizawa (2009), Weiskopf (2008), just to name a few], who have conversely claimed that differences between internal, biological processes and putatively extended ones not only apply but may actually be crucial to undermine the idea that inner and outer are functionally equivalent. I conclude this section by acknowledging that functionalist defences of the extended mind apparently stall, being plagued by the criticism moved against the very idea of functional isomorphism. [Kiverstein and Farina (2011)].

In section 4, I suggest a way to get out of this apparent impasse by appealing to what Sprevak (2009) has labelled the Martian Intuition, “*the thought that creatures that are physiologically different from us can nevertheless share the same types of mental states with us*” [Kiverstein and Farina (2011), p.38]. In agreement with Sprevak (2009) however, I notice that the Martian Intuition is not sufficient to grant the existence of extended cognition and that playing this card may come with a cost. In conflating the constraints on extended cognition originally provided by Clark & Chalmers (1998), the Martian Intuition seems to license an overly permissive version of the extended mind, one so rampantly liberal that it doesn’t seem to stand any change of being true.

In this scenario, who is to say who is right and which side of the debate is correct? Shall we endorse the “overly” liberal criteria formulated by proponents of EMT, or rather embrace the “stricter” conservative provisos presented by many of its opponents? [Rowlands (2009)]. I argue that a solution to what I shall call “our Goldilocks problem²”, though ardently craved, hasn’t yet been readily forthcoming and therefore acknowledge the impasse in which the debate about the functional roles has fallen. The critical appraisal of the stalemate between extended and embedded accounts of cognition shall ultimately provide me with a solid background, which I intend to use in the next chapters as a starting point to overcome the stand-off I sketch here. I conclude the section and the chapter by hinting at Wheeler’s (2010) recent revival of microfunctionalism as a possible

² Weiskopf (2010) also discusses a Goldilocks problem. His Goldilocks problem however doesn’t entirely coincide with the one I discuss here. In this chapter, I just borrow this cool and neat label from him.

way to tame the Martian Intuition. Although I find Wheeler's venture most intriguing and promising, I rather prefer to fight the battle for the extended mind on an untraditional turf and thus turn my attention to an alternative and somehow neglected line of argument for EMT that appeals to Complementarity.

1.2 The Situated Cognition Movement: a very Condensed Chronicle

The situated cognition movement in the cognitive sciences holds that doing is essential for knowing and claims that all our knowledge is structured, scaffolded and profoundly entrenched in physical and socio-cultural contexts. In essence, the situated programme invites an *in situ* understanding of cognition and favours forms of thinking on the fly while encouraging the offloading of cognitive resources in the environment. The movement comprises a number of different antecedents, including philosophical and psychological ones. However, it has organically developed as a coherent paradigm only after the '70s, to provide a profitable alternative to dominant accounts in cognitive psychology that described cognition in isolation from the body and the world. For this reason, the situated movement has been often characterised as anti-Cartesian, embodied and embedded. In this section, I shall link this movement to externalist claims about cognition. In doing so, I shall ultimately highlight the relevance and the significance of the "situated angle" to these emergent and quite original understandings of our cognitive abilities.

Nowadays views that describe cognition as generated from the actions and activities of physical individuals situated in specific environments have become increasingly popular. However, it hasn't always been like this. During the late '70s and early '80s in fact the more prominent and widely respected account of the human mind was one that envisaged a sort of "methodological solipsism" in the cognitive sciences [Fodor (1980)]. This account suggested that a successful description of our mental states and cognitive functions could have been only achieved internally, without the need to study the interactions of the individual with her body and the world. Accounts as such are nowadays referred as individualist conceptions of mind and cognition. [Wilson (1995),

(2004)]. For these strong individualistic conceptions, cognition can only take place inside the head as it is “*wedged between perception (on the input side) and action (on the output side)*”. [Wilson & Clark (2009), p. 56] In this kind of cognitive sandwich [Hurley (1998)] cognition merely occurs as computational and is always achieved through processing of mental representations. Crucially, this processing of mental representations is language-like, meaning that it is produced and governed by means of an underlying mental syntax. This underlying, innate mental syntax hinges upon formal manipulation of symbols and depends on the rules that govern their production rather than on broader patterns of interdependence between individuals and their environs. Views that explain the emergence of cognition in these terms tend to describe the human cognitive architecture as universal across individuals from different populations and innately or genetically specified. Fodor’s *The Language of Thought* (1975) and *The Modularity of Mind* (1983) are likely to be the most striking expressions of this kind of view in philosophy. Other prominent specimens are the works of Noam Chomsky (1968) in linguistics, of Pylyshyn (1984) in the cognitive sciences and of Newell and Simon (1976) in artificial intelligence. [Wilson and Clark (2009)].

Philosophical concerns about individualistic accounts of cognition were first raised by Burge (1979) and Putnam (1975), who strongly questioned the ability of these disembodied models to satisfactorily account for mental content. In truth, Putnam’s twin earth argument it’s an argument against the claim that linguistic content is fixed wholly by internal factors but then it has been extended to mental content too. [McGinn (1977)]. Putnam’s most famous argument against linguist content is probably the so-called “Twin Earth” argument [Putnam (1975)]. Twin Earth, according to Putnam, is a planet that is exactly like our Earth except for the fact that on Twin Earth there is no water but another liquid, which looks superficially identical but is indeed chemically different. Putnam randomly abbreviates the complex formula describing the structure of this liquid as ‘XYZ’ and subsequently specifies that the inhabitants of Twin Earth, whose language is English, call this liquid “water”. Now, Putnam invites us to set the date of our Gedankenexperiment somewhere in the past, at a time (1750) in which both the inhabitants of Earth and those of Twin Earth did not possess the theoretical and empirical knowledge necessary to know that the liquids they both were calling water were H₂O and

XYZ respectively. From this, Putnam continues, it follows that the experience of both people on Earth and Twin Earth with water are identical. [Putnam (1975)].

Now an important question arises here: does a resident on Earth (call him Oscar) and his homologous twin on Twin Earth (call him TOscar) mean the same thing when they say the word “water”? Ex hypothesis, Oscar and TOscar brains should be perfectly (molecule-for-molecule) identical³. Yet, Putnam argues, when Oscar utters the word “water”, this word refers to “H₂O”. On the contrary, when his twin on Twin Earth says the same word, the very same word refers to “XYZ”. This seems to suggest that the contents of an individual's brain do not suffice to decide the reference of terms they use. *“Since Earthling Oscar and Twin Oscar have exactly the same intrinsic properties, yet refer to different substances when they use their ‘water’-words, their intrinsic properties cannot suffice to determine what they refer to”*. This invites us to think that *“If the meaning of a word suffices to determine its reference, then meaning cannot be determined by intrinsic properties either”*. [Curtis (2011), Stanford Encyclopaedia of Philosophy]. As Putnam famously puts it, *“meanings’ just ain’t in the head!”* [Putnam (1975), p. 227].

These philosophical challenges to disembodied models of mind and cognition were launched to undermine the idea that intentional states could be exhaustively taxonomised in accordance with the constraint of individualism. [Wilson (2010)]. The philosophical positions that cast these series of original challenges are now widely known as “traditional externalism” or “passive externalism”⁴. In the last few decades, the idea that intentional states require broader content because they constitutively depend on some sort of external context has spread like a bushfire, leading to a number of revolutionary approaches on situated cognition⁵ and to more radical forms of externalism about the

³ An enormous amount of objections have been raised against this reading. In this section, I will mention just one of these objections and this shall suffice, as the “Twin Earth” case is not supposed to play any argumentative role in this chapter. A good objection to show that this example is in some ways unfortunate is for instance to note that the human body contains between 58% and 78% of “water”. So, the Twin Oscar cannot be an exact duplicate of his earthling twin unless Twin Oscar’s body also consists largely of “water”. [Curtis (2011)].

⁴ [see Wilson (2000)] and Clark & Chalmers (1998) for an in depth analysis of these positions].

⁵ Work conducted on situated cognition has had a very strong impact on different fields, including perception [Gibson (1986)], memory [Clancey (1997)], cognitive anthropology [Hutchins (1995), 2010] and in many

mind. [Hurley (2010)]. These radical forms of externalism have assumed a number of different labels, including *locational externalism* [Wilson (2000)], *environmentalism* [Rowlands (1999)], *vehicle externalism* (Hurley 1998) and *the extended mind thesis* [Clark & Chalmers (1998)]. One way or another, all these expressions have come to support the idea that our mental states aren't merely confined within the physical boundary of the organism but that at least some of them occasionally span the brain, body and world boundary. The extended mind thesis has more than any other view engaged individualistic accounts of mind and cognition. This persistent engagement has produced an impressive number of works that have led EMT to acquire a prominent status in the philosophy of cognitive sciences. It is to such a theory that I turn now.

1.3 The Extended Mind Thesis (EMT)

EMT asserts that mental states and cognitive functions may sometimes supervene on organised systems of processes and mechanisms that criss-cross the boundary of brain, body and world. [Clark (2008)]. EMT therefore aims at individuating “*the specific conditions under which the material vehicles that realize cognition are distributed over brain, body and world in such a way that the external (beyond-the-skin) factors concerned are rightly accorded fully-paid-up cognitive status*” [Wheeler (2010), p. 245], and cognitive systems are taken “*as reaching beyond individuals into their physical and social environments*”. [Clark and Wilson (2009), p.58]. The crucial idea underlying EMT is therefore that some of our cognitive processes can and do actually extend outside our heads. For EMT cognition doesn't exclusively take place inside the biological boundary of the individual but, on the contrary, can arise in the dynamical interplay between neural structures, body and world. EMT claims that these pervasive, intimate, action-orienting and behaviour-guiding interactions result in external features actively participating in an organism's mental activity, becoming functionally integrated in its cognitive superstructure. A laptop, an iPhone, even a notebook or a diary may thus become (because of the function they perform) active parts of the substratum of one's mental

sub-(related)-areas such as affordances [Greeno (1998)] and effectivities [Shaw, Turvey and Mace (1982), just to name a few].

activity⁶. As Sutton has put it: “*external systems and other cognitive artifacts are not always simply commodities, for the use and profit of the active mind: rather, in certain circumstances, along with the brain and body which interacts with them, they are the mind*” [Sutton (2010), p.190]; with this clearly meaning that the realm of the mental can occasionally spread across the brain, body and world boundary. In sum, the claim is that “*cognition ain’t (all) in the head*” [Clark &Chalmers (1998)]; but “*rather that it can embrace bits of the extracranial body and items in the world beyond*”. [Farina (2010),p.226].

Following Rowlands (2009), I propose to understand EMT *as an ontic thesis of partial and contingent composition of some mental processes*”. [Rowlands (2009), p.54]. In what follows I quickly expand upon these bullet points, highlighting the crucial aspects underlying this hypothesis. I conclude this section with a brief analysis of the different forms that extended cognition can assume. In the previous paragraph I have said that EMT is an ontic thesis. To repeat, EMT is first and foremost a claim about the nature and the location of our mental states and cognitive processes. I believe EMT is an ontic thesis because it attempts to describe what these states and processes are, where they are located and eventually tries to group, relate and individuate them. But EMT is also a partial and contingent hypothesis. It is a partial thesis because it affirms that some of our mental states are (partly) “*made up of the manipulation, exploitation, or transformation of environmental structures*”. [Rowlands (2009), p.630]. It is a contingent theory because it leaves open the possibility of different ways of realising the same (type of) mental process. This follows from its direct commitment to mainstream functionalist approaches to information-processing. In endorsing the multiple realisability thesis, EMT naturally embraces the idea that sometimes an external, non-biological factor is required for the realization of some of our distinctive kinds of cognition. Despite its strong commitment to externalisation, no version of the extended mind thesis has ever given up the idea of internal assistance; no form has ever questioned the importance of the on-board neural circuitry for the production of cognitive behaviour-quite the opposite. On an

⁶ This is a direct consequence of what has come to be known as the Parity Principle. I will not discuss Parity and its implications in this section but will return to this controversial issue in the next one, where I shall critically tackle this crucial point in much greater detail.

extended account of cognition none of the factors that constitute and make up an extended cognitive system possess an ontological priority over another. EMT is thus a partial and contingent thesis about the contribution brought forth by the environment towards the emergence of certain cognitive processes. But EMT is also a thesis about the constitution, or better about the composition of mental states and shall not be mistaken for the thesis of the embedded mind. The principal difference with the embedded view is that embedded accounts of cognition typically think of the boundaries of the mind as the boundaries of the biological organism with mental processes standing in a relation of causal dependence on the environment. This difference is nicely captured by the adoption of two convenient short hands that are used to describe the ongoing organism-environment interactions. It is usually said that extended cognition is “organism-centred”, whereas embedded cognition is “organism-bounded”. Finally, it might appear redundant or preposterous to say, but it is important to clarify that EMT does not claim that *all* mental states are constituted (wholly or partly) by processes of environmental manipulation; it rather asserts that only *some* of them are. When I remember where I forgot my keys, by mentally reconstructing the image of myself dropping them into the bedroom’s drawer, I do not suppose that some environmentally enriched manoeuvring is taking place to justify the emergence of such a state! “*Thus, contrary to popular belief, EMT is compatible with the possibility of a brain in a vat. It is just that, if EMT is true, the mental life exhibited by the brain would be somewhat truncated*”. [Rowlands (2009b),p.56].

Before I turn my attention to the main business of this chapter, which is to point to the stalemate between extended and embedded by focusing on parity and on the question about how to individuate the functional roles, I would like to conclude this section with an analysis of the different forms that extended cognition can assume. Wilson and Clark (2009) have distinguished three realms (natural, technological and socio-cultural) within which extended cognition can emerge and have offered for each of these realms an accurate taxonomy. It is to such taxonomy that I now quickly turn.

The first realm gathers all those systems comprising natural resources that can impact upon the behaviours, dispositions and cognitive activities of the cogniser. Oxygen is a natural resource for human respiration as well as meat is a primary resource for nutrition. However neither oxygen nor meat can be said to extend the capabilities of the cogniser. Yet, under certain circumstances, specific natural resources can be used not only to "refuel" a pre-existing system (the respiratory apparatus in the case of oxygen or the digestive system in the case of meat), but also to extend the abilities that such a system possesses. A shell is a resource as such for a little octopus. When threatened, the octopus closes himself up inside the shell, so that the shell can save his life. Although the shell is a non cognitive tool, it nevertheless physically and functionally changes the capacities of the little octopus and so in a way, it seems reasonable to describe the octopus + shell system as an enriched integrated system, one in which the octopus's capacities to survive would be consistently reduced if it were to be a shell-less octopus.

There is also a second and perhaps more powerful form of extended cognition. This form, Wilson and Clark continue, occurs in the technological domain where cognitive agents recruit technological resources. Unlike natural resources, technological ones are mostly manmade and therefore almost entirely artificial. Despite their status, technological resources encompass a wide range of apparatuses, which include both dedicated cognitive artefacts and special devices with more general functions that can eventually be used for cognitive augmentation⁷. In the former category fall all those "instruments" (such as software for recording of data, prosthetic limbs or laptops) that represent permanent features of our everyday life, tools that merely contribute to lighten the computational burden of our brain. To the latter category belong instead more

⁷ I use the term augmentation in the meaning often utilized in the research field at the frontier between human-computer interaction, psychology, ergonomics and neuroscience. To this extent, augmentation indicates the real time integration of inner and outer resources pursued, iterated and substantiated over time to maximize a user performance in a potentially hostile environment. With regard to the couplings with the technological domain, particularly with respect to sensory substitution devices (SSDs), augmentation comes to define some form of enriched perceiving and (perhaps) of enhanced experiencing that is achieved only because of the constitutive contribution obtained by means of the couplings between the human cogniser and such external interactive features. I will return to SSDs specifying these controversial claims in chapter 4, 5 and 6 of this dissertation. Let me briefly notice here however, that augmentation needn't be confined solely to technology. Augmentation, or cognitive transformation as I shall call it, is sometimes also realised through repeated engagement with different socio-cultural activities, which mould, forge and transform our cognitive functions. I shall return to this issue in chapter 2.

sophisticated features (such as iPhones or sensory substitution devices) that become deeply integrated into the perceptual processing of our brain and ultimately give rise to forms of cognitive augmentation. Like natural resources, some technological ones (namely those that act as mere instruments) can serve the organism as inputs to an organismic-bounded activity; but there is a range of cases in which these technological features (especially those that act as cognitive supplementations) seem to go beyond mere causal aid and become functionally integrated into a larger cognitive system. Sensory substitution devices belong to this latter category and their case is striking and particularly instructive. I shall return to this issue in much greater detail in the next chapters of this dissertation as sensory substitution will constitute one of the empirical case studies I will analyse to set up my defence of EMT. For now, let me complete this taxonomy and look at the third and final example of extended cognition that Wilson and Clark invite us to consider.

A third form of extended cognition emerges in the socio-cultural sphere. Socio-cultural systems are established where there is a stable and persistent reliance between single individuals and their activities and other individuals, and their cultural, intellectual and ethnic products. These products and actions serve as a basis for a wide range of other cognitive activities. One of the most prominent examples of an extended socio-cultural cognitive system is probably the writing system. The writing system has not just fed into some pre-existing cognitive abilities that agents possessed but has rather contributed to modify the very mechanisms that govern, for instance, short – long term memory while at the same time constituting, a reliable and relatively durable cognitive resource that has forged education, influenced commerce practises and determined military conquest in the Western world for millennia. [Wilson and Clark (2009)]. Other prominent cases of extended socio-cultural cognitive systems are those involving mathematical notions, gestures, parental care and group relations. In all these cases the cultural resource becomes factored in the individual neural circuitry so as to sculpt the individual's functions and capacities. As Wilson and Clark have noticed, *“for many individuals, such socio-cultural resources are like natural cognitive resources in that they can be taken for granted as part of the normal conditions under which their cognitive abilities develop, they acquire specific skills, and they learn particular facts”*. Wilson & Clark

(2009), p.63]. Socio-cultural resources are therefore worth a mention in this taxonomy because they play a crucial role in many of the abilities that characterise us as humans. Socio-cultural resources make it possible, for instance, to distinguish human culture from primate cognition. Although “*there may be animal cultures, it is only in Homo Sapiens that we find diverse cultures of cognition, social structures, and products that whatever, their own origins, now significantly augment the cognitive capacities of individuals who are embedded in them*”. [Wilson & Clark (2009), p.64].

Let me conclude this section with a brief recap. Extended cognition arises as a synthesis of activities of individual lifetime learning, technological couplings, and collective socio-cultural practises. It occurs when any internal or external resource becomes so finely tuned, so deeply integrated into the human bio-physical architecture that it triggers the formation of a larger system able to cope and engage in new forms of intelligent problem-solving behaviour. This persistent engagement leads to the emergence of cognitive machines “*intrinsically geared to self-transformation, artefact-based expansion, and to bootstrapping processes of computational and representational growth*”. [Wheeler & Clark (2008), p.3588].

1.4 Parity and Problems with Parity

In the previous section I have introduced the hypothesis of extended cognition and quickly familiarised the reader with the dimensions in which it seems to occur. In this section I critically discuss EMT by focussing on the debate about how to individuate the functional roles. I begin by quickly revisiting Clark and Chalmers’ seminal Gedankenexperiment (1998), the springboard for much of the debate surrounding the extended mind today. I use their mental experiment to explain the idea of parity of function. Having explained Parity, I then present some of the criticism that has been cast to undermine the idea of functional equivalence. [Weiskopf (2008); Adams and Aizawa (2009); Rupert (2009)]. In short, friends of EMT seem to understand the functional roles that define a mental state in a coarse-grained way. By contrast, opponents of EMT assert that these functional roles must be understood in a fine-grained way. In this section, I review the rich dialectic underlying this debate and focus on Weiskopf’s, Rupert’s and Adams and Aizawa’s arguments against

functional equivalence. I conclude this section by suggesting that the series of arguments opponents have developed make standard-functionalist defences of EMT stall.

In their 1998 paper, Clark and Chalmers famously ask us to consider two different forms a standing belief might take by comparing the strategies that Otto and Inga deploy to visit an exhibition at New York's MoMA. Inga, a healthy subject, hears about a new exhibition at the Museum of Modern Arts in New York and realises that she wishes to see it. Upon hearing this information, Inga uses her biological memory to form/retrieve the belief that MoMa is on 53rd street, and makes her way downtown. At the same time, Otto hears about the very same exhibition. He also likes the exhibition's theme and decides to visit it. Unfortunately, Otto suffers from Alzheimer's disease. His medical condition prevents Otto from reliably using his biological memory to form or retrieve the belief that MoMa is on 53rd street. However, as a compensatory strategy Otto has learned to rely upon a notebook, in which he writes all the stuff he can no longer remember with his biological brain. Otto always keeps his notebook ready to hand, so that when he needs it, he can smoothly retrieve the crucial information from it. In the case at stake here, Otto uses the notebook to retrieve information about the location of MoMA and then sets off.

Having introduced their thought experiment, Clark and Chalmers now ask us to compare the cases of Otto and Inga and invite us to reflect on whether we should attribute to both Otto and Inga a standing belief about the physical location of New York's MoMA. Clark and Chalmers believe that "*the information contained in Otto's notebook plays the same causal role in guiding his actions as Inga's biological memory does in the guidance of her actions*". [Kiverstein and Farina (2011), p.37]. For this reason, Clark and Chalmers count Otto's notebook as part of the causal machinery that instantiates his standing beliefs. We shouldn't treat Otto's case differently from Inga's case, they argue, just because the states that drive Otto's behaviour are partly offloaded onto the environment and therefore located outside of Otto's physical boundary. This thought stands behind what has come to be known as the "Parity Principle". In Clark and Chalmers' original treatment, PP runs as follow:

"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”. [Clark & Chalmers (1998), p.2].

PP therefore invites us to assess whether a state can count as a belief, in part, on the basis of the causal role it performs. For Clark and Chalmers it doesn't really matter where the lodger of this causal role is housed. It can be located within the confines of the biological body, or rather span the brain, body and world boundary. What makes something a belief is for them a matter of the causal relations that this lodger entertains to inputs and outputs and to other mental states. In other words, Clark and Chalmers do not believe that the physical details of a state that stands in these causal relations can matter when it comes to decide whether the very same state counts as a belief or not. The case of Otto and Inga is thus quite instructive because it seems to provide strong theoretical support for the claim that beliefs, a paradigmatic case of mental states, can supervene on mechanisms that are distributed across brain, body, and world. The more general thesis I have introduced in the previous section, the one that asserts that mental states in our actual world occasionally supervene on organised systems of processes and mechanisms that criss-cross the boundary of brain, body and world seems to be the straightforward implication of this mental experiment too. *“EMT in fact looks like a thesis that any philosopher of mind committed to functionalism should sign up for”*. For it seems to be a direct implication of the core assumption of functionalism that it is a state of mind's causal role that makes it the type of state that it is. [Kiverstein and Farina (2011), p.37-38]. As Clark has noticed:

“All one needs is the very weak functionalism captured in the Parity Principle: roughly, if a state plays the same causal role in the cognitive network as a mental state, then there is a presumption of mentality, one that can only be defeated by displaying a relevant difference between the two (and not merely the brute difference between inner and outer)”. [Clark (2008), p.15].

Inner and outer, biological and non-biological, mental and artefactual can therefore combine, merge and amalgamate to realise a type of mental state. This realisation can sometimes only occur if internal and external work in partnership to make the right kinds

of causal contribution in the instantiation, production and guidance of successful purposeful behaviour. Where the material vehicles that make this causal contribution possible are housed is for EMT only incidental, what is relevant is instead the job, the function that these material vehicles perform. Quite often these jobs and functions can be performed better when biological agents work in close, symbiotic partnership with the resources located in their milieu, recruiting items that are stored beyond the physical boundary of their skin and skull. In some other cases however, and more on this in chapter two of this dissertation, the relevant task cannot be accomplished unless we rely on processes that are situated outside the biological skinbag of the organism.

Although Parity was undoubtedly central in the argument that Clark and Chalmers have developed for EMT, it has so far proven far from being obvious. Much of the criticism about EMT has in fact been generated by the related question of whether to individuate functional roles in a coarse-grained or fine-grained way. This crucial concern has been the real stumbling block on the path toward a successful and complete corroboration of EMT. Opponents of EMT have repeatedly engaged Clark and Chalmers on this issue while famously arguing that the functional roles that define a mental state must be understood in a fine-grained way. There are, they have argued, substantial differences between inner and outer and it is precisely these differences that ultimately undermine any attempt to use Parity to develop an argument for EMT. It is to this persistent criticism that I now want to turn.

Opponents of EMT have repeatedly claimed that the differences between internal biological processes and allegedly extended ones are so crucial and significant to undermine the idea that inner and outer are functionally equivalent. In the discussion of Parity presented above, I have however shown that it is precisely this functional equivalence that is required for functionalist defences of EMT. If opponents of EMT can successfully demonstrate that the idea of functional equivalence is deeply flawed then it would seem that they have a strong argument to resist EMT. In a recent paper, Daniel Weiskopf (2008) has contended that putative cases of extended beliefs such as those realised by the Otto + notebook system, ought not to be counted as genuine cases of belief because:

“Beliefs are normally informationally integrated with, and updated in concert with, other beliefs (and further mental states of the subject, such as desires). But most alleged cases of externally located mental states do not share this feature. So, by the functionalist principle, they cannot be beliefs”. [Weiskopf (2008), p. 268].

In a similar vein, Rupert (2004, 2009) and Adams and Aizawa (2001, 2009) have questioned the very idea of extended memory by contending that extended memories don't fill the right kind of functional roles to count as proper and genuine memories. [Kiverstein and Farina (2011)]. They have contested that alleged cases of extended memories can be rated as genuine cases of memory, on the grounds that extended memories don't behave anything like internal, biological ones. Extended memories in fact do not exhibit a wide range of phenomena {such as negative transfer [Rupert (2004), p. 413] or recency, primacy, or chunking effects [Adams and Aizawa (2001),p. 91; (2009), p. 61], that are instead typical of internal, biological ones. Extended memories do not exhibit key signature features of human semantic memory. [Kiverstein and Farina (2011)]. Extended memories thus significantly differ from internal ones and cannot be assimilated or compared to them. On the top of this, Adams and Aizawa have also highlighted the fact that Otto's use of motor and visual skills to access the contents of his notebook radically differs from Inga's mode of access of her biological memory. [Adams and Aizawa (2009), p.68-70]. Crucially in fact, Inga needs to deploy neither motor nor visual skills to retrieve the important information she needs to reach New York's MoMa.

The argument for EMT I presented above was based on parity and precisely needed for its corroboration the functional equivalence of internal biological processes and extended ones. Following Clark and Chalmers I suggested that if these two types of processes (external and internal) are functionally equivalent then both should be accorded equal treatment when assessing their status as beliefs. The considerations rehearsed in the previous paragraph however seem to point to important functional differences between inner and outer. These crucial differences in turn seem to indicate that internal biological processes and putatively extended ones cannot be functionally equivalent. Without this

functional equivalence in place however, any respectable functionalist defence of EMT is dismantled and devitalised. It is dismantled and devitalised because it is deprived of its major argument for treating extended processes as cognitive ones. Couldn't we, say, re-engineer our external resources so as to render these functional differences less pervasive and make these extra-biological features work more like the internal ones do?

Suppose Otto was to modify his notebook so as to make it work more like our internal biological memory. [Sprevak (2009), p.508]. His notebook would at some point become so different from any of the notebooks we are accustomed to in our actual world that we could not reasonably deduce from Otto's case anything about the mind and its functions in the real world. The most we would probably be allowed to surmise would be the logical possibility of EMT. EMT would be logically possible in the sense that there wouldn't be any contradiction in supposing possible worlds in which memories can actually extend. All opponents of EMT are however prone to concede this much. What is at stake in this debate is rather to decide whether the mind physically extends in the actual world we inhabit, and a suitably re-engineered notebook seems to be totally powerless to tell us anything about this. To repeat, the objections moved by critics of EMT point to the existence of significant, fine-grained differences between the functional roles of internal biological processes and those of putatively extended ones. Furthermore, all these differences seem to be factual and grounded in our actual world. Are thus opponents of EMT right to insist on such a fine-grained functional equivalence and does its denial entail a rejection of EMT? Clark remains sceptical about the prospects of this criticism. Here is what he writes as a preliminary response to placate his opponents: "*[the] claim was not that the processes in Otto and Inga are identical, or even similar, in terms of their detailed implementation. It is simply that, with respect to the role that the long-term encodings play in guiding current response, both modes of storage can be seen as supporting dispositional beliefs. It is the way the information is poised to guide reasoning...and behaviour that counts*". [Clark (2008), p.96]. In short, Clark doesn't deny the fact that intracranial and extra-cranial processes differ in terms of fine-grained functional roles, he completely agrees with his critics on this. Clark simply rejects the assumption that such differences should necessarily matter when it comes to assessing the

parity of inner and outer. The sort of functional equivalence that Clark is seeking to establish is rather determined at a fairly coarse-grained level.[Clark (2001)]. Clark thus believes that drawing the boundary between the cognitive and the non-cognitive this finely would only cause us to scale new heights of anthropocentrism and neuro-centrism. [Clark (2008)].

Opponents of EMT remain unconvinced by this response and demand more clarity. They insist and focus on the fine-grained understanding of the differences between internal and external, as this focus they believe, contribute to undermine the case for EMT. So, here we face an apparent stand-off. Who is to say who is right and how do we possibly get out of this impasse?

1.5 The Stalemate

Clark has suggested a way to get out of this apparent stand-off. To do so, he has appealed to what Sprevak (2009) has called: “The Martian Intuition”- *“the thought that creatures that are physiologically different from us can nevertheless share the same types of mental states with us”* [Kiverstein and Farina (2011), p.38]. The Martian Intuition not only grants the possibility for a variation in physiology, but it also endorses a degree of variability in the attribution of psychological states. Just as we can abstract away from physiological differences in evaluating whether a living being shares identical types of mental states with us, so we can also abstract away from some (but of course not all) psychological differences. The Martian intuition thus entails that it is possible for an organism with psychological states to exist, even if such an organism has a diverse corporeal and biological architecture. An intelligent morphon might well have green stuff instead of neurons, it might be made out of aluminium rather than say titanium or carbon, and it might not even have axons or synapses but rather possess some other kind of electrochemical transmitters travelling along the body to connect the fibers. There wouldn't be any reason, however, to argue that such an organism does not possess mentality. [Sprevak (2009)]. A Martian may well be able to remember facts and events even if in its performances in psychological tests it did not consistently show negative

transfer, neither recency, primacy or chunking effects [Wheeler (2010), p.261-264]. Adams & Aizawa, as we have seen above, have emphasised the fact that Otto uses his visual and motor systems in the retrieval of crucial information from his notebook. We can however conceive Martians using their visual and motor systems to access stored sources of information because their memories are stored in either a motor or a visual format [Sprevak (2009), p.511]. The Martian Intuition thus seems to suggest that despite non-standard methods of retrieval, and crucial fine-grained differences found in the structure of the bio-physical architecture, the Martian's mode of access to stored sources of information via visual and motor skills should still be counted as remembering. The Martian Intuition therefore provides proponents of EMT with a very powerful weapon to fend off most of their bitter enemies.

The Martian Intuition seems in fact to grant the possibility that we can theoretically abstract away from fine-grained functional differences in determining whether a state qualifies as a mental state of a given type. At the same time the Martian Intuition also suggests that tying our mental states to the fine-grained details of human psychology is a hazardous move. It is a hazardous move because this move entails a biologically chauvinist understanding of our mental states. This chauvinist understanding is indeed manifestly in conflict with the spirit of inclusiveness that the Martian Intuition seems to encourage. Despite the fact that the Martian Intuition provides us with very powerful means to resist much of the bio-chauvinist criticism raised against functionalist defences of EMT, its deployment comes at a cost, a very high cost as I shall notice.

In their seminal paper, Clark and Chalmers (1998) have appealed to the existence of some "glue and trust" conditions to justify their claim that the mind extends beyond the skin and skull of the organism. These conditions were formulated in order to prevent the mind from spreading rampantly into the world and offered as requirements needed for an external resource to effectively count as part of the mind. The glue and trust conditions say that an external resource counts as part of our mind if it is (1) portable (2) easily accessed and (3) automatically endorsed. While the first two constraints are quite unambiguous the third one remains a bit murky and seems to require additional attention.

Let me quickly explain what Clark and Chalmers meant with the locution “automatically endorsed”. An external resource is for Clark and Chalmers automatically endorsed when it is not subject to critical scrutiny or cross-checking, this meaning that “*its mechanisms are sufficiently robust to ensure against deliberate tampering or arbitrary manipulation*”. [Smart et al. (2008),p.15].

Now, Mark Sprevak (2009) has noticed that for each of the glue and trust conditions proposed by Clark and Chalmers to grant the possibility for the mind to extend, we can effortlessly conceive a specific case of Martian cognition that fails to meet the requirements needed for effective mind extension. We can in fact imagine, Sprevak argues, an insomniac Martian whose memories are readily retrieved only if it has had a very relaxing night’s sleep. Being an insomniac however, this very rarely happens. We wouldn’t want to say, Sprevak continues, that the poor insomniac “Martian” fella does not experience memories just because the conditions for retrieving and accessing them are very seldomly met. Such a conclusion would in fact conflate with the spirit of inclusiveness advocated and endorsed by the Martian Intuition. It would equally well run against its central tenet that asserts that living beings that are psychologically different from us can nevertheless share our mental states. Now, Sprevak shows that we can successfully run similar arguments for the other two of the glue and trust conditions abovementioned [Sprevak (2009), § 5-6]. This possibility, on his account, is sufficient to establish the inconsistency of the Martian Intuition with the constraints originally given on extended cognition by Clark and Chalmers⁸. Yet without such constraints in place, he concludes, the mind threatens to spread rampantly into the world. The kind of functionalism that licenses EMT therefore appears to be overly liberal and disproportionately permissive in its attribution of mental states; so permissive and liberal that it starts looking genuinely implausible. [Kiverstein and Farina (2011)].

There are indeed a number of different responses that attempt to tame the so-called Martian intuition. Most of these responses try to avoid the radical counterintuitive consequences highlighted by Sprevak. The strategy these responses generally deploy aims

at individuating a number of criteria for the characterisation of functional roles that are neither too liberal nor too conservative. The problem of finding a level of granularity for the individuation of functional roles that is just right isn't however a new problem for functionalist theories of the mind⁹. So far, the solution to this Goldilocks problem hasn't unfortunately been the most forthcoming.

The most efficacious attempt to tame the Martian intuition is, no doubt, due to Michael Wheeler [Wheeler (2010), (forthcoming)], who proposes to renounce the condition of a single level of granularity tailored to all our mental states and rather looks at what Clark (1989, 1999) has called “microfunctionalism” for a stable solution of our Goldilocks problem. Clark has noticed that “*microfunctionalism specifies a system only in terms of input output profiles for individual units and thus is not crucially dependent on any particular biological substrate*”. [Clark (1999), p.40] In a similar vein, Wheeler has argued that in microfunctionalism, “*there are certain key properties of flexible generalization and graceful degradation that are at least partly realized beyond the skin*”. [Wheeler (Manuscript), p. 26]. Wheeler has appealed to these properties, which he claims need to be displayed by any system worthy of the label “cognitive”, to elaborate an account of functional roles that is compatible with EMT. He has tried to demonstrate that these functional roles are fixed at a very fine level of grain, while at the same time arguing for the impossibility of realising them only internally.

By keeping the formal characterization of these functional roles at a very fine-grained level he has hoped to find the proper structure capable of supporting the rich behavioural patterns needed for cognitive extension. [Wheeler (2010) §6]. It is therefore an implication of his microfunctionalism that a system must realise a certain fine-grained functional profile and this fine-grained functional profile is required if we want to label something as cognitive. This functional profile doesn't however impede extended cognition nor precludes the existence of extended minds – quite the opposite. The Wheeler's response to the Goldilocks problem looks quite consistent with assessing each cognitive process on a case-by-case strategy. [Kiverstein & Farina (forthcoming)]. The

⁸ Clark could however object that these conditions were aimed at the claim about extended bases for dispositional beliefs. So taking them as fully general might be misleading.

thing we have to do is simply to look for the right functional profile. When we find it we can account for the cognitive.

I certainly don't mean to dismiss Wheeler's venture and I surely find his microfunctionalist project most intriguing and perhaps even compatible with my approach. I am fascinated by his quest for functional isomorphism but I also believe that in order to strengthen the case for EMT we need to take into account the functional differences between internal and external. Functional differences do matter and contribute to buying cognitive transformation, while allowing for the production of the kind of augmented cognition that EMT ultimately seeks to establish. So, in order to establish this kind of cognition, I turn to a perhaps more fascinating line of argument; one that in the literature directed at EMT has quite often been neglected. This line of argument is concerned with so-called second wave, "Complementarity defences" of the extended mind. I find in this Complementarity understanding an equally illuminating and perhaps even more promising set of arguments for EMT. It is to this Complementarity approach that I now turn.

⁹ Block (1978); Lycan (1991).

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Chapter 2

2.1 Introduction

In the previous chapter I have introduced EMT and have discussed its crucial tenets. I have presented the Parity Principle, highlighted some criticism and acknowledged the stalemate in which the debate between embedded and extended has fallen. In this chapter, rather than combating the battle for the extended mind on a traditional, purely functionalist turf, I concede that there are significant and undeniable fine-grained differences between internal, biological processes and putatively extended ones. In agreement with opponents of EMT, I thus reckon that extended cognitive systems are endowed with quite different properties from systems that are “brain bound” but, *contra them* argue, that it is precisely these differences that allow human minds to transcend their biological limitations. I therefore look at a less explored line of argument for EMT that is to do with the idea of complementarity.

So-called second wave, Complementarity defences of EMT assert that diverse constituents of a soft-assembled system¹⁰ can perform quite different role and possess different properties while interlocking to trigger complementary contributions that favour flexible thinking and acting. [Farina (2011)]. I thus defend this complementarity version of the extended mind thesis and argue that complementarity becomes crucial when it comes to describing the development and evolution of human cognitive behaviour. [Sutton (2002); Sutton et al. (2010)]. Opponents of EMT [such as Sprevak (2009) and Adams & Aizawa (2009)] but also some friends of it [Rowlands (2010) and Wheeler (forthcoming), to name a few] have noticed that Complementarity alone isn't yet sufficient to establish extended cognition and that we need to add something to it if we want to address the causal-constitutional conflation. EMT is often accused to confuse the claim that “*some problem solving behaviour is causally dependent on a part of the*

¹⁰ Softly-assembled systems are provisionally assembled units working in the service of successful phenotypic transmission. Softly-assembled systems are made up via temporary bio-ecological operations of assemblage that occur between neural and non-neural resources. These operations deal with specific problems arising in the course of one's experience. Softly-assembled systems lie at the core of the phenomenon of cortical plasticity in human development and to, Thelen and Smith(1994), they are the defining feature of a dynamic account of development.

external environment for the claim that a part of the external environment can form a part of a cognitive process". [Farina (2010), p.227]. This is the causal-constitutional conflation. Second wave theorists have developed a number of responses to deal with this objection. Sutton (2010) for instance, wants the best argument for EMT to be independent of functionalism and has tried to shift the debate away from Parity. He focuses on the rich scaffolding in the context of complementarity to show that once this rich scaffolding is established embedded pretty much collapses into extended. Menary (2006) instead explicitly rejects functionalism and adds to complementarity the dimension of integration¹¹. In this section I look at the rich dialectic underlying the debate generated by Complementarity and try to bring out some of the differences within the 2nd wave camp.

Having discussed complementarity and highlighted the differences within the 2nd wave camp, I then turn to the main business of the chapter, which is to show how complementarity allows us to escape the stand-off mentioned above. The goal of the chapter is thus to show how complementarity can provide a solid and robust response to embedded understandings of human intelligent behaviour. To do so, I firstly argue that plasticity is a pre-condition for EMT and then sketch an argument for EMT based on it. Plasticity is a pre-condition for EMT because it makes it possible for our cognitive processes to expand and extend into the environment so as to integrate and literally fuse into our own bodies the tools we use for thinking. Through plasticity in fact these tools become geared into working in symbiotic partnership with our brains and form an entangled, symbiotic and integrated system of cognitive analysis. But plasticity also determines, via continuous environmental engagements and repeated socio-cultural activities, the shaping and sculpting of our cognitive functions. In this chapter, I therefore make a developmental argument for EMT based on the ontogeny of cognitive systems. I argue that our on-board neural machineries come to be dovetailed to fit with the

¹¹ I should stress here that Menary's picture is probably closer to the more diachronically-based version of EMT on which I have been working with my supervisor Julian Kiverstein. Sutton is in no way opposed to diachronic explanations; just he thinks that they don't deliver metaphysical constitution claims about current cognitive states and processes. His diagnosis, and more on this below, is that we should keep the diachronic explanations but drop the constitution claims. I'd be inclined to agree on this point with Sutton. In what follows, however, I try to establish the metaphysical claims via diachronic explanations.

particular socio-cultural environs to which they are exposed. This exposure allows humans to transform, transcend and quite often augment their cognitive functions and at the same time opens up to processes of deep intelligent self-engineering and restructuring. Plasticity therefore contributes to getting us something we wouldn't get if we were to rely exclusively on our brains or on our biology. This point is crucial because it forges the connection between plasticity and Complementarity I was looking for. To further strengthen this connection and thus to reinforce my case for Complementarity and EMT, I conclude my argument by focussing on a series of empirical studies which confirm the profound enmeshing and dovetailing of internal and external, while crucially revealing the way in which biological and non-biological reciprocally intermingle in moulding and forging our cognitive functions.

In the final section of this chapter, I eventually address some criticism. Critics have objected that it seems difficult to see how we can establish an argument for synchronic, here and now extensions on the grounds of diachronic, developmental considerations. They have typically contended that the kind of dovetailing I have been defending is powerless against the causal-constitutional charge that is always levelled against EMT. EMT, it is argued, confuses a perhaps necessary causal contribution from the external world for a cognitive one. I respond by showing that even though the developmental argument I made might not provide a knock-down argument against individualism, it surely calls into question any intracranial, brain-bounded understanding of human cognitive behavior as it seems to empirically undermine any view that thinks of the brain as the single, individual container of the mind. [Kiverstein and Farina (2011)].

2.2 Complementarity: what is it?

EMT, as we have seen before, asserts that some mental processes are symmetrically coupled, deeply interweaved, with external vehicles in the environment in a way that allows such states to extend outward from their cranial prison and form a system that is a cognitive system in its own right. To substantiate this claim, functionalist defences of EMT have appealed to the parity principle. By breaking down classical and individualist distinctions between brain, body, and world, Parity has attempted to challenge the very

idea that the core realiser of cognition is restricted, bounded and confined to the physical boundary of the organism. Significant objections to Parity have been moved and, as we have seen in the previous chapter, all these objections (mostly related with the question of how to individuate the functional roles) have driven the debate into a treacherous stand-off. In this stand-off the embedded conservatism has seemed to stand better changes of corroboration over its more contested, “extended” neighbour. The parity-based, purely functionalist understanding of EMT depicted in the previous chapter, isn’t however the only approach that proponents of EMT have been using to argue for cognitive extension.

Another line of argument consistently deployed in the literature directed at EMT concerns what John Sutton has famously dubbed the Complementary contribution of inner and outer resources. [Sutton et al. (2002); Sutton et al. (2010)]. In agreement with critics of EMT, proponents of this approach concede that there are undeniable, fine-grained functional differences between internal and external but argue that it is precisely these differences that allow human minds to transcend their biological limitations. As Menary has put it: there seems to be a: “*Complementarity between what the biological brain can do and what the environment provides, such that inner processes and vehicles and outer processes and vehicles work together to complete a cognitive task*”. [Menary (2006),p.341]. This understanding of EMT therefore entails that outer states or processes need not to replicate the functions and the roles of internal biological ones but rather that different components of a cognitive system can coalesce and reciprocally intermingle in the production of flexible cognitive behaviour. Second-wave defences of EMT are therefore based on what has come to be known as the ‘Complementarity Principle’. [Sutton (2010)]. This principle embraces both historical and developmental considerations and seems to invite us to try “*to make the world smarter so that we can be dumb in peace*”. [Clark (1997), p.180].

In truth, complementarity themes can be found in Clark’s seminal work (1997). In *Being There* (1997), Clark highlights the crucial transformative power of artworks, pieces of technology, media, social networks and institutions for human cognitive behaviour, while illustrating the frequency with which we rely, in rich and interactive ways, on the

capacities of specific non-biological features. These extra-cranial features are, Clark argues, quite often “*alien but complementary to the brain’s style of storage and computation. The brain need not waste its time replicating such capacities. Rather, it must learn to interface with them in ways that maximally exploit their peculiar virtues*”. [Clark (1997), p. 220]. Thus, rather than causally aiding the production of cognitive behaviours, these complementary, non-biological/extra-neural factors become “*equal (though different) partners in coordinated, coupled larger cognitive systems*”. [Sutton et al. (2010), p.524]. The focus of complementarity approaches is therefore on the many different ways in which diverse components of a cognitive system, intermingle and function together in triggering, driving and forging complex and flexible kinds of cognition. Clark himself has envisioned in this complex process of reciprocal interweavements the roots for what he has argued to be the more stimulating, credible and attention-grabbing argument for EMT. As he put it:

“The argument for the extended mind thus turns primarily on the way disparate inner and outer components may co-operate so as to yield integrated larger systems capable of supporting various (often quite advanced) forms of adaptive success. The external factors and operations, in this model, are most unlikely to be computationally identical to the ones supported directly in the wetware”. [Clark (1998), p. 99]

Elsewhere¹² Clark has further reinforced the idea that external factors can impact in multiple and significant ways upon our biology so as to create augmented systems whose cognitive power goes well beyond that of the naked brain alone. Complementarity is thus clearly a key theme, a trade mark label of his own work. Here however, it seems fair to do a bit more citation and crediting. While standard Complementarity themes are peculiar of Clark’s seminal works and can also be found in earlier treatments [such as Rowlands (1999) for instance] harking back to and building on Wilson (1994) and Haugeland (1998); the idea of picking out Complementarity as a clear alternative route to EMT that

¹² See for instance, [Clark (2001), (2003), (2006), (2010)].

differs from parity should be ascribed to Sutton (2002, 2006, 2010), whose treatment has subsequently forged the basis for Menary's defence of extended cognition based on the idea of cognitive integration. [Menary (2006 2007, 2010)]. Complementarity has also recently become a central theme in Rowlands (2010).

Although in the literature directed at EMT there is enormous and unambiguous evidence suggesting the relevance of Complementarity, most of the critics have only focussed on a functionalist understanding of cognitive extension. As a result, this second strand of thinking about EMT has been largely forgotten. It seems to me however, and much more on this in the next couple of sections, that the appeal to Complementarity and to its integrationist flavour, is liable to become instrumental when it comes to describing the way in which we accomplish many of our distinctive types of cognition.

In what remains of this second section, I quickly look at the debate generated by Complementarity, answer the question of whether Complementarity alone is really sufficient to establish extended cognition and investigate the rich dialectic underlying the second wave camp, trying to bring out some differences between two of its leading proponents, namely Sutton and Menary. Before doing that let me however notice that the distinction between Parity and Complementarity, with the latter conceived as an alternative to the former, isn't accepted by all. Clark for instance doesn't buy this distinction. He doesn't buy the two waves story because he thinks that both Parity and Complementarity work together and become reciprocally instrumental when it comes to defending EMT. So, on his account, there is nothing like a second wave, as the so-called second way is believed to be part of the original treatment.

Other friends of EMT have however noticed that Complementarity alone isn't yet sufficient to establish extended cognition. Both Rowlands (2009, 2010) and Wheeler (forthcoming) have argued that one can't get extended cognition from complementarity alone. Sure, they reckon, the differences argument deployed against parity defences of EMT is powerless against Complementarity because Complementarity precisely predicts and requires such differences. However, the focus on the many different ways in which

internal and external couple and intermingle leave the Complementarity version of EMT vulnerable to another objection. If EMT precisely needs these differences to account for cognitive processes, what reason do we have for thinking that external processes are really part of cognition? In other words, given the existence of specific undeniable differences why should we attribute to external processes a fully cognitive status? We certainly cannot do it by virtue of a simple analogical extension. If EMT wants to treat the external resources as cognitive, it therefore needs to offer a proper criterion for demarcating and distinguishing “*factors that are genuinely parts of a cognitive system from factors that are only making a causal contribution*”. [Farina(2010),p. 227-228]. In short, the Complementarity response seems to “*deflect the differences argument only by leaving EMT vulnerable to the mark of the cognitive objection*”. [Rowlands (2009),p.4]. This objection has been further pressed by critics of EMT, who have all argued, with different strategies, that what is external to the bio-physical architecture of the cogniser can only ever make a causal contribution.

Proponents of EMT have responded in a variety of different ways. One strategy has tried to tame the mark of the cognitive objection by showing that EMT isn't itself incompatible with any plausible criterion that wants to distinguish genuinely cognitive factors from merely causal ones. This is the strategy that both Rowlands (2009, 2010) and Wheeler (2005, forthcoming) have embraced. Let me look at this very briefly. Rowlands has argued that far from contradicting EMT, the mark of the cognitive can be used to support it and that we can find the conditions needed to establish such a mark in the scientific practise of cognitive scientists. He has individuated a set of conditions to determine whether something can count as cognitive. A process P, he believes, counts as cognitive if and only if:

“(1) P involves information processing—the manipulation and transformation of information-bearing structures.(2) This information processing has the proper function of making available either to the subject or to subsequent processing operations information that was (or would have been) prior to (or without) this processing, unavailable. (3) This information is made available by way of the production, in the subject of P, of a representational state. (4) P is a process that belongs to the subject of that representational state”. [Rowlands (2009), p. 8].

In a similar vein, Michael Wheeler (2010, forthcoming) has envisaged the need of a mark of the cognitive to set up a stable defence of EMT. EMT, he says, needs a functionalist, “*scientifically informed, theory-loaded, locationally uncommitted account of the cognitive*”. [Wheeler (2005, forthcoming)]. Clark (2010a, 2010b) however has explicitly rejected this idea and replied that the attempt to identify a mark of the cognitive is unlikely to bear any fruit because we already possess an intuitive grip on the kinds of coarse-grained behaviour patterns that we believe are characteristic of key cognitive processes, such as the holding of a standing (dispositional) belief. [Clark (2010a,b)]. Thus, a very basic and moderately liberal plea to folk psychology would, on his account, suffice to direct us in working out what counts as cognitive and what does not. [Farina (2011)].

Second-wave defences of EMT have implicitly embraced Clark’s understanding of the mark of the cognitive but have tried to deploy a series of different strategies to tame the causal-constitutional charge. Sutton¹³ (2010 and elsewhere) for instance, wants to shift the debate away from Parity and thinks that one should be able to reconstruct or retain functionalist-style parity claims within the mature, complementarity-based alternative version of EMT. Parity, he claims, doesn’t get you far towards that best version. It is not really much of a methodological tool or guideline in practice, he notices, to ask whether we would accept a state or process as cognitive if it were in the head. For Sutton all the relevant methodological tools and guidelines should instead be directed to assessing the integrated/coupled performance and potential of hybrid inner-outer systems. For this reason, he has argued that Complementarity alone is enough to get extended cognition and that there is nothing to add to it on the condition that we understand Complementarity correctly – that is, on the condition that we define it as a label for a multidimensional framework in which rich scaffolding takes precedence over metaphysical claims.

¹³ I am deeply grateful to John Sutton for the discussion of this point.

Sutton therefore deals with the causal/ constitutive issues by first describing, in rich detail, the whole range of differently-influential causal processes within causally-interactive or holistic systems. He then uses our descriptions to do science to manipulate and examine those causal factors which we suspect are in some sense (more) uniquely relevant. In other words, Sutton wants to avoid relying on a particular metaphysical theory of constitution or realization, because he thinks that is too fragile and too uncertain as a basis to build a science of extended cognition. Scientists, he notices, are dealing with differently-relevant causal factors and processes all the time and they are in general unworried about causal/constitutive issues. The sun or oxygen is excluded from being part of an extended cognitive process of mine because it makes no unique or differential or specific contribution to this cognitive process, that's distinct from its contribution to all other cognitive processes. So, to reiterate, Sutton thinks that we build our best framework by trying out and studying and (thus) assessing and revising the most relevant dimensions on which cognitive systems and cognitive states and processes differ, and in particular by studying cases which fall towards the more extended regions or corners of the resulting multidimensional spaces. Once we've done that, he claims, we then have the choice of remaining "embedded" but not at all any longer "merely" embedded, as we have seen how wildly different in nature those regions of the space are, and we have transformed psychology and science by studying them in detail; or, we can run with the Quinean/ Churchland (1982) philosophy of science that excellence of theory is our best measure of ontology, and decide that the label "extended cognition" really does well describe what happens in those regions. So, once we focus and accept how rich and strong scaffolding is in the context of complementarity, this is already to have conceded enough ground to undermine embedded, as embedded has pretty much collapsed into extended.

To crude Complementarity Menary (2006,2007) has instead added the dimension of integration. Integrationism, he claims, favours "*the co-ordination of bodily processes with salient features of the environment and allows the organism to perform cognitive functions that it would otherwise be unable to*". [Menary (2007) p. 3]. When the representational vehicles of these processes, he has claimed, are offloaded onto the

environment and adequately manipulated in the service of adaptive behaviour, those external features become literally parts of our extended cognitive system. While not rejecting the framework offered for Complementarity, Menary finds an answer for those metaphysical claims avoided by Sutton by focussing on Integrationism. The Complementarity understanding of EMT combined with this integrationist flavour therefore best describes my idea of cognitive enhancement/transformation. Cognitive transformation is precisely the flavour that I want to add to Complementarity in order to deal (if ever possible) with the metaphysical claims¹⁴. I call this transformation, realised via brain plasticity, with different names (such as Integrationism, cognitive dovetailing, enmeshing or symbiotic partnership between internal and external). In what follows I try to show how the idea of cognitive transformation can be used to highlight the distinctive, integrationist character of Complementarity.

2.3 Neural Plasticity and EMT

Having introduced Complementarity, quickly looked at the debate generated by it and discussed the rich dialectic underlying the 2nd wave camp, I now turn my attention to the main business of this chapter, which is to develop a complementarity argument for EMT based on the enmeshing of organisms and their cognitive developmental niches. In human beings these cognitive developmental niches are entrenched, deeply rooted in socio-cultural activities and quite often implemented via technological enhancements. I will argue that a large part of our distinctive intelligent behaviour is the result of the enmeshing, on multiple timescales, of our on-board neural machineries with external resources (either technological or socio-cultural ones). I find evidence for this profound dovetailing of inner and outer and for the idea of cognitive transformation and enhancement, in work carried out on neural development by cognitive neuroscientists. This work on neural development reveals the distinctive “integrationist” character of Complementarity. It is to this fascinating line of experimental work that I now turn.

¹⁴ I remain extremely sympathetic with Sutton’s perspective and really think that his approach is probably the most effective to escape the causal-constitutional charge always levelled against EMT. As a philosopher, however, I am tempted to defeat my opponents on their own metaphysical territory. Whether I succeed, this remains to be seen.

The human brain begins its long journey toward maturation around the third week after conception with the formation of a neural tube atop the length of the embryo. By the fourth week, the brain's formation actually begins with an extraordinary 250,000 cells growing every minute [Thompson (1993)]. From just very few cells the infant's brain reaches, in a couple of years or so, about 80 per cent of the size of an adult's brain. Our brain doesn't just spontaneously 'pop' into existence but it is rather the outcome of an enduring process of neural growth and persistent development. What drives this process? The remarkable expansion of our brains is driven and boosted by the formation of synaptic connections among neurons. In a new-born infant, each of the neurons that made up her brain connects up to form a network of new synaptic connections with other neurons. This process is known as synaptogenesis and is reported to occur at an impressive average rate of 2500 connections per neuron. This number of connections further expands to reach an average of 15000 per neuron during the third year of life. [Eliot (1999)].

In the thick of this swarming activity, how do specific brain regions come to acquire specific cognitive functions? What is the dynamics underlying the developmental process? There are basically two alternative hypotheses that have been proposed to try to explain the process through which the brain acquires specific cognitive functions. One attractive hypothesis is the so-called proto-map view. The proto-map view has been famously endorsed by Pasko Rakic and his group of researchers in a series of pioneering studies [Rakic et al. (1988); Rakic (2009)], just to name a few]. According to Rakic, "*neurons at their birth ... contain the genetic instructions essential for finding their final place of residence in the cortex, where they form a basic species-specific pattern of subcortical and cortico-cortical connection. Although these connections can be refined by spontaneous and extrinsic activity after their formation and modified in response to injury, they are remarkably stereotyped in each species*". [Clowry et al. (2010), p.277]. The idea is basically that neurons at birth set up a primordial map and this pre-specified map is subsequently used by the brain to respond to external stimulation. The proto-map view therefore describes the human brain as a predetermined set of pre-specified cognitive tools and neurons as fixed and constrained to develop specific

functions in specific cortical areas. This nativist understanding of development stands in opposition and is typically contrasted to an alternative hypothesis, the so-called proto-cortex view. [O’Leary & Stanfield (1989)]. The proto-cortex view states that all our cortical neurons, at least at the onset of their cortical development, have the same potential. The proto-cortex view therefore describes the cortex as immature at birth and neural regionalization as largely driven and regulated by external influences. [de Haan & Johnson (2003)]. The functional organisation of the cortex, on this account, is not pre-specified but rather “constructed” and “scaffolded” on the basis of experience. [Quartz & Sejnowski (1997); Mareschal et al. (2007)]. Our brains are moulded by the many different activities we engage in and forged by the different environs we come across. Our cognitive capabilities in turn depend upon the presence, frequency and timing of experiences undertaken in early stages of development. Cognitive development is thus, on such an account, best described as a process of progressive localisation and specialisation of cortical functions.

There isn’t, at present, wide agreement among scientists on which of these accounts of cognitive development we should favour. There isn’t such an agreement because scientists lack definitive evidence and empirical findings are contradictory. In what remain of this section however, I will try to link up the constructivist account of neural development mentioned above with the idea of cognitive integration and will argue that the former provides vital front-line support for the latter. The constructivist view quickly outlined in precedence in fact, highlights the power of humans to re-engineer their brains by factoring non-biological, extra-cranial resources into their very functioning. This process of self-engineering is of particular interest for us because it points us to a profound dovetailing between the biological and the cultural, the sort of Integrationism sought by Complementarity, and this can be certainly used to mount a solid defence of EMT on the basis of empirical grounds.

Let me start my discussion by showing how neural growth is experience dependent. I will then widen and generalise the range of my considerations so as to include our higher cognitive functions. Before doing that however, I need to establish my claim at a lower

level. So, let me look at the neurons first. In a nice study conducted in the late '50s, Chow and colleagues demonstrated a degeneration of retinal ganglion cells in infant chimps reared in darkness. [Chow et al. (1957)]. The retinal ganglion cells are basically the cells that are responsible for transmitting visual information from the retina to other brain areas, such as the thalamus and the hypothalamus. This study by Chow is worth a mention because it laid down the groundwork for another, perhaps more important study, carried out by Rasch and co-workers only few years later. In 1961, Rasch and colleagues not only confirmed the findings found by Chow and his group but proved that the actual number of retinal ganglion cells is reduced by 10% of normal when the chimps are fostered in darkness. Pretty much in the same period, other studies conducted on monkeys discovered variability in the number and size of the cell contained in the lateral geniculate nucleus, the area of the brain that firstly receives the visual information from the eyes. These studies testified to a consistent cells-reduction (of the order of 40%) in chimps divested of visual input in early stages of development and showed that adults monkeys could only experience forms of gross perception. [Von Noorden et al. (1970); Baker et al. (1974)]. Analogous results were discovered for olfaction. [Kupfer et al. (1964)]. Unilateral occlusion of the nostril of a rat pup in early stages of development permanently restricts the rat's access to olfactory cues, decreases the size of its olfactory bulb and causes significant cell death. [Pinilla et al. (1989)].

Further empirical evidence for the claim that neural growth is experience dependent comes from another study by Hubel and Wiesel (1963). Hubel and Wiesel analysed response properties in cat cortex, by recording the electrical activity in the visual cortex of kittens that had one eye lid sewed after birth, just before eye opening. The kittens, in the Hubel and Wiesel experiment, were reared in this monocular condition up until their third month of age. At that point, the sewed-eye was open and the relevant electrophysiological measures undertaken. Hubel and Wiesel found that in general the visual receptive properties of neurons located in the lateral geniculate nucleus were similar in size to those of adult cats, but remarkably discovered a significant shrinkage in cells receiving inputs from the deprived eye. [Paton (2008), Hubel and Wiesel (1963)]. In particular, 85% of these cells were found to respond to the non-sewed eye, very few

were instead responsive to the deprived eye. Their experiment therefore revealed that the visual input to the deprived eye didn't change the pattern of cell sensitivity; "*cells responding to the nondeprived eye continued to maintain their dominance, and it was only through the occlusion of the nondeprived eye at an early age that the balance was restored*". [Kiverstein and Farina (2011),p.43] [see also Wexler (2006)].

Having shown that neural growth is experience dependent, I now provide evidence for generalising my claim to perceptual functional specialisation. I start by looking at hearing and sight. In both these cases the specialisation of the cortex appears to be experience-dependent. This much is established by a number of very relevant studies to which I now turn. In 1987, Neville and Lawson conducted an experiment in which they used electroencephalograph to compare the brains of congenitally deaf patients with those of subjects who became deaf after the age of 4. Neville and Lawson remarkably discovered substantial differences in the event related potential components of the congenitally deaf subjects. This has lead them to argue that a lack of auditory input in early stages of development determines, in congenitally deaf infants at least, a reallocation of the auditory cortex for other functions, such as sight. On these grounds, they have also argued that, due to this early lack of auditory stimulation, deaf subjects develop enhanced visual perceptual skills and perform better at visual tasks if compared to hearing subjects. [Neville and Lawson (1987)].

Further support for the fascinating idea of functional reallocation outlined above comes from a study on Braille reading carried out by Sadato and colleagues (1996). Sadato and co-workers scanned with positron emission tomography (PET) the brains of a mixed group of congenitally and early blind subjects in order to measure the activation of their primary visual cortex during tactile discrimination tasks in Braille reading. In line with the findings discovered by Neville and Lawson, Sadato and his group found further empirical evidence for the hypothesis that cortical areas are reallocated and rearranged to deal with different functions when they fail to process their standard, typical inputs. In particular, Sadato and colleagues showed that the occipital cortex in blind Braille readers is subject to reorganization and that this reorganization supports the processing of non-visual

sensorimotor information. Analogous findings were also reported in a subsequent study by Cohen et al. (1999).

Is it this capacity of functional reorganisation confined to early stages of development or solely emerging when there is a permanent loss of a sensory modality? In other words, does cross-modal plasticity extend or persist into adulthood? “*Could the brains of typically developing adults also reorganise in this way so as to support different functions?*” [Kiverstein and Farina (2011), p.44]. There is good empirical evidence that seems to point to this direction. In 2001 Pascual-Leone and Hamilton published “The Metamodal Brain”, a milestone for everyone interested in plasticity. Among other things, in this study Pascual-Leone and Hamilton presented the results of an experiment they conducted on a group of adult subjects.

Pascual-Leone and Hamilton gathered a group of normal-sighted adults and blindfolded them for a “training” period of 5 days, from Monday morning until Friday evening. During these five days the subjects: 1) couldn’t leave the hospital, 2) had to navigate through the hospital while blindfolded, 3) had to learn how to read Braille. At the end of the fifth day- that is, on Friday evening, the participants’ brains were scanned using fMRI. fMRI remarkably revealed an activation of the visual cortex when the participants were asked to discriminate sameness or difference of Braille symbols or to distinguish, for instance, the pitch of tones. These results have led the authors to conclude that, no matter of the age, after a relatively extended period of sensory deprivation, particular areas of our brain (the visual cortex in the case of instance) can take on new functions (auditory or tactile ones). This result is quite striking because it reveals that cortical plasticity isn’t merely confined to childhood, but extends into adulthood. [Kiverstein and Farina (2011)].

At the beginning of this section, I have introduced the idea of synaptogenesis. Synaptogenesis enables, via synaptic proliferation, the remarkable expansion of our brain during early stages of development. This remarkable expansion is due to an explosion of connections among different neurons. The term explosion may appear a bit excessive but it actually gives us a good idea of the specific evolutionary function that this process is

able to grant. Synaptogenesis in fact guarantees to our brains to settle seamlessly and adapt comfortably to virtually any environment by forming a vast number of connections that result in being instrumental for the child's survival. This explosive proliferation comes however to an end. It reaches its peak around the third year of the child's life. After the third year of life, this overabundance of synapses becomes no longer evolutionarily beneficial. Each synapse to be active and responsive in fact requires a certain amount of energy. When the child has engaged with the surrounding environment and has developed the set of skills necessary for his existence, the overabundance of these synapses no longer favour his evolution but rather threatens his survival (because of the synapses' energetic consumption). So, after the production has reached its peak, synapses gradually begin to recede as the brain undergoes the so-called process of "synaptic pruning". Synaptic pruning, otherwise known as controlled cell death or apoptosis is a process that is performed to reduce the excessive number of connections formed in the brain and therefore is executed by the organism to maintain its functional efficiency. During this process an unspecified number of unnecessary, dormant and redundant connections are pruned and die off. [[Huttenlocher (1979); LeDoux (2002); Sousa (2006)]. According to a conservative estimate [Eliot (2001)] the infant can lose up to 20 billion synapses during maturation. [Wasserman (2007)]. Here a natural question arises: what happens to the other synapses?

The connections that are not dormant but regularly activated in the many different engagements in which the child is involved gradually become instrumental for the organism and are obviously kept. But here comes the interesting point. These connections are not only kept but with training and reiterated practice they are strengthened and reinforced. Every time the kid learns to do something new, say from her caregivers or from her peers, new synaptic connections are formed and every time that the kid repeats the activities she has just learned, the relevant neural circuitry gets reinforced. Synaptic elimination therefore occurs through the adoption of the use it or lose it principle. [Kiverstein & Farina (2011)].

The neurons that are frequently deployed in motor-engagements survive and flourish, but those clusters that are not used become neglected and soon wither and die out. Synaptic

pruning thus nicely illustrates the experience-dependent character of the brain's functional organisation. It is the experiences we undertake in the world that in fact forge our brains. But how do we form these experiences? Most of these experiences are formed via continuous engagements and training in socio-cultural activities and these activities quite often involve the skilful use of cultural artefacts [Iriki and Sakura (2008); Renfrew & Malafouris (2009); Malafouris (2010); Vaesen (2011)]. Socio-cultural activities and skilful mastery of cultural and technological artefacts therefore mould and direct the development of our brain. [Park and Huang (2010); Kitayama and Park (2010)]. Any dexterous activity we recurrently engage in the wider world changes the structure and the functions of our brains. Brains like ours, are altered by these activities so much that we can be said to possess a "culturally modified brain". Not by chance, many neuroscientists have appealed to this expression to highlight the plastic adaptability of our minds that work by incessantly absorbing new stimuli and changing as culture evolves. [Kiverstein and Farina (2011)]. The neuroscientist Michael Merzenich warns:

"Our brains are vastly different, in fine detail, from the brains of our ancestors...In each stage of cultural development...the average human had to learn complex new skills and abilities that all involve massive brain change...Each one of us can actually learn an incredibly elaborate set of ancestrally developed skills and abilities in our lifetimes, in a sense generating a re-creation of this history of cultural evolution via brain plasticity." [Doidge, (2007), p.288].

In the final part of this section, I focus on the idea of culturally modified brain as briefly exposed above and find good empirical evidence to support my claim in research undertaken on language acquisition. [Meltzoff et al. (2009), Kuhl et al. (2007)]. A number of studies on language acquisition in fact show the importance of socio-cultural engagements in moulding and forging our higher cognitive functions. It is widely known that in early stages of development infants possess the outstanding capacity for distinguishing sounds across the languages of the world. [Kuhl et al (1975)]. This truly outstanding capacity appears to be universal as it is spread at birth among different people and cultures across the globe. This capacity however gradually narrows with age and development. In particular, it is reported to narrow around the eleventh month of age. [Kuhl et al. (2006)]. But why does it narrow? Studies say it narrows because of 1)

the particular socio-cultural environments in which the child is immersed and because of 2) the specific language, her native language, that the child is trained to learn. This particular socio-cultural exposure triggers the activation of certain brain areas which determine an activation of specific brain functions and these in turn cause the shrinkage abovementioned. Other prominent studies have stressed the importance of social interaction for learning capacities, and experiments have further shown that language learning is profoundly gated by social processes [Kuhl et al. (2007)]. All these findings eventually seem to corroborate the idea that culture makes humans as much as the reverse and at the same time they suggest the possibility for our on-board neural circuitries to become dovetailed to fit with the particular socio-cultural environment in which our brains grow. [Kiverstein and Farina (2011)].

It is therefore the actions and the engagements we undertake in the world that determine which cluster of neurons is likely to thrive and flourish. Connections that are repeatedly activated get reinforced and prosper; those that lie dormant are simply cut off and soon whiter. The connections that are reinforced are typically those that are capable of fusing with external resources and factoring them into their very functioning. This fusion of internal and external transforms and enhances our cognitive functions and occurs by means of active coupling via manipulation and cognitive integration. All the studies mentioned in this section testify to the profound impact of culture and technology on our brains and nicely unveil the way in which the internal machinery is sculpted and tailored by the different resources we use in the course of our development. Culture is therefore “embrained”. Our internal machineries are assembled and constantly refined through development and this process of refinement appears to be the reflection of the symbiotic partnership we develop with the milieu since the very instant we step into the world. What is crucial and distinctive about the development of our plastic brains is therefore that they develop to work in partnership with the external environment. This is the idea of cognitive integration I was after. As a result of continuous engagements our brains progressively learn to play a role within densely coupled systems and treat the extra-cranial resources we use as reliable structures. These non-biological structures eventually become different (extra-neural) but complementary parts of the machinery that realises our cognitive capacities. [Clark (2003)].

2.4 Extended Cognition or Extended Cognitive Systems

I want to conclude this chapter by addressing some criticism and discussing a series of concerns that have been recently raised against EMT by Adams and Aizawa (2009). Adams and Aizawa have argued that a cognitive system can have among its parts components that are located in the external world. From this it doesn't however follow that the contribution these components are making to the overall cognitive system is a cognitive one. [Kiverstein and Farina (2011)]. Extended cognitive systems, they have claimed, are one thing; extended cognition quite another. To endorse their view, they invite us to consider the following example: an air conditioning system, they say, is a system in which very different components (e.g. the compressor, the condenser, the thermostat, the fan, the evaporation coil and so on) are all profoundly interwoven via simple but steadfast connections. However, Adams and Aizawa notice, not every components of the air conditioning system can be regarded as performing the function for which the system has been originally assembled – the cooling of the air. [Adams and Aizawa (2009), pp. 116-117]. The evaporation coil, they maintain, is causally responsible for cooling the air but the condenser and the fan certainly do not play any role in this process. Analogous consideration can be run for a sound system. Not every element in a sound system produces sound: *“The speakers do, but the receiver, amplifiers, volume controls, tone controls, resistors, capacitors, and wires do not”*. [Adams and Aizawa (2009), p. 118]. Adams and Aizawa have argued that the same principle applies to cognitive systems and that therefore the external constituents of a cognitive system can at best be causally necessary, but can never become cognitive. [Adams and Aizawa (2009), pp. 130-132].

A preliminary response to this worry is to say that it does sound a little odd to hear that the evaporation coil is, all on its own, causally responsible for cooling the air in the house. Take the evaporation coil out of the larger system in which it is installed and the house isn't certainly going to feel any cooler [Kiverstein and Farina (2011)]. It does sound equally strange to me to affirm that the speakers are, once again on their own, uniquely accountable for the production of the sound. Again take out the speakers of the larger system in which they are integrated, the sound system that includes the receiver,

the resistors, the volume controls, the tone controls, the amplifiers, the capacitors and the wires, and you ain't going to hear any sound. Both the air conditioning system and the sound system are made up of different components each of which is assigned a particular function in performing a highly specific role. However, it is only when all these components are finely tuned and properly interacting one other that you can get cooler air in the apartment and proper sound in your room. If cornered I would be inclined to concede that the evaporating coil or the speakers are perhaps special and that they might actually play a particularly crucial role in the process that leads to the production of the sound and to the cooling of the air. Adams and Aizawa might therefore have a point when they argue that the evaporation coil and the speakers are the "core realisers" of air condition and sound production: without them in fact there wouldn't be any cooler air or fancy sound in the room. But this consideration doesn't have a grip on my argument, because I don't deny this. What I am saying instead is that these core realisers cannot do the entire job on their own. It is only by entering in a symbiotic partnership with all the relevant components that characterise their system that these "core realisers" come to perform their "allegedly" special or unique function.

Now in the next few paragraphs, I want to argue that this is true also of the external components of an extended cognitive system and that through development we get something genuinely new that we wouldn't otherwise get from the naked brain on its own. For this reasons, I will now try to show that our on-board neural circuitries, the internal components of an extended cognitive system, successfully achieve their functions only when they enter in a quasi-symbiotic relationship of partnership with the external resources. So, my next step is to show that we get extended cognition only when all the components of the system are properly integrated and finely tuned to each other so as to form a single, entangled unit of cognitive analysis. The strategy I deploy aims at demonstrating that cases of extended cognition are quite different from those cases proposed by Adams and Aizawa (the air conditioning and the sound system). Substantial differences not only apply but might actually be crucial to decide the dispute in favour of EMT. A closer look at these differences might help us better address this point.

An extended cognitive system is a system that is subject to transformative processes of re-structuring; an open unit whose properties are constantly transformed and refined by the many activities to which it is exposed. An extended cognitive system is therefore an entangled unit of analysis in which the relevant functions come to perform their distinctive role through development and learning. By contrast, the elements that comprise the sound system or the air conditioning system (or any other system of this kind) are pre-designed and rigorously assembled to perform a fixed function and this function cannot be changed nor modified. They are built in a particular way and their mechanical architecture doesn't allow for any change. One can easily boost the performances of a sound system or increase those of an air condition system by reengineering some of their components but the functions that these components perform are fixed in stone and cannot be switched. The speakers can't be used to plug in the system, nor can the wires be utilised to regulate its volume. Furthermore, extended cognitive systems are systems in which our brains continuously learn new functions and gradually factor external resources into their processing operations. The sound system or the air conditioning system clearly cannot learn any new function. In sum, extended cognitive systems are ensembles in which different components are jointly deployed to construct, refine, transmit and pass specific strategies or knowledge. On the contrary, the air conditioning system, the sound system and any other system of this kind are just bolted onto a room and their functions are not subject to any form of restructuring or development. In short, extended cognitive systems are unities in which our brains are *“geared into working in partnership with external resources and these external resources become grafted into the workings of the internal neural circuitry so that at least some of their cognitive functions can only be accomplished through the symbiotic partnership that the internal have formed with the external”*. [Kiverstein and Farina (2011), p.47]. In such systems, the inner comes to perform the function it does only because of the regular exchanges it entertains with the many different components that characterise its structure. Air conditioning systems, sound systems or systems alike do not display any of these properties; ergo the analogy with extended cognitive systems doesn't hold up. It thus follows that the considerations that Adams and Aizawa have made to undermine EMT fail to apply to extended cognitive systems and this clearly

means that extended cognition remains unaffected by them. Adams and Aizawa's worry seems to be substantially undermined. An opponent of EMT could still resist my claim and object that the developmental considerations I have made are powerless when it comes to establishing synchronic extension. EMT, she might argue, is a thesis about here and now extension not a claim about diachronic evolution. Cognitive dovetailing of the kind I have been defending at best grants diachronic evolution but fails to establish synchronic extension and therefore doesn't seem to escape the causal-constitution conflation that plagues functionalist defences of EMT.

An opponent may thus be prone to concede that I have demonstrated that the environment can make a necessary contribution to cognition; yet, she will deny that I have shown that such a contribution is cognitive. Ken Aizawa (in private correspondence) has replied to my previous response by challenging my argument with the following counter example. He has asked me to consider the way in which the stomach gets adapted to processing alcohol in regular drinkers. The stomach, he has argued, is certainly caught up in the processing of alcohol and gradually gets adapted to dealing with this environmental input; however, we don't want to say that the bottle of grappa in the drinks cabinet becomes part of the subject's digestive system. Aizawa has highlighted the fact that diachronic considerations do not establish anything stronger than causal necessity and has then challenged me to show the way in which his counter example differs from the developmental cases I have presented above. A crucial difference can be found, I believe, if we look at the relevant outputs. When an external factor becomes geared to work in symbiotic partnership with our internal neural machinery, the output the subject is producing is not only artefact involving but is rather recycled by the brain as an input of its processing in a way that Clark (2006) has described as anarchic cognitive self-stimulation. In the examples of dovetailing I am interested in we have got an external structure, *which is part and parcel of a coupled-neural-bodily unfolding* [Clark (2008), p.126], whose outputs and effects are organism-involving; in the sense that they are being recycled to trigger new kind of self-generated cognition that then "*loop out beyond the purely neural realm*" [Clark (2008),p.126]. The case of the digestive system proposed by Aizawa is arguably different, I believe. The outputs of the digestive system, I am sure the reader doesn't want me to specify what

these outputs really are, do not include the bottle of grappa in my cabinet even if my digestive system is finely tuned to dealing with grappa. [Kiverstein and Farina (2011)].

I don't expect that this reply will placate the critics. I am sure they will confirm that I haven't provided a knockdown argument against individualism. I might not have provided a knockdown argument against individualism but I think these developmental considerations make an elegant case for Complementarity, highlight its distinctive Integrationism character and provide strong empirical support for the view that describes our minds as hybrid and humans as peripatetic self-assemblers [Donald (2000)]. To the extent to which my view supports this understanding of human nature and cognition, it also inevitably calls into question and significantly undermines any bounded-intracranial account of cognition; any view that describes the brain as the container of the mind.

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Chapter 3

3.1 Introduction

Phylogeny is a term of Greek origins characterised by a combination of two words (phylon and genesis), indicating race and birth respectively. Phylogeny can be defined as the study of evolutionary relatedness among species or taxonomic group of organisms in an ancestor/descendant relation. The study of the phylogeny of groups of organisms is crucial for the understanding of human evolution because it allows us to explore, through the history of the development of human cognitive abilities, the diversification of lineages, patterns and rates of trait evolution. It is no surprise that the study of phylogeny of organisms has therefore come to play a crucial role in the so-called nature/nurture debate. The expression nature versus nurture was originally coined by Richard Mulcaster (1582) when he wrote that “*nature makes the boy toward, nurture sees him forward*”¹⁵. A few decades later, William Shakespeare used the same expression in his “The Tempest” where Prospero describes Caliban as “*a devil, a born devil, on whose nature/nurture can never stick.*” [Shakespeare (1611) IV.I]. The debate around nature and nurture however gained increasing importance only after Francis Galton (1874), influenced by Darwin’s “Origins of Species” (1859), re-proposed the dichotomy to highlight the contrast between the contributions of genetic heredity and those of the environment toward social advancement. Since then the nature-nurture debate has acquired a prominent status and a central role in different disciplines (including psychology¹⁶ and biology¹⁷). The word nature has been identified with the idea that people act as they do because of some sort of genetic predisposition. The word nurture instead has come to characterise the thought that people think and behave in certain ways only because they are taught or have learned to do so.

¹⁵ Colman and Woodhead (1989), however suggest that the originator of this dichotomy may have been Socrates or his amonuensis Plato (370s BC).

¹⁶ A version of this debate has characterised the diatribe between nativists [such as Pinker (1994, 2002)] and behaviourists [such as Skinner (1938) or Guthrie (1952) to name just a few] for almost a century.

¹⁷ This is what I will be investigating in this chapter.

The former idea has offered the basis for nativist theories in philosophy and psychology that describe the human brain as a sort of Swiss army knife; a collection of extremely specialised cognitive tools [Barkow, Cosmides & Tooby (1992)]. The latter claim has instead provided the conceptual palette necessary for alternative accounts of human evolution that try to re-locate and offload some of the constituents of cognition in the external environment. A recent and fast-growing body of research on the human genome has shed some light on this debate and has offered evidence to support both sides of the dispute. Nature, it is often claimed, endows the individual with a set of inborn abilities; nurture instead takes up these inherited abilities and forges them as we learn and mature. End of the story? Not really, the nature/nurture dichotomy still rages on and continues to set scientists, philosophers and psychologists on fire. The disagreement is mostly centred on the issue of how much of whom we are is inherited via genes and how much is instead forged and shaped by the milieu. Can Complementarity inform this debate? In which case, can it offer us the means to resist or challenge such a dichotomy by providing an alternative route to explain human evolution?

Now recall, Complementarity is the idea that cultural and technological resources in the environment can sculpt our brains so as to give us cognitive abilities we would otherwise lack. In the previous chapter we have seen that sustained experiences may affect both brain structure and its cognitive functions [Park & Huang (2010)] and that brain processes are malleably forged by social practices and cultural tools, in a way that has led many researchers to speak of our brain as the encultured brain. If this process of rewiring and re-engineering of our internal biological circuitries is realised, via plasticity, by means of cultural exposure; couldn't this process also entail a redefinition or better a reconceptualization of the way in which we think of our biological natures? In other words, couldn't our biological natures be thoroughly plastic rather than fixed in stone and pre-determined at birth?

If biology can provide us with an understanding of phylogeny that shows how our nature can be plastic this would provide further support for the idea of Complementarity that I have been defending. Conversely if work on biology offers us an account of human

nature as fixed and biologically pre-determined – a genetic determinist account of phylogeny - this would significantly and inexorably undermine complementarity approaches and along with them destabilise any view that on Complementarity grounds attempts to re-locate human cognitive behaviour outside the boundaries of the skin and skull of the organism. In this chapter I explore the tension between gene-centrism and alternative accounts of evolution and investigate the rich dialectic underlying this fascinating debate.

In section 1, I quickly introduce the gene-centric view of evolution and argue that this doesn't fit with the idea, endorsed by Complementarity defences of EMT, that inner and outer work in symbiotic partnership. In section 2, I present another approach to describing evolution that is instead concerned with the idea of niche construction. I emphasise the prominence that this paradigm has acquired in contemporary biology, explain its crucial tenet (namely the notion of ecological inheritance) and sketch an analysis of the differences with gene-centrism. In section 3, I investigate the points of contact of the paradigm of niche construction with the cognitive sciences. In particular, I focus on the way in which niche construction has been used to argue for and against the extended mind thesis. In section 4, I argue that although niche construction provides a valid understanding of evolution, it doesn't yet suffice to capture all the mechanisms that drive it and therefore introduce developmental systems theory as a way to account for the multiple dimensions that characterise the development of an organism. Evolution, I argue, is best understood as a change in the spectrum of developmental resources. This wide spectrum of resources doesn't solely encompass genetic or cultural factors but rather embraces equally necessary and reliably replicated epigenetic, bodily, social, ecological, epistemic and symbolic resources. [Stotz (2010),p.483]. In section 5, I eventually propose to reconceptualise the notion of niche construction within the developmental context and suggest combining it with the developmental considerations endorsed by proponents of developmental systems theory. In agreement with Stotz, I thus propose to speak of ontogenetic niche construction. Ontogenetic niche construction, I argue, makes the transmission of biological information more reliable and its focus on the individual and on a context of plastic adaptability allows us to better account for the learning processes involved in development. I conclude the section and the chapter by

showing that ontogenetic niche construction ultimately provides us with the means to affirm that culture and biology are not only analogous but both complementary and instrumental for organisms to achieve biological fitness in the long run.

3.2 The Gene-Centred View

The gene-centred view otherwise known as the selfish gene theory attempts to describe evolution through the differential survival of competing genes. It essentially asserts that those genes whose phenotypic effects effectively promote the reproductive success of the organism throughout generations will be favourably selected in detriment to their competitors. This idea lies at the core of the following passage:

“Genes are competing directly with their alleles for survival, since their alleles in the gene pool are rivals for their slot on the chromosomes of future generations. Any gene that behaves in such a way as to increase its own survival chances in the gene pool at the expense of its alleles will, by definition, tautologously, tend to survive. The gene is the basic unit of selfishness.” [Dawkins (1989),p.38].

Since hereditary information is assumed to be transmitted from generation to generation via genetic material, evolution is believed to be best understood from the perspective of genes. Proponents of this approach argue that genes are the driving force of evolution, which exclusively takes place by change in their frequency. As Dawkins nicely put it: *“the special status of genetic factors is deserved for one reason only: genetic factors replicate themselves, blemishes and all, but non-genetic factors do not”*. [Dawkins (1982), p. 99]. In a similar vein, evolutionary biologist Maynard Smith (1999) has bluntly argued that evolutionary changes are changes in nature not in nurture¹⁸. Since non-heritable factors do not possess the capacity to replicate themselves and lack the potential to produce the kind of variation upon which natural selection is taken to act, these non-genetic variants are barred from impacting upon the processes that drive natural selection. Neo-Darwinists thus rely on the concept of genetic inheritance to

account for trans-generational stability of traits and therefore explain evolution purely in terms of the changes that occur on genetic materials. In short, there is a master plan within the genes and this master plan drives the evolution of living things. The blueprint for the development of each of these living things is thus encoded in the genome and pre-specified in a set of instructions that become available to the organism through the process of genetic transfer from parents to offspring.

The Neo-Darwinian synthesis was a crucial hallmark in the history of contemporary biology; this hallmark however came with controversial after effects. One of these after effects, as we have seen above, is gene-centrism and the understanding of evolution as the mere unfolding of the organism out of its programmed blueprint [Stotz (2006)]. Another is the correlated underestimation of the role of development and extra-genetic factors in the processes that drive natural selection. A third is to do with the revival of nativism and especially with the link quite often established between gene-centric accounts of evolution and domain specific theories in psychology and cognitive science¹⁹.

In this chapter, I argue against Neo-Darwinian accounts by calling into question their gene-centric view of evolution. I also attempt to disentangle the link between gene-centrism and nativism aforementioned, by rejecting the very idea of a fixed human nature restricted to specific biological constraints. The key to separating nativist claims about cognition from gene-centric accounts of evolution is to acknowledge that what individuals inherit from their ancestors is not a set of unchangeable developmental outcomes, but rather an ability; the ability to develop a mind. As Griffiths and Stotz (2000) put it: *“it is possible to wholeheartedly endorse the idea that the mind is a product of evolution without necessarily accepting the claim that the mind is constrained to develop or to reason in certain, limited ways”*. [Griffiths and Stotz (2000), p.31]. The sequence of arguments I will present will be based on a series of topical studies involving niche construction²⁰ and developmental systems theory(DST

¹⁸ For similar understandings see also [Burt and Trivers (2006); Hull (2001); Kitcher (2000); Maynard Smith and Szathmáry (1999,1995); Haig (1997); Cronin (1991)].

¹⁹ [Pinker (1994); Keil (1989)]

²⁰ [Odling-Smee et al. (1996, 2003); Sterelny (2001, 2003, 2010); Wheeler and Clark (2008)]

henceforth)²¹ and shall find corroborative evidence in the overlapping of the two. Although significant differences can be found between these two approaches, in this chapter I will try to reconcile them together through the idea of an ontogenetic niche. I will try to show that appealing to developmental niche construction and to the notion of exo-genetic inheritance is not only possible but can also provide the means to support the hypothesis of extended cognition. The focus on the life cycle of the organism and on the enmeshing between genetic and non-genetic causes of development given by DST shall ultimately provide an argument for Complementarity.

3.3 Niche Construction: a Primer

In a series of ground breaking studies evolutionary biologist Richard Lewontin has highlighted the intricate and multifarious variability of the bond between genotype and phenotype [Lewontin (1974, 1991, 2000)]. Along with his fierce critique of genetic determinism, Lewontin is also widely renowned for his strong rejection of adaptationism. [Levins and Lewontin (1985)]. Adaptationism is the research program in biology that *“regards natural selection as so powerful and the constraints upon it as so few that direct production of adaptation through its operation becomes the primary cause of nearly all organic form, function and behaviour”*. [Gould and Lewontin (1979), p. 584]. Gould and Lewontin (1978) have famously labelled the excesses of adaptationism the *“Panglossian Paradigm”* and have attempted to ridicule it off the stage of proper science [Dennett (1995)]. Not everything has been adapted to fit precise purposes, nor all traits are atomized features that had been naturally selected; rather *“spandrels”* play a vital role in the process that drives the evolution of living beings. Spandrels, as Gould call them, are side-effects of adaptations; by-products of evolution that did not originate by the direct action of natural selection but were instead later recruited and co-opted for secondary utility [Gould (1997); Pievani & Serrelli (2011)]. Adaptationism for Gould and Lewontin, doesn't take into account the crucial role of these co-opted patterns. As a consequence, it seems to overemphasise the role of genes and natural selection while

²¹ [Gray (1992); Griffiths and Gray (1994, 1997, 2001, 2004); Oyama (1985, 1999, 2001) Jablonka and Lamb (2005), Godfrey Smith (2009), Stotz and Allen (2011)].

undermining the function of phyletic and developmental constraints. Lewontin has further specified these ideas in a trilogy of papers that went to press in the early '80's. It is to these papers that I now quickly turn.

In these pioneering papers (1982, 1983a, 1983b), Lewontin has further characterised his rejection of adaptationism and has attacked the 'lock and key' metaphor that has been used by adaptationism to describe the process of natural selection. The so-called 'lock and key' metaphor sees adaptations as solutions (keys) to the problems posed by the environment (locks). [Griffiths and Gray (2001)]. Organisms, on a neo-darwinian account, are believed to adapt to their ways of life because they were made to fit those specific ways of life. Their genome, it is argued, already contains a set of pre-specified instructions and these instructions emerge by fitting into a series of unchangeable developmental outcomes. In place of this conventional model that describes adaptation as a 'fit', Lewontin has proposed the metaphor of construction. Organisms, he maintains, do not just accommodate to their environs but rather select and actively construct them in ways that increase their chances of survival. Organisms do not merely obey the genetic code they inherit but act and impact upon their milieus [Sterelny (2001)] and therefore determine which features in the external world are relevant to their evolution by assembling them into a modified environment. Along with genetic inheritance this modified environment then triggers evolutionary mechanisms and adaptations that are crucial for survival. This idea of co-construction seems to be quite inconsistent with gene-centric accounts of development as endorsed by pure adaptationists.

It is inconsistent, because the adaptationist explains evolution as a gradual process in which genetic information guides the organism through a series of unchangeable developmental outcomes and describes the emergence of salient evolutionary changes purely in terms of accumulation of small and random mutations that happen at the genetic level. On their account, as we have seen above, the organism is conceived as a static unit and is precluded from playing any relevant role in the evolutionary chain. The idea of co-construction realised by virtue of active environmental engineering profoundly challenges this view. To standard adaptationism that envisages only one dimension of (genetic)

inheritance, this view contrasts the performative role of the environment in shaping most of our evolutionary traits. Lewontin's metaphor of construction therefore endorses a considerably revisited model of the actual process of natural selection. It in fact entails a redefinition of the causal relations that evolutionary biology must seek to model. [Griffiths and Gray (2001)]. The most detailed and efficacious attempt to develop this new metaphor into a well-defined paradigm capable of accounting for biological evolution has been undertaken by Odling-Smee and his collaborators. Their work on niche construction is contained in a series of pioneering papers that went to press during the last decade. [Odling-Smee et al. (1996), see also Laland et al. (2001), to name a few]. The current prominence of the term niche-construction in the literature is due to the work of this group of researchers. It is to their work that I now turn.

Niche construction, as defined by Laland et al. refers to: "*the activities, choices and metabolic processes of organisms, through which they define, choose, modify and partly create their own niches*". [Laland et al. (2000, pp.132-3)]. More recently, Odling-Smee, Odling Smee et al. (2003) have broadened further the range of this definition and argued that organisms can transform natural selection pressures by incorporating ontogenetic processes and cultural practises into their evolutionary dynamic. This definition endows the metaphor of construction proposed by Lewontin with a transformative content and therefore further contributes to differentiate this account from neo-Darwinian views about evolution. Neo-Darwinists in fact do not believe that cultural practises and ontogenetic processes are instrumental in human evolution. Cultural activities, on their account, just mirror variations in the milieu in which different populations of humans have evolved but do not possess any transformative power on their own. Niche construction instead grants cultural activities with a selective power and it is this power that humans exploit to alter and actively scaffold their environs. Cultural activities therefore "*add a second knowledge inheritance system to the evolutionary process through which socially learned information is accrued, stored, and transmitted between individuals both within and between generations*" [Odling-Smee et al. (2003),p.258]. Unlike Neo-Darwinian accounts of development, proponents of niche construction thus add to the dimension of genes another dimension; the dimension of cultural inheritance.

This new dimension of cultural inheritance allows theorists of niche construction to account for the phyletic and developmental constraints that adaptationists want to neglect. However, for advocates of niche construction, cultural inheritance isn't on a par with genetic inheritance. There is certainly an analogy between the two, but they are separate and the latter quite often takes primacy over the former. Although theorists of niche construction call for a more integrated perspective, one in which (unlike adaptationism) genes are not the only causes of development; they still understand evolution with the gene's eye and therefore still attribute to genes a special role.

In order to clarify their position, Odling-Smee and colleagues (2003) discuss a series of cases illustrating the power of niche construction in heterogeneous taxonomic groups. One of these cases, perhaps the most famous, is the spider's web. The presence of the web, they argue, alters the sources of natural selection within the spider's selective niche and allows (for instance) the consequent emergence of new web-based strategies for communication and camouflage. [Wheeler and Clark (2008)]. Other prominent case studies are those involving the insect pupae cocoons and the caddis fly larvae houses. In all these cases animals engineer the selective environments of the constructors. But there are other, perhaps most striking cases of niche construction in which the animals not only change the selective environments of the constructors but also alter the environments of the constructor's descendants. [Laland et al. (2001)]. Among these cases, the most cited is probably that of the earthworms that modify the structure and the chemistry of soils through their burrowing behaviour. [Lee (1985)]. As a result of restless digging activity of previous generations, successive generations of earthworms are exposed to altered environments and these modified environments in turn trigger the emergence of new selective pressures in subsequent generations. [Ihara and Feldman (2003)]. Bird's nests, female insect's oviposition site choices and beaver's dams are other good examples. All these cases in fact, nicely illustrate the so-called phenomenon of ecological inheritance by showing the importance of environmental manipulation for successful biological and organic evolution.

Before discussing some of the dialectic underlying the debate between neo-Darwinists and advocates of niche construction with regards to the examples abovementioned, let me explain the notion of ecological inheritance. The so-called ecological inheritance is one of the crucial tenets underlying the phenomenon of niche construction. Odling-Smee (1988) describes ecological inheritance as the legacy of modified selection pressures. Ecological inheritance is therefore to do with the inheritance of a modified ecological environment or as Laland and colleagues (2000) have put it: “*it refers to a modified functional relationship that the organism experiences between itself and its environment as a consequence of niche constructing activities that involve its genetic or ecological ancestors*”. [Laland et al. (2000), p.23]. Niche construction thus not only alters selective environments but also changes developmental environments. That is, niche construction not only generates ecological inheritance but also forges genetic legacy and in doing so it causes what Sterelny (2010) has called evolutionary feedback loops. “*The key to the niche construction approach therefore is the inclusion of organism-induced environmental modification bequeathed from the modifying generation to its offspring.*” [Riede, Semiotic Encyclopaedia Online, <http://www.semioticon.com/seo/N/niche.html#>].

Having specified the idea of ecological inheritance I can now focus on one of the examples I mentioned above, namely the case of the beaver’s dam, and see how a neo-darwinist (such as Dawkins) would interpret such a case. Having presented Dawkins’ understanding I will then quickly try to show why his interpretation fails. Dawkins (2004), a leading proponent of the gene-centric view and a critic of niche-construction, has dismissed the possibility that evolution can impact upon or across whole ecological systems. He has famously argued that natural selection can only operate against variations of replicators. In particular, in the case of the beaver’s dam Dawkins has pointed out that these variations of replicators cannot assume the form of mechanisms of selective pressures operating on beaver genes. [Hunter (2009)]. “*A beaver that lives by a stream quickly exhausts the supply of food trees lying along the stream bank within a reasonable distance. By building a dam across the stream the beaver creates a large shoreline which is available for safe and easy foraging without the beaver having to*

*make long and difficult journeys overland.....*In order to explain such a phenomenon, Dawkins however continues, we do not necessarily need to appeal to niche construction because “*we can understand the dam, and the lake, as part of the (extended) phenotypic expression of beaver genes. In sum, it is enough that we accept that beaver dams must have evolved by Darwinian natural selection*”. [Dawkins (1982), p. 200]. On these grounds, Dawkins has therefore claimed that the idea of active scaffolding endorsed by proponents of niche construction to account for variation of phenotypic traits is problematic at best, deeply flawed at worst.

Now, it seems to me that Dawkins’ understanding of the phenomenon of niche construction is somehow limited and a bit too restricted. In particular, it occurs to me that Dawkins doesn’t seem to fully appreciate the evolutionary significance of beaver dams. These dams are not just the products of the activity of a single organism; rather they are the result of consistent efforts of an entire community of beavers. These dams in fact last for many years being used by several different generations of beavers and therefore seem to possess a generational length that stands above that of beaver genes. [Reid, Semiotic Encyclopaedia Online]. By constructing these dams, beavers directly engage in downstream niche construction, reshaping the developmental environment of the next generation. [Sterelny (2009)]. In particular, when a new generation of beavers comes into the world, it comes into a modified world; a world that has been successfully forged and manipulated by its previous ancestors. The construction of the dam therefore determines the beaver’s survival by providing the means to access new sources of nutrition, influencing mating behaviours and increasing the biological fitness of the new-borns. It therefore seems to me that beavers dams significantly impact upon the existence of many generations of beavers. To the extent that the dam impacts upon beavers’ existence, it also becomes a resource for triggering genes and alleles selection. This ultimately shows that niche construction is not just a by-product of natural evolution but rather that it is a driving force behind it, a force that can operate at a longer range by generating phenotypic variation across multiple generations of organisms.

This understanding of niche construction as a driving force of evolution is also endorsed by Eva Jablonka (2004), who also believes that epigenetic mechanisms can play a crucial role in selecting phenotypic traits. She warns: "*ecological inheritance may be facilitated or dependent on epigenetic inheritance mechanisms. Clearly, co-developing partners may induce epigenetic variations in each other. For example, nutrition-based developmental programming by the mother during her pregnancy can lead to offspring with the same preferences, which aids the construction of the same food-related environment*". [Jablonka (2004), cited in Hunter (2009), p.214]. In this scenario, the environment capable of endowing the individual with the greatest fitness advantage becomes quickly instrumental and therefore preferred for the development and transmission of the relevant epigenetic changes through successive generations.

Although niche construction is a pervasive phenomenon of great evolutionary relevance, its importance has been neglected for a long time. Only very recently (in the last decade or so) it has acquired a prominent status in biology and has become the centre of a vast interdisciplinary debate. Among the disciplines that have benefited of this debate, there are the cognitive sciences. In the cognitive sciences the idea of enhancing cognition through manipulations and external couplings with environmental resources has been received and widely acknowledged. [Clark (2008); Menary (2007)]. The notion of niche construction and the idea of ecological inheritance (also known by philosophers as “cumulative downstream epistemic engineering”) have become crucial in the debate dedicated to the hypothesis of extended cognition [Sterelny (2003, 2010); Wilson (2004); Stotz (2010), Wheeler (2007) to name a few]. Additionally, the discussion of niche construction into the realm of cognitive ecological niches has profoundly impacted on the dispute between embodied cognition and evolutionary psychology. [Wheeler and Clark (2008)]. It is to such a dispute that I now quickly turn.

3.4 Niche Construction and the Extended Mind Thesis

Wheeler and Clark (2008), two of the most important advocates of niche construction in the cognitive sciences, have highlighted the tension between an understanding of

evolution and cognition as embodied and a view that describes them as encoded. From the former, they say, we get a model of cognitive development that stresses the kaleidoscopic effects of thought and action. From the latter, we obtain a view that instead emphasises the selective fit of the biological into the external. This view, they continue, largely coincides with evolutionary psychology. [Pinker (1994); Cosmides and Tooby (2000)]. Whereas embodied cognition theorists believe that the brain is forged and sculpted by the dynamic interplay between body and world at different time-scales; proponents of evolutionary psychology tend to privilege an “intracranialist” understanding of cognition that assumes the existence of enduring structures in the brain, moulded by natural selection and encoded in fixed genetic architectures. In their Triple Helix paper, Wheeler and Clark side with proponents of embodied cognition and criticise much of the work related with evolutionary psychology [Pinker (2002); Cosmides & Tooby (2000)]. In particular they focus on the idea of modularity.

Modularity describes the mind as composed of independent, separated and domain specific modules and suggests that any treatment of the brain must necessarily draw its attention on these domain-specific modules because they have established evolutionarily developed functional purposes. By focusing on work conducted on ‘modularization’ [such as Kamiloff-Smith (1992)] - that is by taking a neuroconstructivist perspective [Mareshal et al (2007)], Wheeler and Clark attempt to reject this strong modularity thesis and rather argue for what they call “emergent modularity”; a model capable of accounting both for brain neural specialisation and functional isolation without the involvement of excessive pre-determination or design. Unlike many evolutionary psychologists Wheeler and Clark therefore acknowledge the potential role of the environment, or of environmentally driven mechanisms, in triggering or alternatively disabling the emergence of specific functional modules. Wheeler and Clark thus endorse the idea that innate developmental programs may intermingle with flexible environmental resources to produce the rich cultural, cognitive, and behavioural variation observed in mankind.

In the previous paragraph I said that Wheeler and Clark reject a certain understanding of modularity, one favoured by some prominent evolutionary psychologists. Modularity is a view that describes human nature as constrained to develop in accordance with a range of

cognitive modules. These modules may “mature” during development but are pre-determined and pre-destined to give rise to specific functions. Now, modularity in biology says that the information necessary for the emergence of these functions is fixed and already contained in a sequence of genetic codes prior to birth. Modularity is therefore a claim that envisages discrete genetic specification and strong hierarchical organization among different modules. [Raff (1996)]. These modules govern evolution and direct development in accordance with a set of genetic, pre-specified instructions that are contained within them and that emerge through the contact with the environment. The neuroconstructivist perspective endorsed by Wheeler and Clark stands in opposition to this view. Wheeler and Clark don't envisage the existence of pre-specified modules and rather treat genes as one constraint on the developmental process. As a consequence, they tend to favour attempts to individuate emergent and horizontally extended modules, whose nature lies in the continual openness to radical cognitive change. [Wheeler and Clark (2008)]. The rejection of modularity by Wheeler and Clark does not however entail a rejection of the “special” role played by the genes in evolution. Wheeler and Clark (2008) do not deny the importance of genes. The target of their critique is rather a narrow view of development, which they label as “strong instructionism”. [Wheeler and Clark (1999); Wheeler (2003, 2006, 2010)].

Strong instructionism “*is the claim that what it means for some element to code for an outcome is for that element to fully specify the distinctive features of that outcome, where ‘full specification’ requires that the kind of exhaustive predictive power just indicated may, in principle, be achieved on the basis purely of what may be known about the putatively representational factor*”. [Wheeler (2007), p.377]. In the context of natural selection, strong instructionism therefore indicates the view that asserts that the genotype is the blueprint for the organism, the holy grail of biology, the recipe for development. [Condit et al. (2002); van der Weele (2005); Dupre (2005)]. Strong instructionism is compatible with those views of evolution that deny the role of developmental and phyletic constraints and rather affirms that phenotypic traits are entirely encoded in genes. Thus, strong instructionism largely coincides with Neo-Darwinian accounts of evolution as it seems to impose the so-called full-specification

condition. The idea is that coding for traits means just specifying the form of those traits. According to strong instructionism, the distinctive feature of phenotypical traits can be always predicted on the basis of internal coding factors that on their own orchestrate the journey from genotype to phenotype. The problem with this view, Wheeler and Clark argue, is that it lacks what they call the developmental explanatory spread. There is a complex network of interactions that determines the phenotypic form that a trait can assume and this network of interactions, they argue, cannot be explained by simply appealing to a sequence, a pre-formed string of DNA. Strong Instructionism therefore naively confuses essential participation with unique responsibility²². [Maturana and Varela (1987)].

Wheeler and Clark's denial of those views (abovementioned) that see the human brain as a sort of Swiss Army Knife made up of pre-determined, genetically specified cognitive tools does not however entail their automatic endorsement to alternative accounts of evolution that promise to reduce the "power of genes" and consider traits to be simply dynamic or developmental tout court²³. Wheeler and Clark in fact try to combine the neuroconstructivist idea of emergent modularity abovementioned with the notion of ecological inheritance derived from niche construction and attempt to show how this combination can be used to argue, from an evolutionary perspective, for cognitive niches. Having demonstrated the primacy of the neuroconstructivist perspective, their next step is to show the extent to which niche construction can impact upon embodied cognition.

Wheeler and Clark argue that scholars wishing to pursue research on the field of embodied cognition can find strong allies among the theorists of niche construction²⁴: in particular, they continue, among those who extend niche construction into the realm of cognitive ecological niches. The cumulative ecological niche, on their account, is in fact both a cause of developmental inputs for the growing modules in the brain and a medium,

²² Although strong instructionism might sound like an odd position, a straw position that no serious researcher would be committed to defend, it is however still quite common to hear, as Dupre has noticed, eminent experts talking of the genome as the factor uniquely responsible for the development of the organism.[Dupre (2005); Wheeler & Clark (2008)].

²³ I will analyse DST and its ramifications in the next section.

²⁴ For a list of relevant studies please refer to section 2.

or better a vector of cultural transmission²⁵. The link between the neuroconstructivist perspective they chose to adopt at the brain level and the idea of niche construction they decide to embrace at the evolutionary one is established by phenotypic plasticity and ecological inheritance. Here is what they say:

“Rampant niche construction yields a rapid succession of selective environments, and hence favours the (biological) evolution of phenotypic plasticity. Hominid minds, Sterelny suggests, are adapted to the spread of variation itself. To cope with such variability, we are said to have evolved powerful forms of developmental plasticity. These allow early learning to induce persisting and stable forms of neural reorganization, impacting our range of automatic skills, affective responses and generally reorganizing human cognition in deep and profound ways”. [Wheeler and Clark (2008), pp.3565]. The upshot is that ‘*the same initial set of developmental resources can differentiate into quite different final cognitive products*’. [Sterelny (2003), p. 166].

In short, Wheeler and Clark emphasise the cumulative and transformative power of self-engineered operations conducted upon environments via developmental plasticity. These operations quite often assume the form of new feedback cycle loops. These new feedback cycle loops include cultural transmission of knowledge. Cultural transmission of knowledge actively contributes to alter both the selective landscape for biological evolution and the individual lifetime learning. Following Sterelny (2003), Wheeler and Clark call this capacity of impacting upon evolution, cumulative downstream epistemic engineering. Cumulative downstream epistemic engineering, they continue, works alongside with genetic inheritance and contributes to reorganise human cognition in deep and profound ways. It is through this downstream effect that organisms scaffold their physical structures in ways that can change their fitness. These altered physical structures are then combined with reliably replicated cultural practises in order to realise problem-solving regimes that favour the emergence of flexible thought and reasoning. This maximally highlights the power of what Wheeler and Clark call cognitive niche construction. In particular, it does so by shifting the focus of our attention from mere genetic specification to scaffolded matrices of co-determining factors. But what does this tell us about the notion of human nature?

²⁵ Thanks to Greg Downey for the discussion of this point on his blog.

Cognitive niche construction seems to show us that what is truly special about our nature is its distinctive ability (acquired through an extended developmental period) to openly enter into profound and ultimately modules-changing relationships with a jumbled mixture of culturally inherited practices and non-organic constructs. These practises and constructs are the preferable vehicles of an ecological inheritance that not only complements our intellectual skills but also intimately forges the next generation's (and our own) cognitive development. [Clark (2008)]. The Wheeler and Clark perspective therefore entails a redefinition of the notion of human nature because it emphasises the adaptability of our plastic minds to external structures. In order to clarify this point, I invite the reader to consider the following example²⁶. The methods and skills I absorb during the course of my life to solve some calculations not only impact on my own brain. These techniques are passed and converted into the lessons that I will visit upon my children's brains when they will be in critical formative stages of development. These techniques for expanding mental abilities assume the form of a cultural inheritance that is transmitted to my children and thus becomes my kid's environmental niche for honing intellectual skills. We could consider many other examples of this kind. Among the many, one could also include mind-shaping cultural artefacts (such as language or art), technological enhancements or tool usage. Under certain circumstances, a tool can in fact be used to reduce the computational load of the brain and in doing so it may become active part of our cognitive ecological niche. Unlike internalists in modularity, embodied theorists therefore remain fully open to the possibility of "*artefact-based expansion and snowballing / bootstrapping process of computational and representational growth*". [Wheeler and Clark (2008) p. 3572]. In other words, "*under certain conditions non-organic props and aids, many of which are either culturally inherited tools or structures manipulated by culturally transmitted practices, might themselves count as proper parts of extended cognitive processes*". [Wheeler and Clark (2008), p.3566].

The notion of cumulative downstream epistemic engineering has, however, also been used to criticise EMT. In particular in a series of recent papers, Sterelny (2003, 2010) has used this notion to mount a sustained attack on EMT. I want to conclude this section by quickly glancing at his work on scaffolding.

²⁶ Thanks to Greg Downey for providing such a useful example.

Sterelny (2010) has recently defended, in analogy with Wheeler and Clark, a model of cognition that places a great emphasis on the role of the milieu in supporting, expanding and amplifying our cognitive abilities. He has called such a model “the scaffolded mind”. Focusing on the nature of the functional relationship between a cognitive agent and an external resource and building on the idea of niche construction and on its relevance for social learning, Sterelny has elaborated a multidimensional framework for thinking about this scaffolded cognition. [Theiner (forthcoming)]. More precisely, he has individuated three dimensions in which, he has claimed, human cognition can be scaffolded. These three dimensions are: 1) Trust and Reliability; 2) Interchangeability and Entrenchment; 3) the Individual and the Collective.

The first dimension, trust and reliability, is based on the availability, reliability and access of specific resources in a given environment. The second dimension, interchangeability and entrenchment, concerns the degree to which an external resource can become personalized to fit an agent’s skills or needs. The third dimension, the individual and the collective, instead investigates the power of cognition-enhancing mechanisms (such as language, mathematical notations or cultural and technological innovations) over many generations and in cooperative situations. On the grounds of this distinction, Sterelny goes on to claim that the framework provided by EMT seems acceptable with extremely entrenched or personalised cognitive artefacts, (artefacts that belong to the second dimension such as the chef’s set of knives and the cricket batter’s individualised bat) [Sterelny (2010)], but “*points out that the sciences of mind also need to study more transportable or interchangeable resources, and the stable capacities which mobile agents bring to each interaction*”. [Sutton (2010), p.536].

In particular, Sterelny chooses to focus on the third dimension. The third dimension involves the acquisition of collective cognitive resources. This acquisition, Sterelny claims “*follows a distinctive intergenerational pattern that is markedly different from the individualistic stock examples of the extended mind literature*”. [Theiner (forthcoming),

§2.2]. In cases of collective cognitive resources in fact, the inheritance is passed through cultural rather than through genetic means. As a consequence, the transmission of these patterns of inheritance does not run vertically from parents to offspring, but obliquely draws on the different activities of the many members of previous generations. These collective activities of social groups, he maintains, mature through unique trans-generational trails and are normally mastered by skilled experts in their use by way of continuous and unrelenting coaching. [Sutton et al. (2010)]. In developing considerations on trans-generational effects in cognitive niche construction, Sterelny therefore classifies “*these cumulative built, collectively provided tools for thinking*” as the most “*critical, mind-and-brain-shaping environmental supports for cognition*”. [Sterelny (2010), p.537]. Scaffolding for Sterelny is thus supposed to score highly on multiple dimensions. So, while the extended mind picture²⁷ is not false, extended mind cases can be interpreted as limiting cases of environmental scaffolding.

A canny reader might have noticed the points of contact between Sterelny’s idea of scaffolding cognition on multiple dimensions and the idea of complementarity that I have presented in the previous chapter of this dissertation. Placing different empirical cases within a multidimensional context is precisely what Complementarity is after. Rather than being an argument against EMT, the idea of cognition as scoring on multiple dimensions therefore results as a precious ally for its Complementarity defences²⁸. This empirical project is, I believe, far more fruitful than continuing to debate on whether cognition is really extended or merely embedded. As Sutton has noticed, we should guide our “*scientific focus on the identification and exploration of this multidimensional space of agent–environment interactions which amplify or transform cognitive capacities and practices, rather than any metaphysical claim about whether mind in general does or does not extend into the world*”. [Sutton (2010),p.537].

In this section we have seen that the idea of niche construction and the notion of ecological inheritance can be used to argue for EMT or to undermine its relevance within

²⁷ At least the parity-based version endorsed by Clark and Wheeler.

²⁸ For more details, please refer to the discussion of Sutton’s Complementarity in the Complementarity section of chapter 2.

a context in which scaffolding takes precedence. But are we sure that we can't find any form of support for EMT elsewhere? That is, are we really sure that the framework provided by niche construction is the only one within which we can defend EMT? I believe that a more powerful and potent defence of EMT can be mounted on the basis of developmental considerations. It is to such considerations that I now want to turn.

3.5 Is it a Revolution? Developmental Systems Theory (DST)

As we have seen earlier in this chapter, mainstream biology quite often describes evolution in terms of changes in gene frequency. Neo-Darwinian accounts envisage the existence of a profound dichotomy between nature and nurture characteristics of development and take genes to program and code for phenotypical traits. DST is a radical challenge to dichotomous accounts as such. Proponents of developmental systems theory endorse a view that renounces the ontological priority of any particular entity (the genes in the case of neo-darwinian accounts of development) and favour an understanding of evolution in which developmental information is not isolated in small sequences of DNA but can be equally well applied to other factors required for development [Gray (1992); Griffiths & Gray (1994), (2001)]. Unlike gene-centric view of development, DST describes evolution as a process of co-variation in which evolutionary changes emerge from interactive and interdependent developmental relations between external resources, organisms and their environments.

As Oyama, Griffiths and Gray have put it: DST is “*a way of thinking about development that does not rely on a distinction between privileged, essential causes and merely supporting or interfering causes*”. [Oyama, Griffiths and Gray (2001), p.1]²⁹. Oyama (1985, 1999) has extensively endorsed this thesis while arguing that one cannot distinguish between nature-based and nurture-based characteristics in development because both nature and nurture carry information necessary for the development of the resulting characteristics. This principle has come to be known as the Parity Thesis. The Parity Thesis has been also embraced by other developmental systems theorists (such as

²⁹ For a critical assessment of DST see also Godfrey-Smith (2009).

Griffiths and Gray) who have claimed that “*the role of the genes is no more unique than the role of many other factors*”. [Griffiths and Gray (1994), p.277]. The Parity Thesis is one of the central tenets of DST.

DST defends a view of evolution in which the nature/nurture dichotomy collapses, a perspective that embraces a wider conception of the developmental system, an account in which differences in traits and also differences in fitness are quite often triggered by the kinds of environments one inherits. Development, as Shaffner noticed, is “*an extraordinarily complicated orchestra – but one with no conductor*” [Schaffner (1998), p. 247]. DST therefore describes the developmental system as emerging from the delicate interplay between the genes and the rich matrices of resources available outside the genome [Griffiths and Gray (2004); (2005)] and therefore calls into question the idea of a fixed pre-specified genetic program that endogenously drives our evolution.

Many geneticists have rejected DST on the grounds that it seems an unviable theory. Developmental Systems Theory, they say, gets us close to an unworkable holism, where it is impossible to draw a line and successfully distinguish between genetic and extra-genetic contributions. Sure, they continue, the whole universe is reflected in the complex relations that characterise the organism-environment relation, but science can't be undertaken on such vague premises. Science, they maintain, is based on reductionism and it is all about problem solving and simplification. Science should carve off relevant information from a few sets of elements and then should measure and test such information in a controlled context. Since developmental systems theorists seem to give up on such a context, many geneticists have interpreted DST as a mere theoretical exercise, a fascinating speculation which however cannot be operationalized or rendered scientific. DST, they have claimed, is just philosophy, and from it we cannot extract testable hypotheses. [This objection is discussed in Protevi, (2008)].

In order to avoid such criticism, developmental systems theorists have designed a specific criterion to discriminate between factors that are and factors that are not part of the matrix of resources that characterises the developmental system. Key is the reliable and consistent cross-generational availability of each resource: in short, extended inheritance.

[Stotz (2010)]. The notion of extended inheritance is a consequence of the Parity Thesis and is to do with the idea that what an organism inherits is a wide spectrum of developmental resources that mutually interact to construct its life cycle. This spectrum of resources includes necessary genetic features but also encompasses equally necessary and reliably replicated extra-genetic factors. These include bodily, social, behavioural, ecological, symbolic and epistemic ones. [Stotz (2010)]. The idea behind the notion of extended inheritance is therefore that genetic factors are not only causally dependent on extra-genetic resources for their development but rather that the latter complement the former and trigger new mechanisms of evolutionary significance. In other words, environmental resources such as “*diet, temperature, oxygen levels, humidity, light cycles, and the presence of mutagens can all impact upon the way in which an animal’s genes are expressed, ultimately affecting the animal’s phenotype.*” [Ralston & Shaw (2008),§ 2]. A couple of examples might help us better understand this claim.

Consider the case of eucalyptus seeds. In order to germinate, many types of eucalyptus seeds need to be scorched by bushfires. Eucalypts increase the frequency of bushfires by creating woodlands “*scattered with resinous litter and hung with bark ribbons, which are carried aloft by the updraft as blazing torches and spread the fire to new areas*”. [Mount (1964); Griffiths & Gray (2004), p.410]. Another interesting example that nicely reveals the importance of the environment in determining an organism’s characteristics concerns the way in which sex is determined in crocodiles³⁰. The sex of the baby crocodile is fully determined at the time of hatching and naturally irreversible thereafter by the temperature in which the eggs are incubated. Temperatures equal to or below 30°C generates females. Temperatures equal to or above 34 °C generate males. [Ferguson & Joanen (1982)].

Having introduced DST and the idea of extended inheritance as a way to counter genetic determinism, I can now present the *pars construens* of DST. DST in fact is also characterised by a positive proposal. The positive proposal is the idea that the fundamental unit of evolution is the life cycle. The developmental process or life cycle of

an organism is the structured set of reliably replicated cross-generational developmental resources that are assembled together and intermingle in such a way that the life cycle is reconstructed in each generation and reflected in descendant cycles. The developmental process is thus understood as a complex sequence of developmental events which form and select a unit of repetition in a lineage. [Griffith and Gray (2001), p.296]. For proponents of DST the life cycle of an organism is always developmentally scaffolded and never endogenously pre-determined or genetically preformed. The life cycle is thus the unit of natural selection and the main force that drives evolution. By understanding the individual as a complex matrix of developmental resources – that is by appealing to the life cycle of an organism, DST attempts to liberate biology from the grip of dichotomous accounts of development abovementioned. “*Traits need not be either genetic or environmental, either evolved or socially constructed*”. [Griffiths and Gray (1994), p.304]. Evolution is rather understood as the result of interactive and interdependent processes of amalgamation and co-construction of different, reliably replicated but complementary factors; the sort of environmental resources to which I have appealed above.

In DST the emphasis is therefore put on the developmental sequence of events that leads to the selection and formation of the atomic unit of repetition in a lineage. Despite this extreme commitment to developmental factors and to organism-environments interactions, DST doesn't refuse to acknowledge the transformative power of genetic mechanisms in the processes that drive evolution. Proponents of DST just resist the gene-selectionist drift of that idea. Not by chance, Griffiths and Gray have embraced Lewontin's criticism of genetic determinism. In their papers, they refer to Lewontin as one of the intellectual precursors of DST and quote him in asserting that "*if anything in the world can be said to be self-replicating, it is not the gene, but the entire organism as a complex system*" [Lewontin (1991), p.48].

In the previous sections, we have seen that Lewontin's criticism of gene-centric accounts of natural selection is also shared by proponents of niche construction. To be precise, the

critique of the selfish gene theory was the starting point of the considerations that led to the paradigm of niche construction. The reader might have also noticed a coarse analogy between the notion of ecological inheritance as proposed by Odling-Smee and colleagues and the idea of extended inheritance as endorsed by developmental theorists. At this point, a canny reader might legitimately raise a question. If these two paradigms have so much in common, what are the real differences between them? That is, to what extent does a developmental account of evolution diverge from a constructivist one? This is certainly a good question, one that deserves full exploration. Although niche construction seems to converge toward a developmental conception of evolution, constructivist claims are much more conservative than developmental ones. Let us look at this issue more closely.

The major difference between niche construction and DST is to do with the fact that niche construction still presents a dichotomous account of development. For those who endorse such a view there are two different systems of heredity – one that embraces genetic inheritance and the other that encompasses ecological inheritance. Although genes are not the only cause of development, proponents of niche construction tend to attribute to genes a special role in driving evolutionary changes. Developmental theorists instead simply deny that genes play any special role in natural selection and equate their contributions to that of the other developmental factors.

A second difference between the two accounts emerges if we look at the role of cross-generational influence. Whereas proponents of niche construction limit the role of trans-generational effects to biology and culture, developmental theorists broaden it so as to encompass the contribution of bodily, social, symbolic and behaviour factors. [Laland et al. (2000)]. This is particularly evident in Odling-Smee (1994) for instance. Odling-Smee treats genetic inheritance as the flow of information and extra-genetic factors as the provision for such a flow. [Sterelny (2001)]. Developmental theorists reject the very notion of information and rather equate biological and extra-genetic contributions in the production of the final construct.

³⁰ Analogous considerations apply to some species of turtles and also to many other types of reptiles.

Additionally, for niche construction theorists there are also two different causal processes in development. One triggered by the niche that drives natural selection, the other established by the organism which influences the construction of the niche. DST rejects both these distinctions and rather emphasises the integrative power of developmental resources as given by the entire matrix of interactants involved in a life cycle. So yes, there appear to be substantial differences between these two paradigms, but are these differences sufficient to prevent reconciliation? In other words, should we think of niche construction and DST as competing (perhaps alternative) projects or can we rather reconceptualise them into a more general and powerful context?

Earlier on in this chapter I have shown how niche construction can be used to support non-standard approaches to cognitive science (such as the extended mind thesis). I have focused my attention on the notion of cumulative epistemic engineering in relation to the extended mind thesis and have shown how this notion can be used to argue both for and against it. [Wheeler and Clark (2008); Sterelny (2003, 2010)] In this last section I have introduced DST, have analysed its crucial tenets and pointed out the critical differences between DST and niche construction. I will now try to reconcile DST with its more conservative cousin and will therefore implement the developmental considerations endorsed in this section (in particular the notion of extended inheritance) within the framework provided by niche construction. In line with West and King (1987) and Stotz [2010], I therefore propose to speak of ontogenetic or developmental niche construction. The idea is to reconceptualise niche construction into a developmental context, one where adaptive plasticity and learning play a crucial role. To do so, I will have to resituate the notion of ecological inheritance from an evolutionary framework to a fully developmental one. Expanding the notion of ecological inheritance would constitute a beneficial move, inasmuch as it will allow us to acknowledge the transformative role that plasticity and learning play in evolution. These considerations on ontogenetic niche applied to the cognitive sciences and especially to the extended mind thesis should

eventually provide an argument for complementarity and for the enmeshing of organisms and their cognitive developmental niches³¹.

3.6 Developmental Niche Construction and Complementarity

The ecological process that actively guides and scaffolds the evolution of many species by means of reliable and extended trans-generational effects has first been described by West and King in a ground-breaking paper from 1987 [West and King (1987)]. This paper was issued a year before the release of the first publication on niche construction [Odling-Smee (1988)]. While niche construction has since then acquired a prominent status both in biology and in the cognitive sciences, the idea of the ontogenetic or developmental niche has gradually fallen into oblivion. In a series of recent papers, Karola Stotz (2006, 2008, 2010) has proposed a revival of this theory. In bringing the ontogenetic niche back to the fore she has meritoriously caught the attention of the philosophical community and has offered a new framework to reconceptualise it. It is to her work that I now turn.

According to Stotz, ontogenetic niche construction provides a very powerful framework to understand evolution: it in fact successfully combines the idea of active organisms scaffolding their environs (idea that derives from niche construction) with the developmental claims about extended inheritance. To this explosive combination the developmental niche also adds a special focus on learning and plasticity. The result is quite striking as the theory prescribes that any scientific understanding of the nature of living things must depend on an understanding of the developmental process that drives it. Stotz defines the ontogenetic niche “*as the set of ecological, social, epigenetic, epistemic, cultural and symbolic legacies inherited by organisms, functioning to guide the expression of the genetic potential*”. [Stotz (2010),p.483] The ontogenetic niche thus consistently relies on the notion of exo-genetic inheritance. Exo-genetic inheritance not only involves the heterogeneous contribution of extra-genetic resources, as extended

³¹ It is worth noting here that Cognitive niche construction can be argued to come real close to Ontogenetic niche construction. In the next section however I will try to highlight some differences between these two approaches.

inheritance in DST, but also encompasses social learning and parental care for the offspring. Unlike genetic inheritance, exo-genetic inheritance thus provides a much more reliable and flexible way for transmitting evolutionarily relevant features from parents to offspring. It does so because it puts the individual into a context of adaptive plasticity in which learning processes are involved in the development. In such a context, exo-genetic legacies are not only inherited but also learned via behavioural and developmental plasticity. The ontogenetic niche thus enables the offspring to undergo necessary experiences of future relevance and therefore functions as an informational hub that decides which experiences are developmentally bioavailable and which are not.

Exo-genetic inheritance has however another important role. It also allows parents to control the offspring's gene expression. This function is particularly evident in after birth rearing practises that occur in many species of animals. The licking of puppies by rat mothers not only modifies the protein components of chromatin in the nucleus of the puppies' cell but it also triggers new mechanisms of imprinting, which in turn influence the gene expression of their puppies in the long run. Analogous observations can be made for humans. Recent studies have revealed that parental care and environmental cues have profound influences on the trajectory of prenatal development. The fetal programming hypothesis formulated by Baker (2001) and subsequently developed by Nathanielsz and Thornburg (2003) is a perfect example of this profound influence. Studies on this topic reveal that environmental exposure during critical periods in early development may impact upon the fetus' development. For instance, the exposure to specific hormonal factors in the intrauterine environment triggers a series of vascular and endocrine adaptations in the fetus that determines its weight at birth. This nicely shows that epigenetic mechanisms are induced by environmental cues mediated by the placenta [Gluckman et al. (2007)] and that these factors have important repercussion on the trajectory of prenatal development. [Stotz (2010); O'Malley and Stotz (2011)].

While genetic inheritance is characterised by a sequence of fixed and static features, exo-genetic inheritance remains in continuous interaction with the genome by means of epigenetic mechanisms that regulate gene potential. [Stotz (2008)]. Exo-genetic inheritance thus provides more powerful pathways to transmit the effects of experience

from parents to their descendants. [Lamm and Jablonka (2008)]. Via exo-genetic inheritance, the ontogenetic niche instantiates successful links among different generations. It not only reveals a general interdependence between different generations, but rather highlights “*their proximate dependence via mechanisms that promote orderly transitions in species-typical development for both adult and young*” [West et al. (1988),p. 47)]. Exo-genetic inheritance thus gives rise to “cross-generational phenotypic plasticity”, [Maestriperi and Mateo (2009)] in as much as it induces epigenetic variations in phenotypes through development and changes in their environment. [(Stotz (2010))]. The ontogenetic niche therefore seems to provide a more powerful framework within which is possible to comprehend the mechanisms that drive evolution. The ontogenetic niche is not only a selective self-engineered niche, as the selective niche in niche construction, but rather configures itself as a problem-solving mechanism that actively constructs individual development and learning processes.

In the footnote at the end of the last section I mentioned that cognitive niche construction can be argued to come very close to the idea of ontogenetic niche construction³². Having introduced ontogenetic niche construction I am now in the position to compare these two approaches and quickly investigate the dialectic between them³³. Wheeler and Clark’s cognitive niche construction is done, as we have seen above, in analogy with the niche construction paradigm developed by Laland, Odling Smee and Feldman and also taken on by Sterelny and DST, where the cognitive niche is understood as the selective niche. Within this framework the evolutionary significance of the cognitive niche contributes to create selection pressures partially constructed by the organism itself. The ontogenetic niche theory proposed by West & King and Stotz possesses instead a different evolutionary significance, which is achieved not merely through the adoption of specific selection pressures but via active deployment of developmental resources that are capable of generating evolutionary novelty.

Unlike cognitive niche construction, ontogenetic niche construction therefore fully recognises the fact that we generate an environment, the ontogenetic niche, which

³² Thanks to Andy Clark for pressing this worry in the workshop “Extended Cognition and Distributed Cognition” held at the University of Edinburgh in July 2011.

³³ Thanks also to Karola Stotz for having drawn my attention on this point.

provides us with the necessary resources to develop in new ways, and these new ways provide the necessary material for further evolution as real morphological, cognitive and behavioural novelties. These novelties are inherited through the legacy of these niches which recreate, in successive generations, the conditions necessary to re-develop in the same way. A case in point is bird song learning: birds very reliably inherit a song via its developmental exposure to its father's singing. Another helpful example is the case of the mother's egg. We reliably get from the mother not only genes but a whole egg ready with all the machinery to express genes, including lots of gene products from the mother such as transcription factors without which the inherited genome would forever be dormant. The exact kinds of gene products the mother gives to her offspring depend on the environment encountered by the mother with which she is able to change the future developmental trajectory in expectation of a future environment. Most mothers then go on providing child care which can, among other things, up- or down-regulate the expression of certain genes not just at that particular time but on the long run, which again influences the trajectory of the phenotype.

None of these things seem to be explicitly acknowledged in the writing of Wheeler and Clark when they talk about the evolutionary significance of niche construction. Niche construction does not therefore simply matter both to development (through ontogenetic niche construction) and evolution (through selective niche construction) independently. It matters to evolution by influencing development. Although Wheeler and Clark could claim to have come very close to the idea of ontogenetic niche construction, I reckon this is a possibility; it seems to me that in the end they both try too hard to stick to the paradigm of selection niche construction.

Formulated as the theory that determines evolution by influencing development, the theory of ontogenetic niche becomes highly relevant also for the cognitive sciences. The ontogenetic niche theory in fact offers a profitable alternative to the persistent yet unsatisfactory debate about nature and nurture and therefore contributes to a transcending of both nativist and empiricist views about ontogeny. As such, the ontogenetic niche theory also provides very useful insights to understand the nature of cognition in human beings. The ontogenetic niche theory tells us in fact that there isn't a

real dichotomy between genetic, biological and cultural inheritance and invites us to reconceptualise their relationship into a developmental context. Culture and biology don't travel either on separate nor on parallel trails but mutually interlock to favour new mechanisms of adaptations which in turn trigger new cognitive strategies. The theory of ontogenetic niche thus nicely shows us that inner and outer become entangled and enmeshed to produce an extended process that characterises human cognitive development and evolution.

For the theory of ontogenetic niche culture and biology therefore represent two types of interactants; only two types among the many available in the matrix of developmental resources. These interactants (which also include epigenetic, behavioural, symbolic, parental and ecological factors) become developmental causes only by interacting with each other. This interaction allows their reliable transmission over generations and at the same time explains how the life cycle of the organism is reconstructed. To say that these interactants form an entangled unit isn't however to say that there aren't differences among them – quite the opposite. There are differences, in terms of variability and reliability for instance, but the appealing to the whole matrix of reliably replicated developmental factors allows us to see how these dissimilar interactants co-operate in producing the conditions for development. Genetic and exo-genetic contributions are not only analogous, much less antagonistic. Over cultural-evolutionary time, the properties of biological and non-biological rather intermingle and change each other to give rise to a more dynamical account of the relationships that span the brain, body and world boundary. An account where there aren't hard constraints on development but only soft constraints. It is therefore only by being genuinely active elements and truly multipart nodes in the assembly process that these external vehicles become incorporated into the extended system that regulates them. This system rejects the solidification produced by nativists around fixed properties or hard constraints of the human mind and rather reveals to us a strong commitment to organism-environment interactions with which the milieu drives, forges, transforms and re-orientes the opportunities for action. [Kirchhoff (submitted)].

The existence of these soft constraints highlights the plastic nature of our brains and suggests that processes of reorganization take place in the cerebral architecture due to reconversion of specific structural properties by material-culture and non-biological elements. This multi-layered process of manipulation opens up the space for cultural transformation and for mind-enhancement through technology. The formation of these soft-constraints in fact makes it possible for culture and niche construction to transform, via development, the dynamics of the cognitive system and the kinds of possibilities that are open to us as cognisers. This is basically, once again, the idea of complementarity that I have been defending in the previous chapter. Complementarity comes into play when we realize and acknowledge that even though different resources are similarly reliable, they differ in their copying fidelity, and in this they complement each other: the genetic resource stays remarkably similar for extensive generations, while non-genetic inheritance is dependent on changing environmental conditions and therefore provides plasticity and quick adaptability to these new conditions. In other words, the coupling, the active partnership, the enmeshing and dovetailing of the on-board neural machinery with the external environment not only moulds and shapes our cognitive functions but gets us cognitive results that we wouldn't be able to achieve without this active partnership being realised through the extended reliance on the external structures in the environment. Inner and outer thus work together and in doing so become instrumental for organisms to accomplish biological fitness and their unique nature in the long run. It is therefore out of this multi-layered process of interaction that the abilities of human beings emerge. As Ingold has noticed:

“...There is, in truth, no species-specific, essential form of humanity, no way of saying what an ‘anatomically modern human’ is apart from the manifold ways in which humans actually become. These variations of developmental circumstance, not of genetic inheritance, make us organisms of different kinds”. [Ingold (1995), pp. 207, 212].

Hence, the properties of the on-board neural machinery should neither be privileged nor favoured over non biological ones, because the activities of self-engineering that characterise downstream niche construction by means of trans-generational effects may indeed be driving the process of cognitive assemblage that makes us humans. The

'nature' of an organism is therefore nurtured through the fluid and open-ended unfolding of development that is steered by developmental ontogenetic niche construction. This idea is also present (embryonally at least) in Clifford Geertz's writing and reflected in the following quote, with which I want to conclude the chapter:

"the accepted view that mental functioning is essentially an intracerebral process, which can only be secondarily assisted or amplified by the various artificial devices which that process has enabled man to invent, appears to be quite wrong ... [T]he human brain is fully dependent upon cultural resources for its very operation; and those resources are, consequently, not adjuncts to, but constituents of, mental activity". [Geertz (1962),p.725-730].

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Chapter 4

4.1 Introduction

In the previous chapters I made an argument for EMT and Complementarity on the basis of developmental considerations. I have shown that at least some of our cognitive functions can be sculpted by the environments in which we grow. I have demonstrated that through plasticity humans become geared into working in symbiotic partnership with external resources (such as socio-cultural practises or technological tools) and on these grounds, have called into question any understanding of their nature as fixed and endogenously pre-determined. I have therefore sided with proponents of DST [Oyama (1999); Griffiths & Gray (2001)] and ontogenetic niche construction [West and King (1987); Stotz (2010)] and made a case for cognitive extension and complementarity on the basis of the enmeshing of the organisms and their cognitive developmental niches. In this chapter I take sensory substitution devices (SSDs henceforth) as my empirical case study and discuss them to illustrate and explore the ramifications of Complementarity.

In section 1, I put forward the idea that SSDs are, for visually impaired subjects at least, an example of perceptual enhancement made possible by cortical plasticity and then outline a challenge to this idea. The challenge is that SSDs don't count as real enhancements because the SSD user, through the coupling with the device, is just getting information from the world via a sense she already has. In sections 2 and 3, I lay out two analogous but not homologous versions of this challenge that say that the information the user is processing remains eminently tactile and then critically discuss the arguments offered to support this idea. In section 4, I look at a different challenge. Hurley and Noë agree that SSDs are an example of perceptual enhancement but I disagree with them about the nature of this enhancement. In section 5, I eventually put forward my own view of the form that this enhancement ultimately takes.

4.2 SSDs and Plasticity

Sensory substitution refers to the use of a sensory modality to supply environmental information normally gathered by another sense. SSDs therefore provide through an unusual sensory modality (the substituting modality) access to items of the world that are generally experienced through another sensory modality (the substituted modality). [Bach-y-Rita & Kercel (2003); Auvray & Myin (2009)]. The principles of sensory substitution have been aptly formulated approximately forty years ago by Paul Bach-y-Rita, [Bach-y-Rita et al. (1969)], who conducted experiments with the potential of the skin as a medium for transmitting pictorial material. The goal of Bach-y-Rita's pioneering work was to convey real time images coming from a fixed overhead video camera to the skin of a visually impaired patient, via electro-or vibro-tactile stimulation, in order to allow for spatial navigation. The first systems converted such images onto a 20 by 20 matrix of solenoid vibrators. This rudimentary matrix was embedded on the back of a dentist chair where impaired subjects were seated. These primitive artefacts however presented a series of crucial disadvantages for their users (including lack of mobility and manoeuvrability). In order to overcome these deficits, scientists have since then invested much more efforts in developing devices capable of improving the mobility of the blind and significant achievements have been accomplished. Those rudimentary systems have now been replaced by pieces of contemporary engineering that reflect the more modern advances in technology³⁴. As a consequence, many portable, non-invasive and adaptive

³⁴ Bach-y-Rita's remarkable endeavours have led to the development of two main categories of systems specifically designed to compensate for loss or impaired sensory channel. These are visual-to-tactile substitution devices that convert images into tactile stimuli and visual-to-auditory substitution systems that transform images into sounds. [Auvray & Myin (2009)]. Under the umbrella of tactile substitution fall a large number of different machineries, such as tactile auditory substitution devices [Schurmann et al. (2006)], tactile vestibular substitution features [Tyler et al. (2003)], tactile feedback systems for prosthetic limbs [Rise (1999)], tactile-visual substitution apparatuses [Kaczmarek & Bach-Y-Rita (1995)] and tactile-tactile substitution devices to restore peripheral sensation [Bach-y-Rita (1995)]. The class of visual-to-auditory substitution systems is equally broad as it comprises an equivalent number of conversion features. These include, the vOICe established by Meijer (1992), the PSVA developed by Capelle and his colleagues at UCL [Capelle et al. (1998)], the device known as "SeeHear" chip from Caltech [Nielson et al. (1989)], the prototype designed by Cronly-Dillon and his group [Cronly-Dillon, Persaud, & Blore (2000)], the Vibe developed by Hanneton and his colleagues [Auvray, Hanneton, Lenay, & O'Regan, 2005] and the Kromophone, recently built by Zach Capalbo (2009) at Gordon College, MIT. For a series of old fashioned devices refer to [Goldish & Taylor (1974); Kleiner & Kurzweil (1977); Kay & Kay (1983); Heyes (1984)]. For another cool attempt of substitution the reader might refer to Jack Loomis' work (2001 for instance) and

interfaces have become available and the possibility now exists to offer vision or quasi-visual abilities to impaired individuals by means of either auditory or tactile systems³⁵.

So, sensory substitution devices have been designed to restore or better to compensate, as I shall argue later on, for a loss of a sensory channel by providing impaired patients with an alternative mode of access to the world³⁶. For visually impaired patients SSDs have therefore assumed the form of perceptual enhancements. Visually impaired subjects clearly lack a sense (vision) but once they use the device this can take up some of the slack and their perceptual systems get transformed by the device they are using. In SSD perception in fact the device performs some of the functions of the lost sense partially compensating for the impairment. This seems to constitute, for the visually impaired at least, a form of enhancement and it is the reason why I have chosen to focus on these SSDs to set up my empirical defence of Complementarity.

Can we really consider SSDs as cognitive and perceptual enhancements? Recent work in neuroscience has investigated the extent to which SSDs transform the cerebral architecture of the impaired users shedding more light on the mechanisms that drive this change. *“In the last decades, studies investigating neural processing of blind individuals have shown that sensory loss triggers robust modifications of functioning across entire brain networks”*. [Bubic et al. (2010), p.357]. PET, MEG and fMRI studies have revealed the remarkable plasticity of our brains and led scientists to explore the degree of functional adaptive reorganisation in cortical areas after couplings with these pieces of manmade wetware. Results have highlighted that SSDs effectively exploit the remarkable plasticity of our brains and their capacity to form intermodal connections get factored into the processing of perceptual information. This has been reported to trigger, in impaired users at least, occurrences that are characterised by an interregional correlation

to his project which run from 1985 to 2008 and was concerned with developing and assessing “GPS-based navigation systems for visually impaired people”.

³⁵[Sampaio et al. (2001); Arno et al. (2001); Kupers & Ptito (2004); Ptito et al. (2005); Auvray et al. (2005); Renier & de Volder (2005); Poirier et al. (2006); Chebat et al. (2007); Amedi et al. (2007); Proulx et al. (2008); Merabet et al. (2009); Bird et al. (2009)]. For reviews of current technologies and remaining challenges see, [Merabet et al. (2004); Weiland et al. (2005); Rizzo et al. (2007); Dagnelie (2008); Dowling (2008); Bubic et al. (2010)]. A very interesting question to speculate about is, why aren't these devices doing better? Despite enormous potentialities, the benefits of SSDs for blind people remain largely untapped. [Durette et al. (2008)].

between diverse sensory modalities. [Ptito et al. (2005, 2008); Bubic, Amit & Amedi (2010)]. This phenomenon of interregional correlation is also known as cross-modal plasticity.

Cross-modal plasticity precisely refers to the capacity of reorganisation of some areas of our brain after permanent impairment. The compensatory mechanisms underlying this capacity are in the case of SSDs triggered by the use of the device and this means that SSDs implement the functioning of the internal biological circuitry by becoming integrated and enmeshed into the users' processing of cognitive and perceptual information. [Pascual-Leone (2005)]. A nice study by Ptito and colleagues (2005) has further corroborated this idea by showing that in sensory substitution the tongues can, by virtue of the remarkable plasticity of the brain, be used to act "*as portals to convey somatosensory information to visual cortex*".[Ptito et al. (2005), p.606]. So, via plasticity these devices get integrated into the user's perceptual repertoire and come to work in symbiotic partnership with their internal biological machineries so as to allow blind individuals to undergo some form of experience they would otherwise lack. Cortical plasticity is therefore a precondition for enhancement: without plasticity the user couldn't get the internal working in partnership with the external. It is therefore this plasticity that allows for the integration of bodily and cognitive, of inner and outer. So far so good, many could agree on this. There is another question that needs to be addressed nonetheless.

The studies mentioned above do not yet specify the nature of this enhancement and whether this mode of access is really a new one or not. A sceptical reader might concede that SSDs could be counted, at least in a weak way, as enhancements for the blind users because they effectively enhance their perceptual systems. SSDs get in fact integrated into the perceptual repertoire of visually impaired patients and with training supply a perceptual modality that compensates for loss or impaired sensory channel. Sure, the opponent could contend, SSDs provide such a form of perceptual experience, a channel of information that the user couldn't otherwise access; but the studies you mention don't

³⁶ Note: I am not yet specifying what modality this new modality is. I will address this question in the next sections of this chapter. For an analysis of this point see also [Kiverstein, Farina & Clark (forthcoming)].

yet demonstrate that SSDs bring about a new sensory modality, nor establish the strong form of enhancement that would be expected and required to endorse the empirical defence of complementarity you are after.

So here comes the philosophical challenge. One could concede that SSDs are an example of weak enhancement (analogous to the kind of enhancement the impaired gets when using a cane for instance) but resist the idea that SSD perception brings about something really new. SSD perception, an opponent could say, doesn't count as a form of strong enhancement because SSDs do not bring about a new mode of access to the world, do not transform the users' impaired cognitive abilities and instead just use a pre-existing sense to decode some form of proximal stimulation (either tactile or auditory). SSDs, one could therefore continue, are a case of mere assistance and don't actually count as a case for Complementarity because the blind perceiver is just using the device as she would use the cane. This is probably the right worry to press. This concern is so good that I will pick it up as my challenge in this chapter.

The key-challenge of this chapter will be to show that SSDs constitute a strong case of enhancement and therefore count as shiny examples of cognitive and perceptual transformation. If I can successfully demonstrate that SSDs qualify as strong enhancements and if I can possibly specify the nature of this enhancement then I will have a very bright and strong case for EMT and Complementarity in place. In order to qualify as strong enhancements, SSDs however need to deliver to the visually impaired a new mode of access to the world, something they would otherwise lack if they weren't using the device and were instead relying exclusively on their brains. Do SSDs really provide their impaired users with such a mode? It is here that all the problems begin. As noted above, SSDs can be regarded as mind enhancing tools only if they enhance their users' cognitive functions according to complementarity. If on the contrary SSD perception remains for the visually impaired purely auditory/tactile then these devices would just perform the function of mere tools. In this case the SSD would just end up delivering information about the world via an existing sense and won't be adding anything to the impaired perceiver that she didn't already have.

It seems we face two ways of thinking about SSD perception: 1) SSDs just replace one sense with another; 2) SSDs compensate for the loss of a sensory channel, by providing a form of perceptual supplementation unknown before³⁷. [Lenay (2003)]

Since the appearance of the very first sensory substitution device, neuroscientists and philosophers of the cognitive sciences have debated over the nature of the coupling that characterises SSD perception. If SSDs count as strong enhancements then the challenge is legitimately entailed to raise the question about the mode of access that SSDs give to the perceiver. If these devices are effectively delivering to the visually impaired a new form of perceiving and experiencing, then to which sensory modality does this “acquired perception” belong? Is what we perceive touch? Is it vision? Or is it neither of them but something entirely new?

A solution to these questions hasn’t unfortunately been the most forthcoming. In order to appropriately answer these queries we probably need to know more about the senses, elaborate an account of what constitute a sensory modality, and individuate the sensory modalities at stake when one perceives something. So far, many attempts have been made for providing such an account and although there is a vast number of criteria³⁸ {sensory organ, stimuli and properties, qualitative experience [Grice (1962)], behavioural equivalence [Morgan (1977)], dedication [Keeley (2002)] and sensorimotor equivalence [O’Regan & Noë (2001); Myin & O’Regan (2008)]} that are pertinent for characterising the senses, the notion of sensory modality still remains vague, controversial and in some sense undefined. [Auvray & Myin (2009)]. In this chapter I won’t attempt to taxonomise the senses³⁹ but I shall instead focus on the relevance of some of the criteria mentioned above for SSD perception. In particular, I will now turn my attention to Keeley’s notion of dedication and will therefore discuss a version of the challenge to my thesis that says that SSD perception remains merely tactile.

³⁷ There may also be a third possibility (favoured by Hurley & Noë (2003), Bach-y-Rita (2004) and Heil (1983) that says that the device allows the user to see via touch or hearing. This is not a mere replacement of seeing by hearing but seeing through hearing or touch. I will discuss this possibility in much greater detail in section 4 of this chapter.

³⁸ For a nice review paper on this see also MacPherson (2011).

³⁹ For a series of very interesting works on this issue, the reader might refer to: [Leon (1988); Ross (2001, 2008); Nudds (2004, 2011); Gray (2011); MacPherson (2011); O’Dea (2011); O’Challagan (expected 2012)].

4.3 Keeley's Dedication

In a series of recent papers, Brian Keeley (2002, 2009, manuscript forthcoming) has described the senses as structures that have evolved to detect particular properties in the world. A crucial role on his account is played by the notion of dedication. Dedication is a concept that Keeley borrows from ethology and can be characterised as the “attempts to make philosophically relevant what is biologically important to an organism” [Keeley (2002), p.]. In studying animal behaviour ethologists quite often draw the distinction between “detection” and “reception”. The former describes the capacity to discriminate stimuli behaviourally, whereas the latter accounts for the ability to make such discriminations by virtue of an anatomically dedicated system that has evolved accordingly. In presenting his argument, Keeley compares the capacity of humans to detect weak electric stimuli with that of electric eels. Humans, he says, can successfully distinguish electric stimuli behaviourally (they can, for instance, discriminate fully charged batteries from dead ones simply by sticking them to their tongue). Unlike electric eels, however, humans do not have a wired-up organ dedicated to detect electric fields. The fact, he maintains, that a particular class of individuals (humans in the case of instance) can occasionally respond to a specific class of stimuli (electrical ones) does not necessarily entail the existence in those individuals of a sensory modality for that particular class of stimuli. No one in fact expects to attribute an electrical sensory modality to humans because, as a species, we do not go around measuring with our tongues the electrical properties of the environment.

Humans, Keeley argues, did not get any significant advantage during their evolution from the electrical capacity of their tongues. As a consequence, such a capacity has not fully evolved. Electric eels, on the contrary, have been using their electrical skills to carry out a nocturnal lifestyle, and this capacity has become a determinant for their evolution and survival. [Keeley (2002)]. Now, Keeley thinks that we can generalise the distinction between detection and reception and use it to provide a reasonable account of human's sensory modalities. He believes that possessing an authentic sensory modality involves the acquisition of a genuine, wired-up sense organ that has phylogenetically developed to facilitate survival with respect to an identifiable class of phenomena and for this reason,

when assessing the sensory modality of an organism, he invites us to look at the evolutionary records of its species.

On these grounds, he then goes on to test dedication on SSD perception. He does so by focussing on the tongue display unit (TDU). It seems odd, he notices, to attribute to an impaired SSD user a visual modality. It is odd, he maintains, because when using a TDU, the user can only experience visual detection but not visual reception. It is undoubtedly true that through the coupling the impaired user receives visual information about the world, but she discriminates such stimuli behaviourally, via a tactile capacity. Providing blind individuals with a TDU doesn't therefore suffice to endow them with a sensory modality they did not have before⁴⁰. Even if congenitally blind individuals are endowed with a TDU, Keeley continues, these subjects cannot experience vision because they lack the capacity to see. They don't know what seeing is like; they don't see things and never saw them before. For Keeley the eyes are necessary for seeing and nothing can see that doesn't have a sense that has evolved for detecting properties via light. The coupling with the TDU on his account therefore only allows the agent to jerry-rig "*a sensory system dedicated to the reception of mechanical distortion (his skin) into one capable of providing him with generally reliable information about the electromagnetic spectrum*". [Keeley (2002),p.20]. The TDU, he says, does indeed provide the impaired users with information but only via a dedicated (tactile) channel that has already evolved to detect properties in the world. Since the TDU has not been evolutionarily dedicated to seeing, the "acquired perception" obtained through the coupling with it does not swap from tactile to visual and the device cannot be said to count as a case of strong enhancement.

Keeley's argument looks promising and, prima facie, quite compelling. There are ways to respond however. It occurs to me⁴¹ that his position relies on the sort of nativist understanding of human development that I have been attacking in chapter 3. Keeley is basically saying that we have a fixed sensory nature. He indeed thinks that the kinds of senses we have are fixed in stone, pre-determined at birth and derived phylogenetically. On his account plasticity seems to play a very little role. It in fact seems that Keeley does not recognise plasticity at all, or at least if he does, it seems that he substantially

⁴⁰ The case of SSD is for Keeley analogous to the case of electricity discussed in the previous paragraph.

underestimates the importance of it. In the previous two chapters however, we have seen that our brains are flexible, malleable and highly plastic systems and that they are capable of reorganising and constantly rewiring (no matter the age) so as to accommodate for environmental stimulation. We have also seen that this plasticity of our brains not only contributes to produce the conditions for development but also opens up new possibilities for us as cognisers; redefining the classical notion of human nature. So, given this extraordinary plasticity that characterises our brains and in light of the considerations presented in the previous chapters about cognitive reorganisation and functional restructuring, why should we accept Keeley's deterministic account of the senses? This is a legitimate worry to raise, I guess. There is an empirical case (a sort of twin case for SSDs) that I believe can help us shedding additional light on this point. The case is to do with so-called human echolocators and I believe it nicely undermines Keeley's nativist understanding of the senses⁴².

We all know that many organisms in the animal kingdom (including bats and dolphins) rely on echolocation to get their bearings and to navigate in the world. Less well known is however, that humans can also echolocate. The process is quite simple; the person generates high frequency burst clicks by tickling the palate with the tip of her tongue and then interprets the sound waves that bounce off the objects located in the external environment around her. *“By comparing the outgoing energy with the incoming reflection human echolocators can successfully map the environment surrounding them”*. [Downey, blog post]. With substantial training, blind people can use this ability to do quite impressive stuff. Proficient blind echolocators (such as Daniel Kish) have been reported to use echolocation not only to navigate in the world but also to perform a series of incredible actions (including roller-skating, bicycling, playing futsal, basketball, pillow fights and even video games); all actions that would normally be precluded to other blind individuals.

⁴¹ Thanks to my supervisor Julian Kiverstein for pointing me in this direction.

⁴² Some of the material I use in the next couple of paragraphs is borrowed (but obviously re-worked) from Greg Downey's excellent blog "Neuroanthropology – understanding the encultured brain and body". I thank Prof. Downey for running this site. The reply against Keeley contained in the last part of this section is however entirely original and has not been taken from Downey's website.

Although the case of echolocators is now widely known⁴³ by the public opinion; very little research has been done on human echolocation, and nothing is known about the underlying brain mechanisms that govern it.

A very recent study by Canadian researcher Lore Thaler at the University of Western Ontario has however attempted to bridge this gap and shed some light on this phenomenon. In order to understand the neurological correlates of this quite striking form of human sonar, Thaler and colleagues (2011) have conducted a series of fMRI scanning on the brains of two human echolocators that use click-based echolocation on a daily basis. The study has revealed that echolocation triggers the activation of regions of the brain that are normally devoted to transferring and processing retinal information (such as the calcarine sulcus in the primary visual cortex). This study also showed that blind echolocators can effectively use echolocation in ways that are analogous to vision. Crucially, the capacity to echolocate for seeing can be improved by training. The more experienced the echolocator is, the better she performs and the greater is the cortical activation displayed in area V1. The results obtained in this preliminary study have led the experimenters to conclude that:

*“echolocation enables blind people to do things otherwise thought to be impossible without vision and can provide blind and visually-impaired people with a high degree of independence”*⁴⁴ [Thaler ScienceDaily (May 26, 2011), also cited in the Downey’s blog abovementioned].

What do echolocators tell us about the senses and how can their case help us against Keeley’s nativism? The case of echolocators can help us undermining Keeley’s genecentric account of the senses because it shows us the crucial role played by plasticity in human brains and *“highlights the power of human beings to squeeze perception out of*

⁴³ Daniel Kish also runs a school in California in which he trains other blind people in the use of echolocation and in what he calls "Perceptual Mobility". More information can be found here: <http://www.worldaccessfortheblind.org/>. For a sample of the outstanding ability that these blind echolocators display, please refer to the following video:

http://www.youtube.com/watch?v=vpxEmD0gu0Q&feature=player_embedded (last accessed August 2011)

⁴⁴ Thanks to Greg Downey for posting this on his blog. The full report can be found here: <http://www.sciencedaily.com/releases/2011/05/110525181420.htm> (last accessed August 2011).

a range of different streams of information". [Downey again, blog post]. Basically, the case of echolocators demonstrates that our senses are not fixed in stone and that aptly trained brains can compensate for visual impairment by deploying a series of different perceptual strategies. Crucially, the echolocators also reveal that the organ devoted to seeing must not necessarily be dedicated, as Keeley suggest, nor genetically inherited or evolutionarily developed but can rather be the fruit of mechanisms of ontogenetic perceptual re-adjustments driven by cortical plasticity. Echolocators in fact are usually blind individuals that have either lost sight or had never possessed it before. These individuals however, come to develop a new skill, a skill that changes their brains. This skill endows them with a new perceptual capacity, one that blind non-trained echolocators could not achieve. Crucially, this new perceptual capacity is one that lies dormant in us and it is only disclosed and disinhibited after proper practise. So echolocators capable of recruiting the visual cortex and processing self-generated auditory clicks to do things otherwise thought to be impossible without vision definitely count as a good counter example to Keeley's nativism about the senses. Rather than the eyes in fact these human echolocators use their tongues, which didn't evolve for detecting properties via light, to see. Plasticity and echolocators therefore seems to offer a good ontogenetic way to resist dedication. To the extent that these considerations support the case against dedication they also contribute to undermine the idea that the impaired SSD perceiver can only experience visual detection and not visual reception⁴⁵. (SSDs are in fact just an externalisation of what goes on internally in the echolocators; they are almost a twin case). However, there could still be a way to save the challenge, according to which SSD perception is merely tactile; and this is to say that SSDs just encode spatial contents via cognitive inferences. It is to this version of the challenge that I now turn.

4.4 Cognitive Inference versus Distal Perceptual Awareness

Block and Prinz both accept that the SSD perceiver has experiences with spatial significance but they deny that this spatial significance is visual in character. They both

⁴⁵ Recall the argument Keeley says that because the TDU has not been dedicated to seeing, TDU user can only experience visual detection but not visual reception.

think that the SSD allows the subject to experience stuff in the wider world, but they believe that the experience the device delivers remains tactile in modality. They concede that SSDs encode spatial contents but argue that this only enables us to use some features of the proximal stimulus to make cognitive inferences on the basis of dedicated neural pathways.

In his classical treatment of SSDs, Block (2003) attacks the claim that the phenomenology of TDU is exclusively visual. Findings, he claims, do not provide sufficient evidences to support this hypothesis and reports also sound quite ambiguous and contradictory. To confirm his claim, Block appeals to a study in which Bach-y-Rita himself (1996) reported TDU subjects to experience the image of their percept in space. “*The agent, Bach-y-Rita said, only describes visual means of analysis (e.g. parallax) but not visual phenomenology*” and “*even during task performance with the sensory system, he continued, the subject can perceive purely tactile sensations when asked to concentrate on these sensations*”. [Bach-y-Rita (1996), quote in Bach-y-Rita and Kerzel (2003), p.543]. On these grounds Block has claimed that when perceiving with a TDU the experience that characterises this coupling doesn’t necessarily swap from tactile to visual and has therefore concluded that “*TDU is a case of spatial perception via tactile sensation*”. [(Block (2003),p.286]. In other words, on Block’s account SSDs do encode spatial contents but the experience they enable remains tactile in modality. This is a paradigmatic example of what I have earlier called “replacement”.

In a similar vein, Prinz doubts that TDU users can ever experience anything visual. [Prinz (2006)]. He concedes that once the subjects have mastered the device, they can use the apparatus to avoid obstacles, locate items in the world or adjust their behavioural dispositions accordingly, but he remains sceptical about the possibilities of treating these responses as distinctively visual, for he claims, “*there are conditions under which we can use touch to sense objects that are not in contact with our bodies*. [Prinz (2006), p.4]. Tapping an item with a stick enables us to locate it in the world and permits us to feel its shape and size, driving a car allows us to experience the surface of the asphalt, moving

towards a flame, gives us feedback about our approximate distance from it; yet, the qualities of all these experiences, cannot be said to be visual but rather remain eminently tactile. [Prinz (2006)].

Similar considerations, Prinz continues, apply to the Bach-y-Rita's apparatus. None of the TDU reports seem to unequivocally testify to the emergence of visual experience and none of them actually rules out the possibility of tactile sensations. Prinz therefore argues that there seems to be very little reason to believe that a specific sense can instantiate perceptual states that are qualitatively analogous to those of some another sense simply by delivering the same type of information. [Prinz (2006)]. By using the TDU, Prinz notices, a late blind subject might begin to form or develop a visual imagery of the percept she is currently experiencing and of course the late blind subject can help this process of image reconstruction with the appealing to relevant memories or by relying on associated experiences undertaken in the past (when she had vision). However, this process of visual reconstruction via mental imagery cannot be found in congenitally blind subjects. If a congenitally blind subject testifies to the emergence of visual qualities after wearing the TDU we should be a little suspicious about her report and have little trust of her testimony, simply because the patient has never experienced vision or can discriminate visual experiences as such.⁴⁶ *“My best guess, he concludes, is that prosthetic vision devices simply allow subjects to make automatic inferences about where objects are located in space as a result of tactile information”*. [Prinz (2006), p.5].

In line with Block, Prinz therefore suggests that SSDs at best enable the encoding of spatial contents and that this encoding leads the impaired user to the production of high-level cognitive inferences and associations. These high-level inferences and associations are based uniquely on experienced patterns in the proximal stimulation and are then used by the subjects to perceive the distal environment. Thus, spatial encoding of contents and distal cognitive inferences are, for Block and Prinz, the best an impaired user can get out of the couplings with these devices. In what remains of this section I will try to make the Prinz-Block objection as strong as possible by testing its philosophical accuracy against a

recent study conducted by neuroscientists at Brown University. So, is SSD perception limited to cognitive strategies made on the grounds of proximal stimulation? Siegle and Warren (2010) think not.

In recent study, Siegle and Warren (2010) have argued that distal attribution occurs in sensory substitution and that this is based on distal perceptual awareness rather than on cognitive inferences. Contra Block and Prinz, Siegle and Warren have therefore claimed that “*judgements of target location in sensory substitution are based on an awareness of distal objects, as opposed to cognitive inferences about the environment based on an awareness of proximal variables*”. [Siegle and Warren (2010), p.212]. What empirical evidence can Siegle and Warren provide to support this hypothesis? They appeal to the findings of one of their experiments.

In this experiment Siegle and Warren recruited thirty-one sighted participants. All of them were right-handed and had normal vision. The subjects taking part in this study were blindfolded and subsequently divided into two main groups. The first group was assigned a condition of distal attention (DA), the second was instead given a condition of proximal attention (PA). “*In the distal attention (DA) condition, participants were told to attend to the target and to ignore their arm position when making distance judgments. Conversely, “in the proximal attention (PA) condition, participants were told to attend to their arm position and the tactile vibration and to explicitly triangulate the target location*”. [Siegle and Warren (2010), p.212]. The sensory apparatus used in the experiment was a simple photodiode mounted on the participants’ finger. In using this apparatus, blindfolded subjects had to detect the presence or absence of a target light in a given direction. When the photodiode was successfully pointed at the target, a vibrating motor placed on the back seat of the subject delivered tactile sensations. [Siegle and Warren (2010)].

Siegle and Warren found “*that instructions to attend to distal properties during learning resulted in improved performance and more precise judgments of target distance,*

⁴⁶ This line of argument is quite common in philosophy. Keeley has also embraced analogous considerations

whereas instructions to attend to proximal arm position yielded no improvement in distance judgments". [Siegle and Warren (2010), p.220]. In other words, subjects who were required to attend to the distal targets showed significant amelioration after only a few hours of practice. Those trained to attend to proximal variables instead displayed no considerable progress and their performances were lower-ranked. This suggests, according to the experimenters, that cognitive inferences limit and restrict performances, while perceptual strategies favour them through beneficial ameliorations. This study also testifies to the existence of distal perceptual awareness in sensory substitution and highlights its consistency with perceptual strategies. Overall, these results seem to provide empirical evidence for the claim that distal perceptual awareness can emerge rapidly through the coupling with an SSD and for the idea that while using one of these devices, users are not solely adopting some feature of the proximal stimulus to produce cognitive inferences but are rather deploying perceptual strategies distally. This, according to the experimenters, reveals that distal attribution does not ultimately depend on dedicated neural pathways, but that it rather emerges on appropriate relations between the perceiver's actions and invariant patterns of stimulation. [Siegle and Warren (2010)].

Does this suffice to rule out the Prinz-Block reading of SSD perception? It probably doesn't. The Siegle and Warren response doesn't seem rule out the more conservative reading about SSD perception endorsed by Prinz and Block because both Prinz and Block could still interpret the findings found by Siegle and Warren in terms of automatized inference. Both Prinz and Block could in fact counter appeal to computational theories of perception [David Marr (1982) or Tomaso Poggio (1981)], theories that affirm that perception is always accompanied by some sort of cognitive inference, to demonstrate that these findings just show that the cognitive inference has gone unconscious through practice and that the perceivers just get really good at using sound and touch to perceive things in space. So, Prinz and Block could still say sure there is no inference of the conscious kind going on but there's plenty of non-conscious inference that gets automated when the perceiver gets more skilled. This would be still inference but from tactile sensations!

when arguing against the idea that SSD perception can be visual in modality.

In the absence of empirical evidence that allows disentangling unconscious inferences from direct access, the Prinz and Block understanding of SSD perception looks like a reasonable position to hold, perhaps even more reasonable than the one proposed by Siegle and Warren. Shall we accept the defeat and retreat from the battle? I suggest this might be too hasty. Having presented the challenge in the strongest possible way, I now focus on an alternative approach that provides me with the means to resist this challenge and invites us to think that SSD perception might be vision-like after all. I therefore turn my attention to Hurley and Noë and to the argument they have proposed to endorse the idea that SSD perception constitutes a form of enhancement, whose phenomenology is mainly visual.

4.5 Is it rather Vision?

Hurley and Noë have argued that after substantial training and adaptation the phenomenology of the perception obtained through the coupling with a TDU switches from tactile to visual. Contra Block and Prinz, they have therefore claimed that the similarities between TDU perception and natural vision go far beyond mere localisation or spatial encoding of information and rather extend *to the distinctively visual way in which dynamic sensorimotor interactions with the environment provide information to the TVSS-perceiver*". [Hurley & Noë (2003), p.145]. In what way does TDU perception after adaptation resemble natural vision and in which structural respects is the TDU perception more like vision than touch? In this section, I critically look at the argument that Hurley and Noë have proposed to substantiate this controversial claim. Having shown their argument, I then ask whether Hurley and Noë's sensorimotor theory of the senses really holds up. Despite the points of contact found by Hurley and Noë between vision and SSD perception I make the argument that the differences between them are too great to call SSD perception simply vision. Shall we then fall back on the Prinz-Block position? Certainly not, I argue that the active coupling with the SSD leads the expert user to experience a new quality of perception, a new mode of phenomenal access to the world that is neither exactly tactile nor exclusively visual. I therefore agree with Hurley

and Noë that SSDs count as cases of enhancement but disagree with them about the nature of it.

As I mentioned above, Hurley and Noë have claimed that after successful adaptation the TDU user undergoes an intermodal change in her experience (from tactile to visual). In order to substantiate this claim Hurley and Noë need to demonstrate that: 1) the subject while using the device experiences a visual form of perception or something that resembles vision very closely and 2) that this experience becomes visual in modality because of the user's commitment to learn and connect the inputs she experiences with the motor responses that are characteristic of vision. "*If learning motor responses converts touch into a sense that is qualitatively like vision, then motor responses may be constitutive of sensory qualities*". [Prinz (2006), p.4]. Let me address these two points separately.

Point 1. [(Alleged) Similarities between Natural Vision and TDU Perception]

Hurley and Noë have noticed that both in natural vision and in TDU perception, the user makes perceptual contact with objects at distance and that in neither of these forms of exploration of the world a physical familiarisation with the objects perceived is envisaged or required. Conversely, touch works by establishing the perceptual acquaintance required through direct contact between the object and a specific part of our body. Further similarities emerge, Hurley and Noë continue, when we look at users' reports. TDU users consistently testify, they say, to the emergence of visual effects or of visual illusions after wearing the device. These effects and illusions typically include "*parallax, perspective, looming, zooming and depth effects, and the waterfall illusion*" [Hurley and Noë (2003), p.145; for an extended treatment see also Bach-y-Rita (1995); Bach-y-Rita et al. (1969)]. Furthermore, Hurley and Noë argue, that both natural vision and TDU perception seem to be governed and directed by specific laws of occlusion. "*You see, or TVSS-perceive, objects around you only if they are not blocked from view by other opaque objects*". [Hurley and Noë (2003), p.144]. TDU perception is therefore, on their account, linked to natural vision in manners that are not exclusively captured by its spatial significance. These alleged similarities however are not sufficient to demonstrate

that TDU experience becomes, after training, distinctively visual. In order to establish this claim Hurley and Noë need to show something more. They need to show the role that motor responses play in converting tactile sensations into something that is qualitatively like vision.

Point 2. Inputs and Motor responses: the experience becomes distinctively visual
The distinctively visual character of TDU perception, Hurley and Noë have argued, “*stems from the way perceivers can acquire and use practical knowledge of the common laws of sensorimotor contingency that vision and TDU perception share*” [Hurley and Noë (2003), p.145; O’Regan and Noë (2001a,b); Noë (2002)]. One of the essential components on their account is therefore the concept of qualitative adaptation, which depends on processes of sensorimotor integration and is carried out via a motor element.

In their seminal paper, O’Regan and Noë (2001) have conjectured that proficient users of the TDU are able to individuate and pick up on different patterns of contingencies that hold between the movements they make and what they are able to perceive. [Kiverstein (2007)]. O’Regan and Noë have called these patterns of dependencies “the sensorimotor dynamics” and these are believed to govern TDU perception. To explain the role of these patterns in TDU perception, Hurley and Noë (2003) invite us to imagine a situation in which the perceiver has to move around a given object. As the perceiver moves around the object, they claim, different portions of it become available to the camera and are automatically mapped into tactile sensations. When the perceiver approaches the object, the image related to the mapping expands, as if she were seeing properly. Conversely, when she moves away from the object the size of the related image shrinks. “*Subjects, they argue, cannot become attuned to these rich sensorimotor dynamics if they are not in control of the device*”. [Kiverstein (2007), p.130]. On these grounds, Hurley and Noë go on and claim that: “*what it is like to see is similar to what it is like to perceive by TDU because seeing and TDU-perception are similar ways of exploring the environment: they are governed by similar sensorimotor constraints, draw on similar sensorimotor skills, and are directed toward similar visual properties, including perspectively available occlusion properties such as apparent size and shape*”. [Hurley and Noë

(2003), p. 145]. These similarities, Hurley and Noë conclude, go far beyond the mere spatial encoding of contents and therefore extend to encompass an experience that is visual in character.

The nature of the SSD perception seems on their account to depend on the amount of sensorimotor contingencies that this acquired perception shares with natural vision. Crucially, the more the user masters the device, the more invariants her acquired perception shares with vision. The more invariants the acquired perception shares with natural vision the more it resembles it. [O'Regan, Myin, & Noë (2005)]. The importance of mastering the device to acquire the sensorimotor dependencies necessary to trigger visual skills and to develop visual-like spatial abilities is confirmed by some reports. It is to these reports that Hurley and Noë appeal. "*Very soon after I had learned how to scan, the sensations no longer felt as if they were on my back, and I became less and less aware that vibrating pins were making contact with my skin*". [Guarniero (1974), p. 104 - quoted in Deroy and Auvray (forthcoming), § 2]. Once the subject masters the tool, Hurley and Noë notice, one can for instance move the camera from the hand to a head-mounted display or just reposition the tactile pins from the subject's back to her abdomen or vice versa without any loss in the performance. [White et al. (1970)]. An explanation for this is that "*trained users no longer feel the images on their skin but they acquire a direct perception of distal objects*". [Auvray & Myin (2009), p. 1047; Bach-y-Rita & Kercel (2003)]. Further confirmation for the idea that TDU perception is visual comes from another anecdotal report. Bach-y-Rita and colleagues (1969) recall that during an experiment involving a subject with a matrix of solenoid embedded in his back, Bach-y-Rita caused, without the participant knowing, the camera to zoom abruptly. This triggered a rapid expansion of the size of the related tactile image on the subject's back. As a consequence, "*the participant had a rapid backward movement, as if an object was arriving in front of her*".⁴⁷ [Auvray & Myin (2009), p. 1047; Bach-y-Rita (2002)]. Now, does the Hurley and Noë sensorimotor theory of the senses really hold up? Do the arguments offered and the reports presented suffice to unequivocally establish the claim that SSD perception is visual? Does this really persuade us? There are indeed a number

⁴⁷ For similar experiments see also [Bach-y-Rita (1972, 2004); Hanneton et al. (1999); Lenay et al. (2001)].

of objections that one could move in order to undermine Hurley and Noë's understanding of SSD perception, namely the idea that such a perception is visual. First, one can look at some other empirical evidence. In a nice study Sampaio and colleagues (2001) measured, using a standard Ophthalmological test, the visual acuity of blind subjects perceiving with a TDU. Visual acuity was reported to be pretty poor, circa 40/860. This is indeed good empirical evidence that seems to suggest that TDU perception is substantially different from natural vision. [Sampaio, Maris & Bach-y-Rita (2001)].

But there are also a number of common-sense objections that could be used to mount an attack on Hurley and Noë's understanding. Leon (1988) has for instance argued that saying that the TDU enables sight in blind subjects makes little sense. He claims that this idea: *"is not more persuasive than the suggestion that we would hear sounds and various properties by means of the eyes, simply because we observe an optical transformation of an aural input by using, say, an oscilloscope"* [Leon (1988), p. 252]. Ross has further claimed that the use of a TDU does not qualify as vision because it is not a kind of direct perception. [Ross (2001)]. Additionally, Deroy and Auvray (forthcoming) have noticed that the use of an SSD does not provide its user with characteristically visual sensations, like colours, the feeling of empty space or other modes of phenomenal presence of objects. [Deroy & Auvray (forthcoming), § 1]. These are all crucial and very important differences that seem to make consistent the point that SSD perception cannot be considered analogous to vision. So, there seems to be compelling reasons to say that SSD perception is not entirely visual.

Does this reading automatically favour the alternative claim that SSD perception stays tactile? Not really, in what remains of this chapter I argue, in line with empirical findings, that the coupling with these devices leads the user to experience a new quality of perception. Crucially, this perception possesses both visual and tactile components and can therefore be said to be both seen and heard/felt. If this new mode of access to the world is not only tactile neither exclusively visual, what exactly is it? In the next section I cash out my own view of the form that this enhancement ultimately takes.

4.6 Neither Touch nor Vision but something entirely new: Quasi-vision or Artificial Synaesthesia?

In a recent study Malika Auvray and co-workers at CNRS Paris, gathered a group of normal sighted subjects and blindfolded them for a period of fifteen hours. [Auvray et al. (2007)]. During this period the participants were trained with the vOICe and asked to fill in a feedback questionnaire while using the device. In this questionnaire the experimenters asked the participants to describe the sensory modality involved in their perceiving and what it felt like to perceive with the device. The replies came as very varied and showed that the phenomenology of SSD perception was ultimately task-dependent. Testimonies indicated that *“localization tasks were more likely to be apprehended either as giving rise to visual experiences or as belonging to a new sense...Some participants also mentioned a resemblance with the auditory modality”*. [Auvray & Myin (2009), p. 1048]. Most of the subjects however provided alternative descriptions of their qualitative experience when they were asked to describe what it felt like for recognition tasks. *“One of the participants reported that his experience was felt as visual when he was locating an object in space and as auditory when he was recognizing the shape of the object”*. [Deroy & Auvray (forthcoming), § 5]. Quite surprisingly, nearly all the subjects emphasized the fact that they simply had the feeling of mastering a new tool. While subjects could experience visual-like abilities, the very same people had nevertheless difficulties in developing full-blown visual awareness⁴⁸. As a consequence, the conveyed qualitative experience was not automatically associated to either audition or vision but rather reported to occur as something entirely new, whose nature was essentially task-dependent.

When a subject uses the TDU to perceive, its usage certainly delivers, via vibro-tactile pins placed on the body, a tactile representation of the space surrounding the subject. This tactile sensation persists over time until the subject learns how to decode the stimulus that causes it. After proper training however, the user gradually gains veridical representations of things out there in a three-dimensional space and her perception of

these items changes, leading to a new type of experience. Crucially, as noted in the previous paragraph, this new type of experience doesn't entirely qualify as tactile nor exclusively as visual, but possesses both components.

Maybe we could call this experience quasi-vision? Deroy and Auvray (forthcoming) offer an interesting account of this idea of novel, quasi-visual perception in their new paper. SSD perception, they argue, is neither less than visual nor just pseudo-visual; but it is quasi-visual in the way that goes beyond vision. They say that SSD perception provides a novel mode of experience in the sense that when the device is integrated into the processing of perceptual info, and successfully incorporated into the user's cognitive repertoire; the visually impaired gets a mode of access to the world that depends vertically on pre-existing modes of perception whilst nevertheless counting as something entirely new. This new mode of access therefore emerges from users' pre-existing sensory modalities, and its novelty is determined by the fact that it no longer aligned with them. So SSD perception, according to Deroy and Auvray, stands at a new level above the pre-existing perceptual modalities and its various sensory divisions. [Deroy and Auvray (forthcoming)]. Unfortunately, Deroy and Auvray don't really cash out this idea in more details⁴⁹, but their account of SSD perception seems to be in line with the findings mentioned in the previous paragraph; where remember, we saw that the phenomenology of SSD perception doesn't remain in one modality (either auditory/tactile or visual) but rather switches in accordance to the task given to the subject. However, if the phenomenology of SSD perception doesn't stay in one modality but exploits the pre-existing senses to give us something new, couldn't we just speculate that SSD perception, in giving us something new, blends vision with hearing or touch? As preliminary evidence for this idea, consider the report cited in the previous paragraph in which the subject reported to have both visual and auditory experiences.

⁴⁸ It is important noting here that all the subjects of this experiment were normal sighted and therefore had consistent experience of natural vision in the course of their lives.

⁴⁹ As far as I know they are trying to work out the details of this idea in an another co-authored paper, which however is in its early stages.

But how can we cash out this idea of blending of the senses? In developing an interesting position on the senses which says that there are multiple factors and dimensions we have to take into account in thinking about the nature of them, Fiona MacPherson (2011) has recently noticed that *“if the subjects have experiences with both vision-like and touch-like representational characteristics then perhaps they have a sense that ordinary humans do not”*. [MacPherson (2011), p.139]. One can in fact imagine such experiences, phenomenally at least, *“to be partly like touch, partly like vision and partly distinctive. Thus, MacPherson argues, people who use a TDU device, at least once they have adapted to it, are using a sense partly like vision, partly like touch, and partly unique”*. [MacPherson (2011), p.]. I fundamentally agree with this take and propose to label this new sense as a kind of artificial synaesthesia⁵⁰. I find some empirical confirmation for this speculation in a series of very recent empirical studies conducted by neuroscientists on SSDs. It is to such evidence that I now turn.

Before doing that however, let me spend few words describing the phenomenology of synaesthesia. Synaesthesia is a neurologically-based condition in which stimulation of one sensory or cognitive pathway leads to automatic and unintentional occurrences in a second sensory or cognitive pathway. [Cytowic (2003)]⁵¹. In synaesthesia, *“sensory experiences, such as tastes, or concepts, such as numbers, automatically evoke additional percepts, such as colours”*. [Kadosh & Walsh (2006), R963]. For example, a vision–touch synaesthete can experience the feeling of being touched when seeing other humans being touched as well as a grapheme–colour synaesthete can experience colour when reading a digit or a letter. [Blakemore et al. (2005)]. For this reason, synaesthesia is often described as a merging of the senses, a cross-modal union of different sensory modalities. Multisensory integration isn’t however a peculiarity of synaesthetes; it is something that quite commonly happens in non-synaesthetes as well; especially in the later-occipital-temporal cortex. [see, Beauchamp (2005) for instance].

⁵⁰ I borrow this cool label from Ward and Meijer (2010).

⁵¹ [see also Simner (forthcoming); Kadosh et al. (2009); Cytowic & Egelman (2009); Simner and Ward (2008), Ward (2008); Kadosh & Avishai (2007); Mattingley & Ward (2006); Cytowic (2002); Ramachandran & Hubbard (2001a,b); Harrison & Cohen (1996)].

Now, in the field of sensory substitution there is a lot of neuroscientific evidence that suggests that SSD users experience cross-modal occurrences and multisensory integration after immersive training with these devices. Amedi and co-workers (2007) for instance demonstrate that “*the lateral-occipital-temporal cortex is primarily involved in the integration of visual and tactile information about objects*” and show that long-term vOICE users use their visual cortex to “*recognize objects by extracting shape information from visual-to-auditory sensory substitution soundscapes*”. [Amedi et al. (2007), p.687]. Interestingly, this is reported to trigger cross-modal experiences that go far beyond the usual range of the users’ limited residual vision. In two other studies Kupers and colleagues (2006, 2011) have further addressed this point and favoured an account of cross-modal plasticity in SSD users that involves disinhibition of existing pathways over a view that prescribes cortical reorganisation. A number of other neuroscientists working on synaesthesia (such as Walsh, Henik and Cohen Kadosh) have proposed a similar understanding to comprehend and describe the neurocognitive mechanisms that characterise this phenomenon. In particular, they have suggested that synaesthesia is due to disinhibition [Grossenbacher & Lovelace (2001)] or unmasking [Kadosh & Walsh (2006); Kadosh & Henik (2007)] between or within brain areas.

Now, if cross-modal plasticity and multisensory integration in SSD users are explained in terms of disinhibition and this form of disinhibition or unmasking also characterises the phenomenon of synaesthesia, couldn’t we propose that the same thing happens in SSD users? The new type of perception that SSD users enjoy through cross-modal plasticity would just be a variety of synaesthesia, namely artificially induced synaesthesia. This hypothesis seems to be supported by numerous reports that attest to the emergence of synaesthetic experiences after prolonged use of an SSD. In an interesting study conducted by Jamie Ward and Peter Meijer on long-term SSD users (2010) a patient described his experience as:

“Monochrome artificially induced synaesthesia, only in certain frequencies of sound. A small price to pay for very detailed vision, but the consultant's music next door sets me off as well (Bach Mass in B Minor)... The thing I experience is not in color, is in my mind's eye, and can be very distracting. The shapes are consistent and can be reproduced

by the same sound. It is not triggered by all sounds but by vOICe-like sounds (the program, not people's voices). It is almost as if you had a computer with two monitors running simultaneously different pictures, one was a very grey blurred version of the real world, and the other was a pure grey background with a big semi-circular light grey arc on it, and sometimes you switched your attention between both. The arc picture was triggered by the sound of a police car going by my office.” [Ward & Meijer (2010),p.497-498].

Another long term vOICe user also reported that at the first stages of the coupling she just heard sounds without attributing any meaning to them (as proximal stimulation). [Meijer (1992)]. However, after training, “*she was able to distinguish sounds made by the device from other sounds, and via these sounds she perceived objects as located in a three-dimensional space, thus distally*”. [Fletcher (2002), cited in Auvray et al. (2005), p. 506]. What is particularly striking in these cases is that subjects claim to ‘see sounds’ even when not wearing the device. It looks like their brain has internalized the vOICe rules for mapping between hearing and vision and these rules are deployed both when the device is worn and when it is not by virtue of mental imagery. [Proulx (2010)]. This is a crucial point because it highlights the stability of this synaesthetic experience over time. Stability is a hallmark trait of developmental synaesthesia and therefore this further contributes to confirm the idea that SSD perception might resemble a form of artificial synaesthesia.

So we have seen that some expert users of the vOICe attest to the experience of a synthetic/ artificial synaesthesia – that is, they attest to the capacity to perceive cross-modal auditory evoked visual occurrences and this happens, after consistent training, even when not wearing the device. Although this novel sensorimotor coupling might resemble vision in many ways; the quality of the lived experience that it triggers seems nevertheless quite original and can be compared to the process that accompanies the learning of a new language. Such a process in fact requires new abilities to be mastered, new skills to be evolved, new capabilities to be acquired and eventually, new connections among different sensory organs to be developed.

Thus, SSDs systematically transform the sensory experience of the impaired, by providing a novel perceptual modality that compensates for loss or impaired sensory channel. These devices bring forth novel, hybrid, variant and unfamiliar forms of perceptual sensorimotor interaction with the environment and as Clark has pointed out, they gradually become “*mind enhancing tools*”. [Clark (2003), Menary (2007)]. These mind enhancing tools move the confines of cognition and appear to relocate the bounds of perception as well. As Auvray and Myin have noticed (2009), “*such devices should not be understood as merely external stand-ins for already existing purely internal processes ... but rather taken to transform cognition and perception in a qualitative way*”[Auvray & Myin (2009), p.1051], in a way that would otherwise be precluded to the impaired non-SSD user.

SSDs, via plasticity, thus provide the visually impaired with the means for expanding perception towards new horizons, in ways that would have been impossible without the proper coupling with them. SSD perception isn't therefore a mere substitution but rather an addition, a supplementation or better a complement. The result of this complementation is a biotechnological synthesis that entails the creation of a new space of coupling between a human being and the world. [Lenay et al. (2003)]. SSDs are therefore an example of cognitive and perceptual transformation. Through learning in fact, they get factored and integrated into the impaired user's perceptual processing and therefore become a different but complementary part of the machinery that realises her cognitive capacity.

Now, the reader might disagree with me about the idea of artificial synaesthesia. This is, after all, just an empirically informed speculation and much more work is indeed needed in order to establish the relevant philosophical claim that SSD perception is analogous to a form of artificially induced synaesthesia. In this chapter, I nevertheless hope to have demonstrated that SSDs count as *prima face* cases of strong enhancement at least for the visually impaired, and that as a result they can be taken as strong empirical evidence for Complementarity, regardless of the precise way we cash out the details of the new sensory sensitivity that they enable.

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Chapter 5

5.1 Introduction

In the previous chapter I have made an argument for Complementarity on the basis of SSDs. In this chapter I want to take up the possibility that these mind enhancing tools don't just relocate the boundaries of cognition, but may also stretch the bounds of perceptual awareness. I thus explore the possibility that perceivers, in using SSDs, come to experience forms of extended conscious awareness.

Is the brain the biological substrate of consciousness? In the first section of this chapter I address this question by introducing the so-called neural correlates of consciousness (NCCs henceforth). I show the relevance of the NCCs for any intracranialist⁵², brain-bounded understanding of phenomenal awareness and then quickly look at how various philosophers working on embodied cognition have resisted the idea that the biological machinery of consciousness is located entirely in the head of the individual. The machinery that supports phenomenal awareness, they have argued, isn't just in the head but rather cuts across the brain-body-world division, supervening on the whole embodied subject in dynamic interaction with its milieu. [Hurley (2010, 2007); Noë (2009)].

In section 2, I look at the plasticity of our brain and introduce the distinction between neural dominance and neural deference. I then go on to explain how Hurley and Noë (2003) have used SSDs as an example of deference via external rerouting. The fact that both neural dominance and neural deference occur needs explanation. How can the same neural correlate support different experiences and why do some cases of neural rerouting result in dominance and others result in deference? This looks like a problem for the NCCs.

In section 3, I expand on this point. I outline the so-called Variable Neural Correlates argument and then attempt to answer the questions mentioned above along the lines

⁵² I call Intracranialism or Internalism the view that asserts that the activation of dedicated neural representational systems is metaphysically sufficient to create an experience of a given type. [Kiverstein and Farina (forthcoming)].

proposed by Hurley and Noë. Very roughly, the Variable Neural Correlates argument affirms that the internalist fails to explain why the brain defers in some cases and dominates in others because the argument for NCCs fails to account for the different quality type realised. In order to account for the different quality type realised, Hurley and Noë have claimed, we need an argument for extended phenomenal awareness that focuses on the whole organism in its dynamic interaction with the environment, one that doesn't take the brain in isolation from its extra-neural, bodily and environmental components. In this section I analyse this argument.

Having outlined the Variable Neural Correlates argument I then focus on the criticism that Clark has cast to it. Clark (2009), a leading proponent of extended cognition has famously challenged the idea that the machinery of consciousness can extend beyond the boundaries of the brain and has rather claimed that the biology of phenomenal awareness doesn't allow for a brain, body and world boundary crossing architecture. In section 4, I therefore look at the argument presented by Clark to endorse his intracranialism about consciousness. I embrace Clark's criticism and concede that the variable neural correlates argument can at best establish a stand-off between externalist claims about consciousness and internalist ones.

In section 5, I notice a potential instability in Clark's line of argument. Clark thinks that SSDs support the case for extended cognition, but refuses to count them as examples of extended consciousness. If SSDs count as extending the mind, I argue, then why shouldn't we count them as extending consciousness? Given Clark's commitment to EMT I initially claim that he ought to concede, at least when it comes to SSD experience, that these devices count as cases in which the conscious mind extends. I nevertheless conclude the section and the chapter with an objection that David Chalmers has raised to me in personal communication. This objection overturns my original thought and shows negatively that we can't probably make an argument for extended consciousness, at least based on plasticity and integration.

5.2 The Neural Correlates of Consciousness

The problem of explaining how and why subjective feeling and phenomenal character can arise from physiochemical states and processes in the brain has vexed and intrigued philosophers and neuroscientists for decades; generating a debate that has led to an incredible number of theoretical speculations and empirical studies both in philosophy and in contemporary cognitive neuroscience. Many of these studies have attempted to address the explanatory gap - the question of why brain activity realises experiences with one phenomenal character rather than another - by locating and identifying the so called *neural correlates* of consciousness⁵³. “NCCs are commonly defined as neural representational systems whose activation is sufficient to bring about the occurrence of a specific conscious percept”⁵⁴. [Kiverstein & Farina (forthcoming), §1]. The idea is that the neural activity correlated to the activation of specific cortical areas in a conscious subject is not only necessary, but rather on its own sufficient, to bring about any kind of conscious experience.

Comforted by work in cognitive neuroscience, proponents of NCCs have claimed that the brain is the locus of consciousness par excellence. Some scientists have in fact assumed that for every type of occurrence we experience, there must a locus in the brain such that experience of that type supervenes on neural activity at that locus. Such a locus has been called “the bridge locus”, [Teller and Pugh (1983)] and the neural activity recorded at that locus has been believed to be necessary or at least jointly sufficient to produce experience of the relevant type. Many philosophers have shared the same intuition and thought that the hard problem of consciousness could turn into a scientific problem. Among these philosophers there is certainly Ned Block.

Block (2005a) has explained the idea of an NCC in terms of the minimal supervenience base sufficient to bring about an experience with a given content. In proposing his explanation, he has further distinguished between what he has called core and total

⁵³ For more specific details on this research program, see: [Crick and Koch (1995, 1998); Chalmers (1996, 2000); Metzinger (2000); Koch (2004); Block (2005b); Velmans and Schneider (2007); Bayne (2007); Tononi and Koch (2008); Hohwy (2007; 2010); Kiverstein (2009)].

⁵⁴ Other relevant studies on this topic include [Baars (1998, 2002); Logothetis (1999); Tononi and Edelman (2000); Revonsuo (2000); Kanwisher (2001); Gazzaniga (2004)].

realisers. The core NCC is described as the metaphysically necessary part of a neural representational system that contributes to distinguish one conscious content from another. The total NCC is instead obtained by the sum of the background conditions and the core realiser itself. The total NCC is believed to be – all by itself- sufficient for perceptual experience and it is therefore defined as the metaphysically sufficient condition for consciousness. [Block (2005a,b)]. Given his hard commitment to a purely internalist understanding of phenomenal awareness, Noë has included Block among the leading proponents of what he has called “*the Strong Neural Substrate Thesis*”. [Noë (2007)]. The Strong Neural Substrate Thesis is a view about consciousness that uses the notion of NCCs to support a bounded, intracranial account of phenomenal awareness. Such an account highlights the presence of a strong relation of metaphysical necessitation holding between the core realiser and consciousness itself and predicts that brain activity is both necessary and sufficient for biological sentience. [Koch (2004)]. This account also attempts to address the explanatory gap by adopting an inward focus that aims at crossing that gap by explaining it in terms of the intrinsic properties associated with the neural correlates of consciousness.

In recent years, however, a fast-growing number of critical thinkers working on the field of embodied cognition and several other philosophers quite sympathetic with the extended mind thesis have begun to cast doubt over the validity of this approach. The biological machinery supporting conscious experience, they have argued, cannot be restricted or confined within the skull of the individual cogniser. As a consequence, they have claimed, the brain cannot be said to generate – all by itself – conscious experiences. Among the philosophers who have embraced this position we find Susan Hurley. In a posthumous paper, Susan Hurley (2010) has questioned the idea that the skin and skull of the organism must play a privileged and somehow special role when it comes to explaining the occurrence of phenomenal awareness. She reminds us that: “*brains are in continuous causal interaction with their bodies and their environments*” and so invites us to reflect on the following question: “*why should dynamics distributed within a pre-specified boundary be capable of explaining qualities, while those beyond it are in principle ineligible?*” [Hurley 2010, p. 112].

In a similar vein, Alva Noë (2009) has highlighted the crucial role of the whole organism in an environment in determining the biological substrate of consciousness. Phenomenal awareness, he has claimed, necessitates “*the joint operation of the brain, body and world*”; it is “*an achievement of the whole animal in its environmental context*” [Noë (2009) p.10] and for this reason its correlates must be ecological and not solely neural. There is no magical membrane that retains all distributed phenomenal experiences; rather consciousness is a world-involving dynamic process, an explorative activity steered by implicit knowledge of sensorimotor contingencies linking action with its results in an incessant loop of reciprocal adjustment between the organism and its milieu.

On these grounds, Hurley and Noë have argued that phenomenal awareness supervenes on an entire organism in action and have rejected the idea that fixed neural structures or processes can be entirely responsible for the production of conscious experience. They have therefore called into question the sufficiency (but not the necessity) of the so-called NCCs⁵⁵. Neural activity, they have claimed, is of course both crucial and necessary for the production of consciousness but it does not suffice on its own. It is only when this activity is properly entrenched in the world and rightly coupled to a body that we can experience the kinds of conscious occurrences we normally enjoy. A brain that isn't embodied or entrenched in the natural world in the same way as we are will never be able to experience the same kind of experiences we enjoy. If we are to find explanations for the qualitative character of one's experience we should therefore embrace a broader ecological approach. Rather than searching for a minimal neural correlate of phenomenal awareness we ought to direct our gaze outward to encompass the dynamic relations between brain, body, and world. Proponents of extended consciousness have therefore denied that the minimal supervenience base is entirely neural and that its intrinsic properties are sufficient to produce conscious experience.

The argument they have provided to support this claim has been traditionally included under the umbrella of the so-called Dynamic Sensorimotor Theory of Consciousness (DSM). Hurley and Noë (2003) have argued in favour of this theory partly on the grounds of considerations involving cortical plasticity. Their argument for DSM is known

⁵⁵ An analogous strategy has been undertaken by Thompson and Varela (2001).

as the variable neural correlates argument. I have quickly introduced the ideas underlying this argument in the paragraph above. I will however return to it, in much greater detail, analysing and discussing the crucial tenets of it and its implications for consciousness, in the third section of this chapter. For now, let me just recall the considerations that motivate this argument and focus on how Hurley and Noë have come to formulate it.

5.3 Neural Dominance and Neural Deference

As I mentioned in the previous section, Hurley and Noë turn their attention to cortical plasticity and appeal to it to tackle one of the most puzzling questions related to the hard problem of consciousness – the question of why brain activity realises experiences with one phenomenal character rather than another. Brain plasticity, they claim, is extremely helpful because it shows us biological cases in which we encounter a real contrast in experience. [Kiverstein & Farina (forthcoming)]. But what is the contrast they are talking about? To describe this contrast, Hurley and Noë invite us to distinguish between two cases of plasticity in which the same function seems to be realised in distinct neural circuits. They call these two cases of plasticity, neural dominance and neural deference respectively.

In neural dominance, cortical activity retains its normal qualitative expression despite the nonstandard, abnormal inputs to which it is exposed. In this case, there is a rewiring and the cortical area is activated by unusual inputs, but the neural activity continues to realise experiences of the same type. In neural deference instead, the rewiring is accompanied by a change in experience. Here there is a variation in the neural activity but this variation changes its qualitative expression borrowing its character from the nonstandard input source to which it is exposed. In short, in neural dominance cortical activity preserves its natural expression and its normal qualitative character dominates the nonstandard one. In neural deference instead, the qualitative expression of cortical activity defers to the new input source.

Cortical dominance is nicely illustrated by phantom limb cases in which following amputation of a limb the subject continues to experience limb pain even though no signal

originates from it. Ramachandran and co-workers have speculated that phantom pain is the result of what they have called neural rewiring [Ramachandran and Blakeslee (1998); Ramachandran and Hirstein (1998)]. The patting of a subject's arm triggers the activation of a cortical region that is contiguous to the area that gets activated when someone taps someone else's face. When the subject's arm is amputated however, the cortical region that usually lights up when someone taps someone else's face invades its deprived neighbouring area (the area normally devoted to receive the stimuli from the arm) and takes on its functions. The consequence is that the stroking of the subject's face triggers the activation of the cortical area previously associated with tactile stimulations in the subject's arm. Stroking the face is thus felt and perceived as the stroking of a phantom arm, as well as a stroking of the face [Hurley and Noë (2003)]. The cortex in this case is said to dominate its non-standard inputs. That is, the cortex continues to realise an experience in an arm, even though the arm is no longer there.

Something very similar happens in colored-hearing synaesthesia. In colored-hearing synaesthesia the sound of a word or of a specific letter, triggers the experience of a specific colour. [Hurley (2007); Hurley and Noë (2003); Nunn et al (2002); Ramachandran and Hubbard (2001)]. When synaesthetes listen to spoken words or to specific letters the area V4 usually lights up⁵⁶. [Tootell and Hadjikhani (1998)]. Despite its activation, the area V4 keeps on performing its standard role in processing and realising colour experiences and doesn't defer to new sources of inputs. This, according to Hurley, shows that "*language inputs get routed in synaesthetes not just to their normal destinations but also to this area of visual cortex, where they elicit colour experiences*". [Hurley (2007), p.642]. Once again the normal qualitative character of cortical activity seems to dominate the nonstandard one.

Cortical deference is instead found when blind subjects read Braille. Brain imaging studies in fact reveal the activation of area V1 in the occipital cortex both in congenitally and early blind subjects during Braille reading. [Sadato et al. (1996), (1998); Buchel (1998); Cohen et al. (1997)]. In Braille reading the visual cortex is recruited to process

⁵⁶ V4 is an area of the extra-striate visual cortex that contributes to process colour information. [Zeki (1973)]. V4 is also involved in form recognition and exhibits long-term plasticity.

non-standard inputs. Crucially, these atypical inputs are tactile. In normal sighted subjects, these tactile inputs would have been projected to the somatosensory cortex, but they are now processed by the visual one. In cases of Braille reading, we therefore have an impaired subject, whose visual cortex comes to perform a tactile perceptual function while acquiring a tactile qualitative expression. Thus here we have a case in which V1 is involved in supporting occurrences in different sensory modalities. [Kiverstein & Farina (forthcoming)]. The phenomenology of Braille reading in congenitally and early blind subjects is probably tactile but we certainly have a case in which the visual cortex defers qualitatively to map its nonstandard (abnormal and atypical) tactile inputs. Braille reading is therefore an example of what Hurley and Noë have called “neural rerouting”.

Another example of cortical deference is found in congenitally blind subjects who have undertaken a significant amount of training with a tongue-display unit (TDU) [Bach-y-Rita and Kercel (2003)]. The continuous use of the TDU device activates the visual cortex, at least in congenitally blind subjects. This activation, as we have extensively seen in the previous chapter, in turn induces clear tactile sensations in the blind but not in the sighted subjects. [Kupers and Ptito (2004)]. A rerouting to nonstandard cortical targets takes place in blind subjects and their cortical activity defers to the nonstandard source of input. SSDs are therefore an example of what Hurley and Noë call “external rerouting”. I will return to SSDs explaining, in more details, why they count as an example of deference via external rerouting in the next section of this chapter. For now, I want to establish the idea that there are two cases of plasticity: what we called neural dominance and neural deference.

The fact that both dominance and deference occur needs explanation. These plasticity cases seem to raise a series of crucial concerns for the internalist perspective. How can the same neural correlate support different experiences? That is, why do some cases of neural rerouting result in dominance and others result in deference? In short, why does the brain defer in some cases and dominates in others? And then “*when the brain defers why does the same cortical activity figure in the realisation of experiences of different types?*” [Kiverstein & Farina (forthcoming), § 2]. Here above, we have seen that when the

brain defers we get same neural activity but different type of experience. When it dominates instead, we get the same brain activity and the same type of experience. Answering the question of why the brain defers rather than dominates in some cases will therefore be to answer the question of why neural activity of the same type supports experience with one phenomenal character rather than another⁵⁷. Hurley and Noë claim that the internalist fails to explain why the brain defers in some cases and dominates in others. This is why they think that the internalist cannot explain why experience has one quality rather than another. The internalist fails to explain why brain activity supports experience with one phenomenal character rather than another because the argument for NCCs fails to account for the different quality type realised. But why can't the NCCs explain neural deference and above all, do we have another argument that can give us a better explanation of these two cases of plasticity? Hurley and Noë believe we do.

5.4 The Variable Neural Correlates Argument

On an internalist account of phenomenal awareness the brain is considered as the minimal substrate metaphysically sufficient for the realisation of experiences of a given type. Hurley and Noë however think that it is kind of hard to find conclusive answers to the questions I have raised in the previous section if we stick to the belief that the biological substrate of phenomenal awareness is housed within the head of the organism and confined to the physical boundaries of its brain. They believe that if we want to succeed in explaining the different qualities realised in the experience we need to focus on something else. For this reason, they introduce the idea of the two mappings. There is, they argue, one mapping that correlates the distal stimulation in the environment and the embodied activity of the subject to the sense organ, and there is another mapping that links the changes that take place in the sense receptors of the organ to specific neural activity; this latter leading to the production of the relevant conscious experience. Hurley and Noë argue that the internalist fails to explain the difference in quality type realised because she

⁵⁷ Of course, the internalist could just answer with shrug this question and say: we don't know yet, but one day we might. Such an answer however, would not do justice to the efforts and energy that Hurley and Noë have put to elaborate their case for extended consciousness. So, I think the internalist really needs to answer this objection.

just focuses on the first mapping and on the intrinsic properties associated to the NCCs. In order to bridge the gap and account for the different quality type realised, one instead needs to focus on the second mapping and investigate the changing relations that the embodied perceiver entertains with its own environment. In these changing relations, Hurley and Noë notice, there are often specific patterns and regularities that characterise the subject's interaction with her milieu. Hurley and Noë call these patterns of regularities sensorimotor contingencies [O'Regan & Noë (2001)]. Sensorimotor contingencies are:

“dynamic patterns of interdependence between sensory stimulation and embodied activity. What drives changes in qualitative expression of a given area of cortex....(are) higher-order changes, in relations between mappings from different sources of input to different areas of cortex and from cortex back out to effects on those sources of input, which are in turn fed back to various areas of cortex”. [Hurley & Noë (2003), p.146].

This interaction is partly shaped by the perceiver's movements and partly forged by movements in the environment. Sensorimotor dynamics are thus multimodal and interactive patterns that dynamically link together brain activity with body and world. It is to these patterns of regularities that Hurley and Noë appeal to account for the different quality of experience⁵⁸. [Kiverstein & Farina (forthcoming)]. An example might be helpful to clarify this last bit. The example I mention here is borrowed from Noë's *Action in Perception* (2004). Noë asks us to describe the sensation we experience when sipping a glass of wine. He claims that this sensation can be explained in terms of the agent-environment interaction that takes place in our mouths when the wine rolls across our tongues [Noë (2004), p. 220] The “input”, he claims, is the wine in the mouth of the perceiver, and the “higher-order changes” (as Hurley and Noë have referred to them) are those patterns of interaction that hold between the tongue of the perceiver and the wine that is being sipped. [Kiverstein & Farina (forthcoming)].

⁵⁸ Here it is important noting a potential ambiguity in the way in which Hurley and Noë talk of “sensory input”. The locution “sensory input” can be either used to refer to the proximal changes that take place at the level of the sensory organ or to the distal stimulation that is the source of these changes. In this chapter I take the Dynamic Sensorimotor Theory to refer to the idea that the qualities of one's phenomenal experience depend on patterns in stimulation that emerge through the perceiver's embodied interaction with the environment. [Kiverstein & Farina (forthcoming)]. Some philosophers have investigated this ambiguity even

Now, this idea of two mappings and the appeal to sensorimotor contingencies as a way to connect them seem to provide Hurley and Noë with powerful weapons to fend off their opponents. The focus on the perceiver's embodied interactions with the world and on the higher-order changes that accompany these interactions seems to provide Hurley and Noë with a new set of explanatory tools that allows them to successfully account for the production of conscious experiences. Crucially, this new set of explanatory tools is not available to the intracranialist. It is not available to the intracranialist, because the intracranialist a priori rejects the possibility that the perceiver's embodied interactions with the world can constitute the substrate metaphysically sufficient for conscious experiences. The intracranialist in fact locates the locus of such experiences inside the brain.

But what does this argument tell us about the plasticity cases abovementioned and how does it explain the occurrence of, say, neural deference? In the previous section, I have taken Braille reading and SSDs as examples of neural deference. In agreement with Hurley and Noë (2003), I have taken the former to be an example of neural rerouting and the latter a case of external rerouting. In the last bit of this section, I want to look a bit more closely at SSDs and try to explain how the argument proposed by Hurley and Noë is supposed to account for the kind of deference we find when we use these devices. As one can easily imagine, Hurley and Noë explain the rerouting that occurs in SSDs along the line I have presented above –that is, in terms of the particular way in which a cortical area come to participate in the perceiver's sensorimotor interaction with the environment. Shall we endorse this claim? Let me look at some empirical findings to test this hypothesis.

In a topical study, Ptito & Kupers (2005) recruited a group of early blind patients and trained them up to use a standard TDU. The TDU, as we have seen in the previous chapter, converts visual inputs into tactile stimulation while delivering this stimulation on the tongue of the patient via tactile pins arrays opportunely located. The task in which the participants on the Ptito and Kupers' study were engaged was to determine the

further. For an in-depth treatment of this issue, I invite the reader to look at the nice exchange between Briscoe (2008) and Kiverstein (2010).

orientation in space of a letter (T) presented on a desktop computer. The experiment was conducted on both blind and control subjects, and these were blindfolded. After initial training, the experimenters performed a series of PET scanning on the participants' brains. The experimenters found the activation of "*large areas of occipital (cuneus, inferior, medial and lateral occipital cortex), occipito-parietal and occipito-temporal (fusiform gyrus) cortices*" in blind subjects. No activation of the visual cortex was however recorded in control subjects [Ptito & Kupers (2005), p. 486; Kiverstein & Farina (forthcoming)]. These findings have led Ptito and Kupers to conclude that 1) in blind patients the occipital cortex is recruited for tactile discrimination and 2) that the patients' tongues come to act as portals to visual cortex. [Kiverstein & Farina (forthcoming)].

Now recall the idea of neural deference. Neural deference is a form of plasticity in which a cortical area is activated by abnormal inputs and as a consequence of this activation the cortex realises a new type of experience. While it seems obvious to see that the visual cortex is recruited by abnormal inputs it still remains controversial to determine the type of experience that accompanies the coupling of the blind user with the SSD⁵⁹. For a response to this objection, the reader should refer to chapter 4 of this dissertation. I will just summarise it now. In the previous chapter I have argued that the SSD allows the visually impaired perceiver to develop a new mode of phenomenal access to the world. I have claimed that this new mode of access to the world qualifies as a novel form of perception that depends on other existing mode of experiencing. I have suggestively called this new form of perceiving, artificial synaesthesia. To the extent that the SSD makes available this new mode of perceiving, it therefore also qualifies as a new form of experiencing. SSDs are therefore a case of neural deference "*because tactile inputs are processed by visual cortex to provide the expert users with an experience of a novel type*". [Kiverstein & Farina (forthcoming),§3].

Crucially, the SSD triggers this new mode of access to the world only in skilled and trained users. Only after training in fact, the expert user is able to refer the proximal

⁵⁹ For an in depth treatment of this point, see [Kiverstein, Farina and Clark (forthcoming)].

stimulus to distal objects. That is, she no longer notices the stimulus coming from the device and instead uses these inputs to access and discover objects located in the space surrounding her body. This happens because the user has acquired the sort of familiarity required to deal with the sensorimotor contingencies delivered by the device. Once the user has acquired the capacity to deal with this set of sensorimotor skills, she immediately ceases to feel the proximal stimulation and her attention switches perceptually to the distal causes of it. Qualitative adaptation, Hurley and Noë conclude, thus depends on a process of sensorimotor integration and it is precisely this process that explains the occurrence of neural deference.

“It is...the way in which the neural activity is bound within a larger dynamic of interaction with the distal object – that explains the distinct qualitative character of experience. The intrinsic character of the neural activity itself, or the mapping between the cortical target area and the sources of the afference, does no explanatory work.” [Noë 2007, p. (463)].

We can only explain the qualities of conscious experience if we think of the brain as a part of a brain-body-world system. Conscious experiences are therefore always inevitably tangled in the transactions between animals and the world around them. We can only bridge the explanatory gap between physical goings on and phenomenal awareness by expanding our conception of the minimal substrate so as to encompass embodied action. In short, *“neural activity is always embedded in a sensorimotor dynamic”*. [Noë (2004), p.227].

5.5 Clark’s Intracranialism about Consciousness

In the previous section I have outlined the variable neural correlates argument. In this section I focus on the criticism that Clark has raised against this argument. *Supersizing the Mind* (2008) already contains the seeds of a bounded intracranial account of consciousness. Such an account has been further argued for by Clark in *Spreading the Joy* (2009), where he has doubted that the minimal physical substrate for some forms of conscious experience could include the goings on in the body and the world. Clark has

repeatedly asserted that the vehicles of phenomenal awareness are all in the head and has claimed that arguments for extended cognition do not generalize to support arguments for an extended conscious mind. [Clark (2009)]. In particular he has focused on the variable neural correlates argument⁶⁰ and has attacked it mainly on two grounds. First he has noticed that contents can be used to individuate and categorise different types of experiences. He has then argued that when the dynamic sensorimotor theory of consciousness claims to be able to explain the different quality in experiences, it does nothing but claim its capacity of merely accounting for the contents of these experiences. What the dynamic sensorimotor theory is capable of explaining is therefore just how some kind of cortical activity can realise occurrences with a specific type of content. The sensorimotor theory thus offers us just a method for placing “*various neural states into a content-based equivalence class*” [Clark (2009), p. 971; Kiverstein & Farina (forthcoming)]. Sensorimotor theorists therefore conflate “*a claim about the contents of experience with a claim about the nature of the representational vehicles of experience*”. [Kiverstein & Farina (forthcoming), §4].

On these grounds, Clark has claimed that the dynamic sensorimotor theory of consciousness isn't entitled to hypotheses that the vehicles of conscious experience are constituted by the embodied activity of an organism in dynamic interaction with its environment, at least on the basis of considerations concerned with variable neural correlates. Contents, he contends, are different from vehicles – the bearer of contents. If the argument for the variable neural correlates of consciousness fails to account for the vehicles of consciousness - that is, it only accounts for the contents of the experience, it then follows that such an argument is useless when it comes to arguing for extended consciousness - a view about the vehicles of conscious experience. The argument for the

⁶⁰ Here I focus on the variable neural correlates argument, but Clark has also mounted an attack on what he has called the DEUTS argument for extended consciousness. [Clark (2009)]. The acronym DEUTS stands for Dynamic Entanglement (DE) + Unique Temporal Signature (UTS). The DEUTS argument has been used by proponents of the sensorimotor theory [Cosmelli and Thompson (2011); Noë and Thompson (2004); Thompson and Varela (2001)] to argue for extended consciousness and consists of two different but not separate claims. The first part of the argument (DE) says that brain, body and world are dynamically entangled in such a way that the causal contribution of each cannot be isolated from the causal contributions of the other elements. The second part of the argument (UTS) is instead to do with the idea that neural states must evolve over time in specific ways to support conscious experiences. In this chapter I have chosen not to discuss the

variable neural correlates thus fails to rule out the hypothesis that the supervenience base necessary for the production of conscious experience is biological and pretty much confined within the brain of the individual. It fails to rule out this hypothesis because the variable neural correlates argument doesn't possess any explanatory advantage over the one that endorses the narrow substrate thesis. The variable neural correlates argument doesn't possess any explanatory advantage over the NCCs because one can give other accounts of contents that don't appeal to sensorimotor contingencies.

So, the appealing to extended sensorimotor dynamics, threatens to underestimate the contribution of the standard approach and, correlatively, to overemphasize those of the proposed alternative. [Clark (2009)]. Furthermore, the variable neural correlates argument too quickly dismisses the resource available to the intracranialist. Hurley and Noë have presented the internalist position as if the intracranialist was limited in his explanation of the different quality type realised simply to the NCCs. However, Clark remarks, one can find much more evidence for the internalist understanding if one looks at things more carefully. The intracranialist, he says, is not just keen to correlate, as Hurley and Noë would, particular experiences with some neural activity in the cortex (via NCCs); but she is also quite interested in the relation and the function that specific cortical regions come to perform, in concert with a range of other brain areas, when a number of different individuals execute a task. The internalist, Clark maintains, can therefore still appeal to the many different manners in which NCCs make a given agent functionally poised to do or say certain things. [Kiverstein & Farina (forthcoming)]. This offers her the conceptual link with those theories that think of consciousness in terms of a "global workspace" of information. [Baars (1997)].

According to these theories, neurons group to form coalitions of neurons. [Koch (2004)]. These coalitions or clusters of neurons gradually enter into full competition with each other. This competition is driven by the availability of frontal and sensory areas of our brains. [Baars (1988); Dehaene et al. (2006)]. According to global broadcasting theories of consciousness, the cluster of neurons that wins the competition gets broadcast by

DEUTS because I am more interested in plasticity and integration based arguments for extended consciousness.

those areas and, as a consequence, “*can be consumed by systems that report, reason, evaluate, decide and lay down episodic memories*”. [Kiverstein & Farina (forthcoming)]. In a forthcoming, co-authored paper with Dave Ward and Tom Roberts, Clark has linked the understanding of phenomenal awareness in terms of global broadcasting to his action-space view [Clark (2000)] and has argued that:

“...*what counts for (what both explains and suffices for) visual perceptual experience is an agent’s unmediated knowledge concerning the ways in which she is currently poised (or more accurately, the way she implicitly takes herself to be poised) over an ‘action space’. An action space, in this specific sense, is to be understood...as a matrix of possibilities for pursuing and accomplishing one’s intentional actions, goals and projects.*”
(Ward et al, forthcoming, §5)

Clark therefore thinks that the appealing to global broadcasting of information buys the agents opportunities for action. In particular the information that gets broadcast becomes instrumental for the agent because it can be used to enable her capacity of planning and acting. What really matters for the action-space view are therefore the possibilities for actions not the physical activity deployed to accomplish them. It is thus “*the knowing, not the acting (far less the moving), that bears the explanatory weight*”. [Ward et al. (forthcoming), §5].

Suppose we agree with Clark and implement the action-space view within the internalist understanding of consciousness. At that point, Clark continues, the internalist could fully account for the questions raised by the variable neural correlates argument in terms “*of a theory of contents that tells us how to place patterns of neural activity into content-based equivalence classes*”. [Kiverstein & Farina (forthcoming), §4]. The action-space view would therefore account for the contents of conscious experience in terms of the space of actions that the experience provides. As a consequence the dynamic sensorimotor theory of consciousness would be deprived of its major argument against intracranialism. There wouldn’t be any logical reason in fact to prefer the variable neural correlates argument and its appeal to sensorimotor dynamics to its more conservative

contender, the one that houses the biological substrate sufficient for conscious experience within the cortex of the individual⁶¹.

Clark's criticism is certainly well-grounded. It hits the target and nicely shows that the most the variable neural correlates argument can pretend to establish is just a stand-off between the dynamic sensorimotor theory of consciousness and the intracranialist perspective. These two theories in fact possess compelling arguments to account for the realisation of the different quality in experience and therefore seem to answer (equally well) the concerns I have raised about neural dominance and neural deference. Both also have reasonable explanations for the mechanism that leads to the individuation of the contents of experience. Are we facing a stalemate again? Clark thinks so. He also thinks, however, that the stalemate can be overcome if we look at empirical findings. For this reason he invites us to consider the work of Chris Eliasmith (2008) and Wolf Singer (2001). He says that Eliasmith's and Singer's works can offer us the means to get out of the stalemate and decide the dispute in favour of the intracranialist.

Clark claims, on the basis of the empirical studies abovementioned, that the physical machinery of consciousness requires a high-bandwidth information flow. He believes that the body gets in the way of this kind of high-bandwidth information flow and that it slows down the transfer of information from world to the brain. On these grounds, he then argues that the vehicles of consciousness can't be distributed across the boundaries of brain, body and world; but must rather be located inside the brain because it is only inside the brain that we find the fast temporal binding that is required for the construction of conscious experience. The body, on his account, therefore acts as a low-pass filter⁶²; preventing extra-neural and environmental resources from forming the substrate metaphysically sufficient for conscious experience. In a remote footnote placed toward the end of *Spreading the Joy*, Clark (2009) however acknowledges that this claim, the

⁶¹ So the truth of the action space view would save the internalist. However, the action-space view is not the only resource available to the internalist to rescue his argument. Tillman Vierkant has rightly pointed to me that parallel arguments could also be given for all kinds of internalist views.

⁶² "A low-pass filter is any physical medium that allows low frequency signals through while reducing or blocking higher frequency signals". [Clark (2009), p. 985].

idea that the body acts as a low-pass filter, is historically contingent and only valid for human beings “*circa 2009*”.

It is important to note that in the same footnote, Clark doesn't rule out the possibility that future Brain-Machine Interfaces could change this situation by providing the kind of fast temporal binding that he thinks is required for the production of authentically extended substrates of consciousness⁶³. Clark warns: “*properly ‘jacked-in’ via some future fast, broad-bandwidth interface, we might yet expand the physical substrate of conscious experience itself*”. [Clark (2009), p.987]. He therefore says this could happen, but it hasn't happened yet. So what are the conditions that could make this happen and when would a Brain-Machine Interface support the minimal substrate sufficient for phenomenal awareness? One could say that incorporation is the necessary condition for the emergence of such Brain-Machines Interfaces. When the device is incorporated in fact, it becomes part of the machinery that supports phenomenal awareness and automatically constitutes its supervenience substrate without necessarily allowing for high-bandwidth information flow⁶⁴. In the last section of this chapter I will not look at the argument for incorporation; this will rather be on the focus in the next chapter. I shall however address a related point that is concerned with plasticity and integration.

If Brain-Machines Interfaces can allow for the integration of a tool in a way that supports extended cognition and if Clark himself doesn't rule out the possibility that the same could happen in the case of consciousness, then why can't we presuppose that SSDs provide us with just such a case? In the next section, I come to terms with this question and eventually wrap up the chapter with an objection raised (in private correspondence) by David Chalmers. This objection seems to preclude the possibility mentioned above.

⁶³ This is of course Clark's requirement. One doesn't necessarily need to agree with him. It could be questioned for instance, that consciousness requires (necessarily) high-bandwidth information flow. One could also resist the idea that Brain-Machine Interfaces, *circa 2009*, could not provide such a flow. [Again see Kiverstein & Farina (forthcoming)].

⁶⁴ It may be objected that SSDs are vulnerable to the same concern raised by Clark's bandwidth argument. According to this worry, the interface between the SSD and the user acts as a low-pass filter, excluding the SSD from counting as a part of the machinery that realises consciousness. However, I am not persuaded that the SSD acts as a low-pass filter anymore than I am persuaded that the eyes and ears do. Thus, I am not completely convinced that the bandwidth argument has the force Clark takes it to have. Proper discussion of this issue must however be conducted elsewhere. [Kiverstein and Farina (forthcoming)].

5.6 Extended Cognition but (*probably*) not Extended Consciousness?

Clark (2003) has consistently claimed that SSDs are excellent examples of brain-machine interfaces. These interfaces, he has argued, cause in the aptly trained perceiver an “*extended or enhanced agent confronting the wider world*” [Clark (2008), p. 31]. SSDs, on his account, count as a case of extended cognition because their use brings about, via incorporation, the mastery of novel abilities and consistently enhances the user’s cognitive and behavioural skills. Clark has famously claimed that SSDs should not be regarded, as external stand-ins for already existing intracranial processes [Clark (2003)], but must be rather taken as providing the means of expanding cognition towards new horizons, in ways that couldn’t be experienced without them. [Auvray and Myin (2009)]. In sum, Clark has asserted that the kind of cognition that is triggered by SSDs cannot be reduced to something already available in the brain before their use. He has called these interfaces “mind enhancing tools”, [Clark (2003)] and has used them as a central case in arguing for extended cognition [see Clark (2007), (2008), pp. 35-7 for instance]. In *Spreading the Joy*, as we have seen above, Clark has however claimed that a rejection of the thesis of neural sufficiency for consciousness cannot be justified on the basis of current SSD evidence but has not ruled out the possibility that SSDs or any other Brain-Machine Interface could, in the future, provide the high bandwidth information flow that he believes is required for the production of conscious experiences. So, here comes the question: if SSDs or any other Brain-Machine Interface can support extended cognition via incorporation and if Clark himself allows the same could happen in the future for consciousness, then why can’t we say that SSDs provide us with just such a case? The interface in the case of the TDU is the metal plate delivering the tactile information to the tongue of the subject. In the vOICE the interfaces are instead the earbuds that the skilled user utilises to decode auditory stimulation. In both cases these interfaces, at least in the well-trained user, progressively fade from awareness in a way that suggests that the device has been fully incorporated into the subject’s perceptual repertoire. If SSDs fade from awareness and get factored into the subject’s perceptual repertoire, couldn’t we then count them as cases in which the external device forms part of the supervenience

substrate sufficient for consciousness? Wouldn't this be sufficient for the high-bandwidth information flow required by Clark?

Clark will say no, for the reasons mentioned above. Now, a potentially fruitful response to his understanding of consciousness could be one that emphasizes the idea of Complementarity and is grounded on both plasticity and integration. Now recall, Complementarity is the idea that the differences between internal and external allow for the environment to play a transformative role in cognition. Plasticity, as we have extensively seen in the previous chapters, is to do with the capacity of the brain to rewire and reconfigure itself according to specific environmental stimulation. Integration is what one gets as a result of cortical plasticity when the brain develops to rely on the presence of some external resource (such as SSDs) in its processing.

Now, SSD perception counts as a case of extended cognition because through plasticity the brain comes to work in symbiotic partnership with the technology⁶⁵. SSDs exploit the remarkable opportunism afforded by neural plasticity to get factored into the processing of perceptual information and become incorporated into the cognitive routine of the user in a way that extends her mind. SSD perception also counts a case of Complementarity, at least for the visually impaired, because it allows the user to accomplish something she couldn't accomplish without the device. When the device is finely integrated into neural processing in such a way that internal processing relies on the device to accomplish something it couldn't accomplish without it, the device comes to support the machinery that realises the cognitive process and allows for a brain, body and world crossing architecture. Additionally, when the perceiver successfully masters the sensorimotor dependencies produced by the SSD, her sense of what she can and cannot do in the world changes. After the perceiver has familiarised with the effects of movement on sensory input from the device, she can recognise the shape of objects, avoid obstacles, she can read, catch a ball thrown in her direction, she localise items in the external world and progressively gain the ability to attribute the proximal stimulation the device is causing to the distal causes of it. [Kiverstein & Farina (forthcoming)]. So training with the device

⁶⁵ This point will be on focus in the next chapter of this dissertation.

causes the subject to experience new action possibilities and give her new knowledge of what she can do with her body. Thus, when properly deployed the SSD seems to become a part of a larger system. This larger system also allows the subjects to achieve something they couldn't achieve on their own. This in turn suggests that SSDs support embodied and skilful behaviour in the world. Rather than being low-pass filters, SSDs therefore appear to favour skilful cognitive practises and integration of different perceptual strategies via some sort of high-bandwidth information mechanism that flows through the body into the device. Does this suffice to say that SSDs become a part of the substrate of consciousness? In other words, can SSDs count as a case of extended consciousness?

David Chalmers thinks not. He has objected to me (in private correspondence) that SSDs don't count as a case of extended consciousness because the SSD is performing the same function as the eye. The eye, he has claimed, is a perceptual mechanism but isn't usually thought of as part of the neural correlate of perceptual experience. Since we don't normally count the retina as a part of the supervenience base of consciousness, why should we count the SSD as part of the substrate of phenomenal awareness? In other words, if SSDs are just substituting for the eye why should we think of them as constitutive of conscious experiences⁶⁶?

Now, this is I reckon a very good objection. I could try to respond to this objection by showing that SSDs don't act as a low-pass filter any more than the eyes or ears do, but I want to play this chapter safely. I therefore bite the bullet and stop the discussion here⁶⁷. Despite Chalmers' criticism this chapter has not been wasted because I have negatively shown that we probably don't get an argument for extended consciousness on the basis of plasticity and integration. It has therefore been very useful as an attempt to see how far my ideas can be potentially pushed.

⁶⁶ Despite Chalmers rejecting the idea that SSDs count as cases of extended consciousness; he agrees with me on the point that they can still extend perception and cognition. Chalmers therefore thinks that SSDs can still count as a part of the supervenience base for unconscious perception because of parity type considerations.

⁶⁷ I have however provided a response to Chalmers' objection in a co-authored paper with my supervisor Julian Kiverstein. The paper is forthcoming in F. Paglieri (Ed.), *"Consciousness in interaction: the role of the natural and social context in shaping consciousness"*. Amsterdam: John Benjamins.

Before I conclude this chapter however, let me notice that the Chalmers objection is analogous to the causal/constitutional conflation quite often levelled against extended cognition, except that in this case it is directed to extended consciousness. This objection is therefore similar to the worry that Rupert raises against incorporation. Rather than tackle the question of whether incorporation really buys me extended consciousness, I am now going to look at attempts to argue that incorporation is not sufficient even for extended cognition. So, in the next chapter I address Rupert's criticism and go on to discuss the less bold claim of whether incorporation really establishes EMT.

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Chapter 6

6.1 Introduction

In the previous chapter I explored the possibility that SSDs don't just relocate the boundaries of cognition, but may also stretch the bounds of perceptual awareness. I have initially claimed that SSDs count as cases in which the conscious mind extends but have concluded that we can't probably make a knockdown argument against intracranialist accounts of phenomenal awareness on the basis of them. Rather than tackling the question of whether incorporation buys me extended consciousness, in this chapter I am going to be looking at attempts that argue that incorporation is not sufficient even for extended cognition. So, here I basically address Rupert's criticism of incorporation and go on to discuss the less audacious claim of whether it really buys me EMT. The goal of this chapter is therefore to make an argument for Extended Cognition and Complementarity by further emphasising the role played by man-made artefacts in cognitive extension.

In section 1, I introduce the notion of cognitive dovetailing and show how the idea of incorporation has been used to argue for extended cognition [Clark (2003, 2007, 2008)]. Having introduced the idea of cognitive incorporation, I then focus on a series of topical studies involving the plasticity of the body schema⁶⁸. I investigate the phenomenon of recalibration of the peripersonal space and turn my attention to the so-called bimodal neurons. I suggest that these neurons become the keystone to make a real (both philosophically dense and scientifically robust) distinction between true incorporation and mere tool usage.

In section 2, I discuss Rupert's caveats about incorporation and analyse the responses he runs to undermine EMT. [Rupert (2009)]. In essence, Rupert doesn't buy the inference from incorporation to extended cognition made by proponents of EMT because he doesn't accord to our phenomenology much weight in deciding questions about what

⁶⁸ [Iriki et al. (1996); Obayashi et al. (2000; 2001); Ishibashi (2002a,b); Iriki and Maravita (2004), Maravita, Spence and Driver (2003), Maravita et al. (2002)]

cognitive processing goes on. Since our phenomenology has been systematically unreliable about this in the past, he claims, it is simply not up to phenomenology to decide this issue. And even if we take phenomenology to explain the sense of an extended body, he continues, phenomenology at best just shows us the privilege of organismically located phenomenal experiences thereby supporting the embedded view and its attribution of a privileged role for the organism in cognition.

In section 3, I run my replies to Rupert. Contra Rupert's idea that the intention to reach a rake can still be interpreted in terms of the causal interrelations between the rake and the arm, I propose an argument for transparency that embraces sensory substitution and is based on the distinction between active and passive use. I argue that only active and expert SSD users can experience, through coupling with the device, cross-modal occurrences that compensate for the sensory loss; whereas inactive or naive users fail to do so because they just get stimulation from the device but no cross-modal mapping. I suggest that it is only in active users that the enmeshing between the agent and the device is fully realised and therefore argue that it is only in cases of active use that the tool becomes geared, factored and incorporated into the agent's body schema so that both of them (the agent and the tool) come to work together as an entangled and transparent system of cognitive analysis.

This argument works quite nicely against the first objection that Rupert has raised to counter the idea of incorporation. But it leaves me potentially vulnerable to the second objection that he has moved against the idea of transparency. In responding to my argument, Rupert could in fact still appeal to the emulator theory to reintroduce the interface between the user and the tool and to demonstrate that an embedded understanding of the situation is not only possible but also more feasible. To block his move, I look at what happens when a tool user gets prediction of the kind required for emulation and put forward an empirical hypothesis that suggests that when the brain comes to predict the sensory consequences of movements performed while using a tool, it includes the tool in the model of the body it uses to guide action. In essence, I claim that when the brain is able to predict the consequences of using the tool, it automatically

starts treating the tool as if it were a part of his body. So, contra Rupert, I argue that prediction doesn't so much reintroduce an interface as show how the interface fades away and progressively disappears. The virtues of this second argument against Rupert are therefore twofold. 1) My argument doesn't appeal to subjective and quite controversial phenomenological reports; 2) it seems to offer the conceptual palette necessary to overturn Rupert's counter argument by embracing the same perspective he also endorses.

6.2 Incorporation and the Extended Mind Thesis

Bernard Stiegler has noticed that “*we are now in the midst of a revolution in cultural and cognitive technologies, and in the very foundations of knowledge*”. [Stiegler (2010), p.13]. In his *Technics and Time 1: The Fault of Epimetheus* (1998) he has offered a very original analysis of the relation between humans, technology and time. Drawing on works in various disciplines (ranging from evolutionary biology to palaeoanthropology and continental philosophy) Stiegler has suggested a description of human life as “epiphylogenetic”. He has used this term to describe the consistent reliance of human beings on prosthetic supplementation and has argued that humans are ‘essentially in default’, always in need and ready to promiscuously couple with technical prostheses in order to prosper and survive⁶⁹. Now, prosthetics is a word of Latin origin and denotes addition or better extension. The Oxford English Dictionary defines “prosthetics” as “*the branch of surgery concerned with the replacement of defective or absent parts of the body by artificial substitutes*”. In this section I will examine “prosthetics” in reference to the potential extension of the body by means of artificial resources. I will argue that the coupling with appropriate interfaces maximally emphasises the role of human beings in creating whole *new agent-world circuits*; dynamical ensembles within which augmented agents can emerge. Andy Clark (2008) has discussed a series of cases that

⁶⁹ A similar understanding has been endorsed by Merlin Donald (2000). In his brilliant essay, “*The central role of culture in cognitive evolution: A reflection on the myth of the Isolated mind*”, Donald describes humans as peripatetic self-assemblers of minds. Andy Clark (2003), Norman Donald (1993, 2010) and David de Leon (2003) have also favoured analogous positions. For some criticism and for an understanding that praises the virtues of the embedded view, the reader might instead refer to Jaron Lanier (2010).

nicely show this idea of *new systemic wholes* [Varela, Thompson & Rosh (1991)] achieved via incorporation. It is to such cases that I now quickly turn.

The Cypriot-Australian artist Stelarc has dedicated his art to transforming his biological body. The mission of his pioneering activity is to demonstrate that the body, at least in the way it has been traditionally conceived, is obsolete. The aim of his artistic performances is therefore to offer a new framework within one can reconceptualise the very notion of human being. This is why in his performances Stelarc often integrates pieces of robotics and modern technology in his own body. The most famous among these integrations is probably the so-called “third hand”. The “third hand” is a mechanical actuator that Stelarc occasionally attaches to his right arm. This mechanical actuator is normally used to perform routine functions (such as writing, grasping/releasing objects and so on). Stelarc controls this actuator through a series of electrodes placed on strategic muscles on his legs and abdomen. By commanding these muscles with his brain, he then reports achieving complete mastery over the device. It is worth noting here that the muscle sites Stelarc uses to control the device are not normally activated for hand control. This allows him to move his “third hand” quite independently of the other two. Although the device is not worn all the time, Stelarc reports that after years of practise he no longer feels the actuator as an appended prosthesis but rather perceives it as a genuine bodily extension⁷⁰. Stelarc is in fact fully “*able to operate the third hand intuitively and immediately, without effort and not needing to consciously focus*”. [Clark (2003), p.116]. In other words, the “third hand” has become so finely tuned so deeply and fluently integrated into his own body that it now functions pretty much like his real biological hands function.

This case is quite striking, I believe, as it nicely reveals that human agents have the special capacity to plastically re-negotiate their bodies so as to incorporate always new structures into their own cognitive and perceptual repertoire. The third hand deployed by

⁷⁰ Following Heidegger (1927) and his notion of ready-to-hand, I use the expression “transparent equipment” to describe an “*equipment through which the subject can act on the world without first willing an act on anything else*”. [Clark (2008), p.102].

Stelarc surely constitutes a case of successful incorporation but there are also other cases that deserve careful attention.

Another striking example of incorporation involves the U.S. Navy innovation known as the tactile flight suit. The flight suit (a sort of vest) is mostly worn by inexperienced craft pilots in training. The vest can nevertheless be worn by expert pilots and in their case it allows them to perform more difficult tasks with ease. The suit works by producing specific bodily sensations on the skin of the wearer. More precisely, it generates puffs of air when the helicopter tilts on one side. With training, the pilot gradually learns to interpret these puffs of air as indicating that the craft has just tilted. Expert military pilots get so skilled at interpreting stimuli originating from the suit that they can even use it while blindfolded. [Clark (2008)].

Similar work on tactile substitution has been undertaken on space suit gloves. NASA engineers have realised a series of robots that can perform tasks in space under the direct control of an astronaut in a spacecraft. This control is achieved through a master-slave relation called teleoperation. In short, the astronaut places his hands in controlling gloves situated inside the spacecraft and uses these particular gloves to move and perform specific actions. His actions are then transmitted to the robot, so that when the astronaut moves, the robot follows his commands. This system is called telepresence. It is worth noting that telepresence let the astronauts also experience, via proprioception, the same mechanical resistance that the robot encounters in the exploration of its space [Bach-y-Rita et al. (1987)] and therefore seems to produce a strong and profound coupling between the user and the tool. While telepresence was originally designed to assist astronauts' duties in space, it has nowadays found important applications also in hospitals (robots for clinical surgery) or on the battlefield (bomb-defusing robots).

At this point, a question naturally arises concerning the nature of the relationship between humans and all these tools. How should we think of such cases? It seems that both the craft and the robot act as bodily extensions for their commanders. Both the suit and the glove in fact swiftly and deeply link the pilot and the astronaut to their "tools". The suit and the glove therefore appear to act as sensory interfaces, establishing a direct

communication pathway between the brain and the external device. This direct, high bandwidth communication pathway is aimed at assisting and augmenting the pilot/astronaut's cognitive and sensory-motor functions by smoothly linking her movements to the external tools. This profound coupling, this persisting dovetailing with these interfaces allows both the pilot and the astronaut to develop a kind of close-loop interaction analogous to the one that characterises Stelarc's relationship with his "third hand".

Now, Clark and many other proponents of EMT believe that this persistent dovetailing leads to forms of progressive dovetailing that produce reconfigured bio-technological platforms. They produce these reconfigured bio-technological platforms, they say, because humans "*are biologically designed to fluidly incorporate new bodily and sensory kit*". [Clark (2007),p.270]. These brand new bio-technological ensembles, they continue, are nevertheless achieved only in a context of goal driven activity and motor engagements. This plastic and dynamic understanding of the relationship between the user and the tool would indeed favour an image of the agent as embodied and extended. It is therefore no surprise that proponents of EMT describe this interaction as a case of real cognitive and perceptual extension; extension that occurs because our bodies not only renegotiate their boundaries but come to incorporate external factors via cortical plasticity⁷¹. Is this really sufficient for real cognitive extension? And above all does this process entail extended cognition? There is not wide agreement on this point.

A sceptical reader, one who opposes EMT, might well raise the following worry. We can become expert, he could say, at using a third hand, a suit or a space glove. We could proficiently deploy them in ways that credibly involve a dense sub-personal coupling, and this could even yield transparency in use⁷². Yet, he could claim, we wouldn't necessarily

⁷¹ Let me stress the connection between this argument and the argument I have made for EMT based on plasticity earlier on in this dissertation. In the second chapter of this thesis I have argued that it is the enmeshing, the dovetailing, the symbiotic partnership between inner and outer that sculpts, moulds, and forges (via repeated engagements) many of our cognitive functions and have shown that plasticity is the pre-condition that triggers this process. Since plasticity also plays a crucial role in the argument from incorporation, any challenge to this argument would also count as a challenge to me.

⁷² Let me just say a bit more about this notion of transparency. The idea is that the tool becomes transparent when it is no longer noticed but instead is absorbed in whatever task we are using it to perform. In other

feel the third hand, the suit or the space glove as genuine parts of our body. Yes, he could concede, we could be proficient users of many different tools, and these tools could certainly become transparent in use. This wouldn't however entail the feeling of a lost capacity when one of the tools we have been so expertly using is not available or in use. In other words, the sceptical reader might still press the following concern: why should we talk here of new system wholes, of reconfigured bio-technological platforms and of cognitive extensions, when we can still explain the relationship between the human and the device in terms of a user in command of a detached tool? Aren't all these cases just cases in which the same old mind causally exploits a shiny new tool? Why should we think of human minds as genuinely extended or augmented by socio-cultural or technological tweaks? This is certainly a legitimate worry, perhaps the right one to press. There are ways to respond however. A close look at the impressive body of research on tool use by primates conducted within the last decade by Italian and Japanese neuroscientists shall help us addressing this pressing concern.

Recent studies in neuroscience have reported the discovery, in primate brains, of a class of very specific neurons, the so-called bimodal neurons. Maravita and Iriki (2004) describe these neurons as “*pre-motor, parietal and putaminal neurons that respond both to somatosensory information from a given region and to visual information from the space*”. [Maravita and Iriki (2004), p.79]. The discovery of these neurons is ascribable to Iriki and colleagues. [Iriki et al., (1996)]. In studies conducted on Japanese macaques during the '90s, Iriki and co-workers demonstrated that the visual receptive fields of bimodal neurons in the intraparietal sulcus can expand along the axis of a rake immediately after the rake is deployed to retrieve food pellets presented by the experimenters beyond the animal's reaching space. [Bonifazi et al. (2007), Farnè et al. (2007)]. In conducting this study, Iriki and colleagues also noticed that the expansion of the visual receptive field occurred after only few minutes of practise and relatively short time of training. Furthermore, this expansion was reported to visually incorporate the

words, it is only when the external prop is no longer felt as an appended prosthesis that it becomes geared to work in partnership with its user. This way, the tool's boundaries progressively fade away, the device becomes less obtrusive and the user feels increasingly at one with the tool so that attention can be taken up entirely with the task at hand. In short, transparency seems to occur when the equipment we use becomes like our own bodies, something we don't normally notice in acting.

tool into the peri-hand space of the macaque. Additionally, the extension of the visual receptive field in macaque was temporary and contingent. It in fact contracted back to the pre-tool-use size shortly after rest activity or passive holding. These findings have led scientists to conclude that the expansion of the visual receptive field in the macaques is strongly dependent on the intentional and purposeful use of the rake to reach remote objects.

Analogous results have also been observed in humans. Studies in humans have in fact revealed that in patients affected by unilateral neglect, the use of a rake or of a stick as a tool for reaching actually extends the area of visual neglect so as to embrace the space accessible through the joint coupling with the device. [Clark (2007)]. These findings on humans have led Berti and Frassinetti (2000) to claim that: “*the brain makes a distinction between far space (the space beyond reaching distance) and near space (the space within reaching distance)*” and that... “*simply holding a stick causes a remapping of far space to near space*. On these grounds, Berti and Frassinetti have concluded that “*the brain, at least for some purposes, treats the stick as though it were a part of the body*”. [Berti and Frassinetti (2000), p. 415].

Makin and colleagues (2007) have reported evidence for a representation of the peri-personal space in humans by using fMRI in healthy participants. [Brozzoli et al. (2011)]. Farnè and Ladavas (2000) have also investigated “*how information about the position of a target object perceived through the senses is converted into motor commands*” [Schicke (2007), p.3616] and demonstrated that visuo-tactile extinction in impaired subjects extends to the space around the axis of the rake after the rake has been used by the patient to retrieve tokens dispensed in far distance. [Serino (2006); Serino et al. (2007)]. The variability of the spatial boundary near human peri-personal space has been further highlighted by other topical studies that establish the possibility of modifying peri-personal space by means of different kinds of tool-related experiences [Ladavas (2002); Ladavas & Farnè (2004); Farnè et al. (2005)]. These studies have replicated the results obtained by Iriki and provided further evidence for the idea of plastic reorganisation of body-schema demonstrating that these recalibrations are not only possible but are actually

highly flexible and experience-dependent. [Ladavas & Serino (2010)]. In particular, Farnè and colleagues (2005) have demonstrated that the multisensory peri-hand area “*can be extended differentially by using tools of different length, and that the external border of the area elongated through the use of tools is not sharply limited to the tool tip, but extends (fading) beyond it*”. [Farnè et al. (2005), p.245]. In line with these findings, Holmes, Calvert and Spence (2004) have also found that “*when the tool-use task requires using the shafts or the tips of the tools, visuotactile interactions are stronger at the tips of the tools than in the middle of the shaft. When the handles of the tools are used, however, visuotactile interactions are strongest near the hands and decreased with distance along the tools*”. [Holmes, Calvert and Spence (2004), p.62].

More recent evidence reported by Farnè et al. (2007) has also revealed the existence of cross-modal extinction caused by visual stimulation and has further corroborated the idea that genuine extension of the peri-hand space and successive incorporation of the tool used occurs after active manipulation. All these findings therefore seem to support the idea that in human beings reorganisation of the peri-hand space and subsequent tool incorporation happens⁷³, in a context of motor engagements, through progressive elongation of the visuo–tactile peri-hand space. This has lead researchers to conclude that “*the active use of a tool to physically and effectively interact with objects in the distant space appears to produce a spatial extension of the multisensory peri-hand space that encompasses the whole length of the tool*”. [Farnè et al. (2007), p.440]. Where do all these findings leave us and what is the significance of all these studies for phenomenology and the cognitive sciences?

All these works, I believe, have a profound impact on the way we think of both the space around us and of our relationships with the tools we use to test and explore our

⁷³ Here I should probably be more careful and try to disentangle these two points more clearly. Here is a quick attempt. Reorganisation of peri-personal space and tool incorporation aren't necessarily the same thing. The former is to do with the egocentric content of perception: what is reachable for us and what is our perception of the space. This seems to be about the world. The latter is instead about the representation of the body - and so is about the self. For an in-depth analysis of this distinction, the reader might refer to de Preester (in press) and De Preester & Tsakiris (2009).

environments. These studies in fact suggest that tool-use does not simply extend peripersonal space, but rather “*that the tips of tools actively manipulated in extrapersonal space can be incorporated into the brain's visuotactile representations of the body*”. [Holmes, Calvert and Spence (2004), p.62]. Additionally, these results seem also to confirm that once the perceiver has learned the sensory consequences of carrying out a specific motor action, the on-board neural machinery starts treating these external tools as transparent equipment, real parts of its body. The perceiver’s body schema – “*the neural model of the body that represents the position and configuration of the body in space*” [Kiverstein and Farina (forthcoming), §5] – is thus reconfigured so as to comprise the external tool. It would therefore seem that these plastic neural changes that occur in the brain after tool-use can be used to formulate a scientifically informed and philosophically productive definition of the notion of incorporation. Clark (2008) indeed uses some of these findings to account for cases of reconfiguration and of brain, body, world crossing architecture.

On Clark’s account, this plasticity of the body-schema yields effective incorporation. Incorporation, he however notices, can only occur within a dynamical context of motor engagements and goal-driven activity. The context has to be one in which the perceiver first represents the tool and its properties and then models the situation presented by forming a plan of action in which the tool is successfully utilised. Only in such a context can the perceiver eventually specify a detailed set of instructions to the body about how to carry out the plan. [Kiverstein and Farina (forthcoming)]. Clark argues that this complex strategy triggers the process that leads to the recalibration of the body-schema and that this reflects “*new bodily and promiscuous sensory opportunities*”. [Clark (2008), p.38]. On these grounds, he therefore draws the distinction between genuine incorporation and mere use⁷⁴. Clark finds in this distinction an opportunity to defend

⁷⁴ It is worth noting here that there are many more scenarios that this debate could unfold. The use/incorporation distinction is certainly not the only one at stake. For instance, De Preester & Tsakiris (2009) have noticed that we have to distinguish cases of genuine “incorporation” in which our sense of embodiment is authentically and profoundly transformed from cases of “extension” in which the spatial boundaries of the body are only temporarily and transiently modified. De Preester & Tsakiris argue that one can only find authentic cases of incorporation in patients in which the prosthesis is felt as a part of their body. On these grounds, they therefore suggest that genuine incorporation not only transiently alters motor and perceptual abilities but also establishes deep changes in the “feeling of ownership”. Such changes aren’t however

views that describe us humans not just as ‘inescapably locked-in agents’, subjects whose minds and corporeal capacities are at best apt for mere scaffolding, but rather as cognitively permeable actors [Clark (2007)]; agents in which the use of extra-biological resources is not simply deployed causally but rather becomes skilfully integrated into our problem-solving routine to count as parts of “*a new systemic whole*”. [Varela, Thompson, Rosch (1991)].

This idea of a “*new agent-world circuit*” [Clark (2008)] realised via assimilation of external structures is surely fascinating. It shouldn’t nevertheless distract our attention from the main point of our discussion. One question in fact remains to be answered. What are the conditions for genuine cognitive incorporation? In other words, what does such integration require? The first condition for genuine cognitive incorporation to occur is that there is a possibility of coupling and therefore that the resources to couple with are present and “ready-to-hand”. [Heidegger (1927)]. Other crucial requirements are the reliability and the openness of the system. The system must be mastered by the user and needs to be totally open and also “on-line”. It must therefore be both susceptible of external stimulation – that is, subject to deep and transformative processes of restructuring - and capable of learning new, complex problem-solving strategies. These strategies must be deployed to achieve the delicate temporal tuning of multiple different factors. These factors must in turn feedback in the bodies of information available to the subject while carrying out some sort of on-line problem solving. It is therefore the temporal tuning that leads to successful coupling. It is only when “*such couplings are in place and when the bounds of skin and skull are rendered functionally irrelevant that cognition can extend gracefully into the world*”. [Clark (2010), p.97]. Minds like ours, Clark concludes, are therefore naturally poised, evolutionarily constrained and wholeheartedly directed to promiscuous couplings both with the biological and with the artefactual. This “peripatetic” attitude [Donald (2000)] towards licentious self-

established when the peri-personal space around the body is simply extended through tool usage. [Kiverstein and Farina (forthcoming), §5]. The tennis player in fact doesn’t feel impaired when she ceases using her racket although she may well feel the racket as a part of his body when she uses it for gaming.

assemblage and re-engineering, on Clark's view, substantially weakens any ancestrally-closed, brain-bounded account of human cognition.

6.3 Rupert's Caveat about Incorporation

As we have seen above the phenomenology of tool use is a delicate issue, one in which it is difficult to find widespread agreement. The studies on bimodal neurons and on extension and recalibration of the peripersonal space analysed above invite a number of phenomenological arguments (e.g., smooth coping, sense of location and sense of control) that can all be used to support the thesis that incorporation occurs via motor engagements and goal-driven activity. These "phenomenological" arguments have all been deployed, with different strategies, by proponents of EMT [Clark (2008); Gallagher & Zahavi (2007); (Wheeler (2005))], who on these grounds have defended the idea that cognition extends. However, many prominent critics of EMT have not been persuaded by them. In particular, Robert Rupert in his recent state-of-the-art treatment (2009, see ch.8) has criticised both the range and the validity of these arguments and has proposed to re-describe all the cases of incorporation abovementioned (and similar ones) in terms of tool, body and the causal dynamics of their interaction. In essence, Rupert has argued that we ought to distinguish the "fairly acceptable" claim that incorporation yields new agent-world circuits, re-engineered bio-mechanical systems; from the more radical assumption that buys the inference to extended cognition and therefore envisages literal cognitive extension. Rupert is prone to grant the existence of the former just by giving an embedded account of cases of incorporation but attempts to resist the latter on the grounds of his notion of organism-centred realiser.

In what remains of this section, I analyse the response that Rupert has formulated against the so-called sense of location argument and show the extent to which his response undermines the relevance of incorporation for EMT. In the spirit of presenting the embedded position in the strongest possible way, I then turn my attention to the argument from smooth coping and discuss Rupert's appeal to the emulator theory as a way to counter the idea of transparency achieved through active usage. Before I proceed

any further with my analysis of Rupert's criticism, let me briefly restate, in its strongest form, the first of the arguments I will be analysing.

The sense of location argument is based on the idea that sometimes humans, especially after consistent practice with a specific tool, come to experience a sense of bodily extension and take this feeling as a reliable indicator of the location of their cognitive and perceptual processing. The body, to them, seems to stretch and extend well beyond its natural boundary so as to include the tool being used. In other words, the process of recalibration of the body-schema entails an inclusion of the external tool into the machinery that realises the user's cognitive capacity⁷⁵. The most immediate consequence of this argument, at least for proponents of EMT, is the truth of the extended view. Clark (2003 and elsewhere) has extensively used this argument to argue for EMT and I have comprehensively presented the case he is making for it in the previous section of this chapter. This isn't the only argument that he and his allies have deployed to defend EMT on the basis of incorporation⁷⁶. In discussing these arguments Clark has emphasised the importance of other factors (such as the persistence and reliability of coupling and the mastery of the tool) for successful incorporation. "*The phenomenological sense of an extended presence, however, quite often plays an argumentative role in its own*". [Rupert (2009), p. 165]. This is evident, Rupert notices, when Clark talks about the plasticity of the body-image.

One of the experiments that Clark discusses to highlight the existence of this remarkable plasticity is borrowed from Ramachandran and Blakeslee (1998). This experiment is conducted in the following scenario: there are two subjects sitting in chairs, one behind the other, both facing the same direction as if they were in a single line. The subjects sit close to each other so that the person in the rear can fully extend her arm and touch the nose of the subject in the front. The person in the rear performs this action while blindfolded and holds out her hand to the experimenter who stands in front of her. The

⁷⁵ For a complete treatment of this point see Section 1.

⁷⁶ As I noted in the previous paragraph, another argument that has been used by proponents of EMT to support the idea of cognitive extension is the argument for smooth-coping. I will analyse this argument in more detail later on in this section. One might also mention the so-called sense of control argument. I won't be discussing such an argument in this section nonetheless.

experimenter takes up the subject's hand and causes the person's finger to tap, at irregular rhythm, against the nose of the subject who sits in front of her. In parallel, the experimenter taps with the same irregular rhythm the nose of the person who sits in the rear. Results show that about 50 % of the persons who sit in the rear report the sense that they are tapping their own nose, as if they were perceiving their noses as stretching and extending 80 to 90 cm in length. [Rupert (2009), ch.8].

Now, Rupert makes three considerations about these findings. First, he claims that these results don't tell us anything about the physical location of cognition simply because the location of my nose has nothing to do with the location of my cognitive processing⁷⁷. [Rupert (2009), p.165]. Second, he notices, these reports are clearly wrong and based on an illusion. In truth, everyone knows that the subjects are not tapping their own noses. Third, he tries to explain this illusion of bodily extension in terms of the neural mechanisms that the brain has to deploy for correlating different sources of stimulation with different sensory modalities. In analysing the mechanisms that realise this illusion, Rupert compares the neural explanation of it with the explanation he gives of the studies involving tool-use. He claims that the same neural explanation applies to both cases. The findings on tool-use, he continues, in indicating the existence of neural correlates for the internal representations that describe the way in which the monkey thinks of its own body, seem to favour an embedded interpretation of the phenomenon of incorporation. These findings, Rupert claims, favour a non-extended interpretation of the phenomenon of incorporation because they reveal that the realiser of the relevant experience and of the cognitive state produced is still located inside the head and lies within the neural circuitry that represents the location of the hand or of the arm.

In short, Rupert explains this feeling of bodily extension as a direct consequence of the interactions that occur between and among neural signals. So even though the activation of the bimodal neurons seems to suggest that the user's body-schema might well extend beyond the boundary of the user's body so as to comprise and include an external tool;

⁷⁷ In truth, Clark and proponents of EMT are not making a claim about the location of one's nose as Rupert seems to suggest [Rupert (2009), p.165] - rather the point is about the experience of one's nose and of the

the realiser of the thought of this “alleged” extension is for Rupert still located within the skin and skull of the organism.

This criticism doesn't seem to be particularly challenging for a friend of EMT and certainly doesn't suffice to establish the embedded (organismically-bounded) view against the extended alternative. Clark or any other proponent of EMT would in fact surely agree with Rupert in asserting that there has to be some sort of neural change driven by our onboard neural machinery in order for a tool to become incorporated. But when the tool is actively and proficiently used, she would continue, a reorganisation of the user's body schema would take place and this would make the interface disappear from awareness. Once the interface has disappeared from awareness, she would conclude, the tool would get incorporated and cognition would gradually extend⁷⁸. So, if Rupert wants to succeed in establishing his embedded view as a profitable alternative to extended accounts of incorporation, he needs to provide a preferable and more seductive explanation for the phenomenological feeling of transparency that expert tool users consistently report. Before I turn my attention to Rupert's way to counter the phenomenological claim about transparency I just mentioned, let me briefly recall the argument that postulates its emergence.

The argument from smooth coping is precisely the argument that envisages the emergence of a feeling of transparency in tool-use. This argument in fact says that in specific cases, cases of active and continuous usage, we progressively lose our awareness of the distinction between the boundaries of our body and those of the tool we use. If sometimes and under certain circumstances we are not fully aware of such a distinction, then it would seem that the cognitive theory that best describes the idea of smooth coping is one that draws no firm boundaries between bodily and extra-bodily features; an account that envisages online form of coupling and recruitment, a perspective that entails the possibility of bodily reconfiguration and self-re-engineering. It is therefore no surprise

boundaries of one's body more generally. So the real question to answer is: does the experience of the boundaries of one's body tell us anything about the location of cognitive processing?

⁷⁸ For an in-depth discussion of this point and for an additional defence (centred on SSDs) of the claim that full transparency is achieved through active tool-use, the reader should refer to the next section of this chapter.

that this argument has been used by proponents of EMT [Wheeler (2005); Clark (2003), pp.33-34] to endorse their externalist accounts of cognition.

Rupert strongly disagrees with these views. He reckons that when we perform actions with specific tools in the environment we engage in a series of complex relations with the world and acknowledges that these deep engagements might well give us a sense of fluidity or transparency. This isn't however sufficient, he continues, to prove that when we use a hammer we feel it as a proper part of our body. It is one thing, he maintains, "*to transcend conscious planning and the deliberate issuing of motor commands: it is quite another literally to lose all awareness of external items as separate from one's body*". [Rupert (2009), p.160]. Having made such a claim, Rupert then introduces the emulator theory [Grush (1997,2003, 2004)] to undermine the idea that the best cognitive model capable of explaining cases of smooth coping is the one that draws no firm boundaries between the bodily self and the external resources. Rupert therefore appeals to the emulator theory to: 1) reintroduce the interface between the user and the device that the appealing to smooth coping had removed; and 2) to show that it is still possible to successfully describe incorporation within an embedded perspective.

The emulator theory affirms that the brain scaffolds the on-board neural machinery and that this process of scaffolding leads to the formation of neural circuits that function as models and provide expectations of the sensory feedback by predicting the outcome of, say, the agent's reaching on the grounds of specific stimulation or prior knowledge available to the subject. The interesting aspect of these models, Rupert claims, is that they can also run off-line and therefore can be used by the brain "*to produce imagery, estimate outcomes of different actions, and evaluate and develop motor plans*". [Grush (2004), p.377]. The appealing to the emulator theory thus endows Rupert with the means to resist more radical claims about cognition as it allows him to explain incorporation within an organismically-bounded framework, a context in which the significance of goal-driven activity and motor engagements is substantially reduced. Rupert thus tends to avoid the tempting appeal to what he calls, the "magical force of phenomenology" and rather tries to explain the agent's reaching and the subsequent recalibration of her body-schema in

terms of the changes driven by predictions that occur at the brain level by virtue of attuned activity of specific class of emulator circuits. The emulator-based explanation therefore allows Rupert, at least so he claims, to describe the feeling of transparency as exclusively dependent on the interaction among neural signals.

This way, it becomes possible for Rupert to embrace the idea of new systemic wholes without necessarily committing to the radical claims that go along with this idea, claims and theories that envisage literal mind extension. Appealing to emulator theory thus offers a plausible and more conservative explanation for the phenomenon of recalibration of the body-schema abovementioned. This scientific explanation is, for Rupert at least, more grounded than any other subjective phenomenological report and must be preferred to an extended one because it is less radical and more parsimonious. The important point about the emulator business is therefore that it seems to allow Rupert to keep a foot in both camps. The emulator theory in fact doesn't preclude the formation of reconfigured bio-technological systems as envisaged by Clark, but at the same time invite us to endorse an embedded, organismic-centred account of cognition, because it tends to explain the phenomenon of incorporation in terms of the interactions that occur between and among neural signals.

In short, the emulator theory seems to possess the same explanatory power of more radical accounts of incorporation but it doesn't end up being so drastically radical. The acknowledgment of the explanatory power of this theory invites Rupert to attribute a causal role to tool-use in driving cognition and let him claim "*a privilege to organismically located phenomenological experiences*". [Rupert (2009), p.169]. It is indeed the organism, he maintains, that causally interacts with external props and since the organism plays such a crucial role in cognition, then it seems logical to affirm that it has to be the organism and the neural activity correlated to it that must be considered the centre of this process. Needless to say, that this conclusion would favour Rupert's embedded view over more radical ideas of friends of EMT. Shall we side with Rupert and embrace his embedded account of motor cognition? I suggest this might be too hasty.

6.4 SSDs: a Real Case of Incorporation

Having presented in the strongest possible way the arguments that Rupert has deployed against EMT, I now try to respond to them by drawing the reader's attention to the case of sensory substitution. I therefore discuss the case of SSDs as an example of tool use⁷⁹. I firstly distinguish between active and passive use and then argue that only active and expert SSD users come to experience the feeling of transparency that characterises incorporation. Such a feeling, achieved by means of cognitive and perceptual supplementation, remains however precluded to inactive or naïve users. Inactive users in fact fail to experience this new form of perception because in their case the device is not mastered and it therefore doesn't trigger the kind of cross-modal mappings required for perceptual supplementation. Perception in all these cases remains unaltered and the tool is not incorporated into the user's information processing. Conversely, in cases of active use and direct manipulation the deep and profound entanglement required for real incorporation is achieved because the coupling with the device enables a new space of sensorimotor integration with the environment. This in turn triggers the activation of specific cross-modal mappings that favour the emergence of a new mode of phenomenal access to the world. Crucially, this new mode of access to the world is realised because of: 1) the substantial training that the user undergoes with the device; 2) the manipulations/actions that the user performs with the device in the world; 3) the skills the user develops while performing actions with the device. It is only when all these three factors are combined together that the "tool" becomes geared to work in a sort of symbiotic partnership with the subject, enables cross-modal mappings and thus gets factored and incorporated into the agent's body schema, becoming fully transparent and fading from awareness. In this process of factoring both the agent and the tool become so deeply tuned, so finely integrated with each other that they can be said to form a single, entangled system of cognitive analysis.

This is, in essence, the idea that I develop in the first part of this section to undermine Rupert's embedded and somehow conservative understanding of the plasticity of the

body-schema. Let me describe my first argument against Rupert in a bit more detail. I will then briefly focus on how Rupert could respond to my argument in light of the emulator theory and shall conclude this section and the chapter by showing that his argument rather than reintroducing the interface between the user and the tool, seems instead to favour an understanding in which the interface de facto disappears.

In SSD perception I distinguish two different cases (what I labelled as active and passive use). Let me introduce the case of passive use first. I will then turn my attention to the case of active usage and by highlighting the differences between the two, I shall demonstrate that it is only in the latter case that we get extended cognition and therefore that it is only in active use that we can experience transparency and true incorporation⁸⁰.

The classical example to mention in order to clarify the nature of passive use is the dentist chair built by Bach-y-Rita and colleagues in the early '60s to test the capacity of blind subjects to develop visual skills. [Bach-y-Rita et al. (1969)]. As we have seen in chapter 4, in this experiment the overhead camera responsible for mapping the environment was fixed above the heads of the subjects and these were forced to sit on a dentist chair while embedded pins were delivering tactile information on the back of their chair. Lack of manoeuvrability and incapability of performing free movements in the environment determined in the subjects the impossibility to properly master the device. While using the tool, the users were in fact constrained to perform a very limited amount of actions: they were not allowed to hold the camera, and as a consequence they could only develop a very restricted set of abilities and skills for the discrimination of the received stimuli. However “*once users were given freedom, the possibility to hold the camera and to perform several movements with it, they then became able to perceive with the device*”. [Auvray and Myin (2009), p.1046].

⁷⁹ It is worth noting here that I could make the same sorts of arguments on the basis of almost any artefact. What I am doing here is in fact arguing for artefact extension.

⁸⁰ It seems, prima facie, that the distinction between active and passive use doesn't hold up because tool use is something that is always active. Thanks to my supervisor Tillman Vierkant for pressing this worry and asking me to clarify this distinction through the adoption of an opportune example.

This example is illuminating, I think. It in fact operatively highlights the distinction between active and passive use and at the same time nicely reveals that in standard cases of passive use there is an agent and a detached tool that is delivering either tactile or auditory inputs. These inputs however, aren't used by the subject to genuinely perceive stuff out there. The inputs delivered by the external interface don't mean anything to the user, neither do they let her experience a new kind of occurrence. There isn't a novel perception, there isn't a new mode of access to the world and the device barely replaces the modality the user has lost. Cases of passive tool-use definitely suggest a relation of causal necessity between the user and tool and seem to fit an embedded account, similar to the one embraced by Rupert, in which the device is simply providing inputs to the brain and therefore doesn't become geared or enmeshed in the loop that leads to the production of new cognitive and perceptual functions. Crucially, the device does not become part of the loop because the user simply exploits it as a tool and causally deploys it as a means to ease her performance in specific tasks. This account of passive use isn't however entirely negative. It in fact invites another reading; a positive reading, that suggests that (perhaps) there is something different going on in active use. The idea is that there isn't an agent + a detached tool but rather that there is something new that active use is doing and therefore that there is something different that smooth-coping brings forth. It is only when the user is active in fact that these external inputs come to mean something to her. I suggest that in active use, we have an agent + a tool working together to deliver something new. But what is delivered exactly?

What is delivered, I believe, is the mastery of sensorimotor contingencies that allow the user to genuinely perceive stuff out there in the world. It is in fact only in the case of active use that the device can become geared, via training, to work in partnership with the user and grafted into the cognitive repertoire of the perceiver. This partnership in turn enables cognitive transformations that make the device disappear from awareness and become fully transparent. The idea that active use allows the user to individuate specific patterns of interdependencies in the stream of proximal stimulation generated by the device is however quite provocative and certainly needs more careful attention and

further spelling out. It is here that I can therefore introduce my notion of cross-modal mapping.

As noted above in SSD perception, there are two mappings that are being performed when the perceiver actively uses the device. The first mapping is the mapping that is generated by the device itself. This mapping is shared by both active and inactive users. The device at this stage physically maps the environment onto either auditory or tactile inputs. As a result of this activity of mapping, the user can either get something that might resemble a visual stimulation or an auditory one. Upon receiving this crucial information from the device the perceiver's brain finds in the auditory/tactile stream specific sensorimotor contingencies⁸¹. This is where the second mapping begins to work. The sensorimotor contingencies that become available to the active user inform the perceiver about things that are out there, in the external environment. The brain now starts processing auditory or tactile inputs and gradually transforms these inputs so that they can be understood as being about stuff out there. The device is therefore transforming environmental inputs into outputs that the brain re-cycles and re-elaborates in conjunction with the SSD. Crucially, the outputs the brain is producing are device involving. These outputs in fact contribute to create a new space of biotechnological synthesis between the user and the world and therefore allow for incorporation of the device. Perceiving by means of an SSD in fact requires perceptual-motor learning, which only arises when actions structure perception.

To repeat, in the case of active SSD perception we have two mappings. The first one goes from vision to audition or touch. The second one links audition or touch as experienced by the brain to specific sensorimotor contingencies for the SSD and therefore provides the SSD user with a new mode of phenomenal access to the world and a set of skills that progressively allow the SSD to fade from awareness.[see chapter 4 for an in-depth analysis of this point]. Active tool-use is in fact exploited by the brain to discover, via the coupling with the device, the relevant sensorimotor contingencies that trigger the experience of the new mode of phenomenal access to the world. Thus, active

use seems to be device involving. Through active use in fact the perceiver learns about the sensory consequences of her actions and of her bodily movements. After substantial training with the device the user discovers specific patterns in the stream of proximal sensory stimulation that she experiences and therefore becomes able to refer the source of these patterns of proximal stimulation generated by the device to external objects. [Kiverstein and Farina (forthcoming)].

Crucially, this is something the perceiver can learn and achieve only after she has familiarised with the sensorimotor contingencies produced by the device. Once the perceiver has familiarised with the complex set of sensorimotor interdependencies that hold between self-movement and proximal stimulation – that is, once the perceiver has undertaken substantial training with the device, the second mapping can successfully take place. At this point, the user no longer notices the proximal stimulation but her attention automatically turns to what is causing it and the device fades away from awareness. The inputs from the device are now interpreted as being caused by a distal stimulus [Auvray et al. (2005)], while “*the perceiver comes to understand that the variation in stimulation she has undergone is due to the spatial properties of external things*”. [Kiverstein and Farina (forthcoming), §3]. So, while using the external prop, the agent progressively gets to understand the many different ways in which her actions influence the sensory stimulation generated through the coupling with the device. “*As the user becomes increasingly familiar with the effects of movement on sensory input from the device, the interface linking her to the prop becomes less and less obtrusive and she becomes increasingly at one with the device in a way that leads the brain to treat it as part of the active body*”. [Kiverstein and Farina (forthcoming), §5]. This way, the user of the SSD and the device get amalgamated, the device disappears from awareness and gradually becomes transparent and at one with its user, so that we can think of them (the user and the device) as forming an entangled, integrated system of cognitive analysis.

It is therefore the abilities the user acquires, the skills she develops in conjunction with the SSD that determine whether the device and the perceiver combine and amalgamate to

⁸¹[Noë (2009, 2004); O'Regan & Noë (2001a,2001b)]. For a complete treatment of the sensorimotor

work in symbiotic partnership. [Kiverstein and Farina (forthcoming), §6]. When the perceiver becomes proficient at using the SSD she can individuate and master the patterns of interdependencies generated by the device and her sense of what she can do in the world is automatically reconfigured and profoundly transformed. Training with the SSD thus alters the perceiver's sense of what she can and cannot do with her own body. Through the active coupling with the SSD the perceiver comes to interpret and experience the world out there as a new space of bio-technological coalescence, a space of coupling that enables new action possibilities.

The embedded account doesn't seem to capture (or in any case fails to acknowledge by silently ignoring it) the philosophically relevant difference between the case in which the device is simply delivering inputs (the passive case) and the case in which the device is instead used to genuinely perceive stuff out there (the active case). It is only when the device is actively used that the interface between the device and the user disappears from awareness, and it is only in this case that the device can become fully transparent and be at one with its user. Transparency, on my account, is thus supposed to be the phenomenological marker of incorporation. Transparency buys me incorporation because transparency is precisely what happens when the user acquires the skills necessary for perceiving with the device. Skills are therefore the missing piece of the puzzle, the most crucial factor that the embedded view ultimately fails to take into account.

To this idea of transparency achieved via active tool-use by means of cross-modal mappings, Rupert would almost certainly oppose the appeal to the emulator theory as described in the previous section. He would reject the validity of the phenomenological claim about transparency postulated by smooth coping and further reinforced by my treatment of SSDs conducted above and would probably say that when the brain has learned the sensorimotor contingencies that lead the user to the second mapping, the brain would just start using emulators to predict the movements required for performing actions with the tool. So, by appealing to the emulator theory Rupert would certainly try to reintroduce the interface between the user and the tool that the appealing to phenomenology and smooth coping had attempted to remove. What would be my

approach see chapter 5.

response to this objection and how can I undermine Rupert's rejoinder? My strategy to undermine Rupert's counter argument is to look at what happens when the user gets prediction of the kind required for emulation and see if this is still compatible with an embedded approach.

In what remains of this chapter I therefore attempt to mount an attack on Rupert's understanding of incorporation by showing that even if there is an emulator that is making the predictions for using the tool, when the brain comes to predict the consequences of performing actions and movements with the tool it no longer treats the tool as separate from the body but incorporates it. So, rather than reintroducing the interface between the tool and the user, the emulators actually reveal us how this interface disappears.

As I said in the previous paragraph, in order to counter the transparency argument from smooth coping outlined in precedence Rupert could appeal to the emulator theory and say that when the brain has learned the sensorimotor contingencies necessary to trigger the second mapping and master the device, it just starts using an emulator circuit to predict the consequences of tool usage. On these grounds, he would claim that there is no real incorporation because the presence of the emulator circuit prevents the interface from fading from awareness. Let me just make this point here: isn't being able to predict the consequences of using a tool precisely what the user needs in order to incorporate the tool? If the brain can predict the consequences of performing actions with the tool then it seem to me that the brain has already started treating the tool as a part of its body. In other words, even if an emulator circuit is set up and in place, the brain can still treat the tool as an essential effector thereby ceasing to recognise the distinction between actions carried out with a body part and actions carried out with the tool. I find comfort for this claim in the work conducted by Frederique de Vignemont (2010) and colleagues on the rubber hand.

The so-called rubber hand illusion is evoked when subjects see an inflated rubber glove or a dummy hand being stroked while their own "unseen" hand is patted in synchrony.

[Kammers et al. (2009)]⁸². The stroking results in a feeling of ownership which induces the perceivers to relocate the perception of their own “unseen” hand in the immediate vicinity of the dummy hand/inflated rubber glove that is being stroked. [Botvinick & Cohen (1998)]. In reality, however, the real hand is usually far more distant from the dummy hand/inflated rubber glove than the subjects had thought. In the rubber hand illusion there seems to be a conflict between proprioception which tells the subject that her hand is in one place and vision and touch which tell her instead that her hand is where the rubber hand is. The rubber hand illusion is therefore based on a sort of discrepancy in location. This discrepancy is however quickly overcome by “visual capture” of the tactile sensation, in a way that allows “a *multimodal match that leads the subject to the proprioceptive drift*”. [de Vignemont (2010), p.678].

Now, contra standard neuropsychological taxonomies, de Vignemont (2010) attempts to describe the rubber hand illusion within a more dynamical framework. In particular, she invites us to embrace a model that appeals to Bayesian inference in order to account for the multimodal match mentioned above. Classically, a Bayesian model is a model that uses probability functions to postulate the existence of some sort of a priori knowledge. This knowledge is supposed to determine how a given system behaves in light of specific biological and environmental constraints. A rough comparison can be drawn with the emulator theory. The Bayesian model proposed by de Vignemont, as the emulator theory embraced by Rupert, is characterised by a prior probability distribution for its structure and parameters. De Vignemont argues that the Bayesian model: “*represents the relative plausibility of different locations of the hand and aims at computing the posterior probability, that is, the degree of belief in the prior hypothesis conditioned on the observation of sensory evidence*”. [de Vignemont (2010), p.678]. The model she develops to account for the rubber hand illusion therefore aims at representing the whole lot the subject knows about the procedure and mechanisms that convert and transform the state of the world into sensory information for the subject, so that once the posterior probability is processed the system comes to possess an accurate estimate of the world and the position of the subject in it. Thus, the specific way in which the subject utilises

bodily information influences and determines the way her brain encodes it. This is the model, de Vignemont maintains, that the brain comes up with when it attempts to predict inputs. The interesting fact is that in this model the brain resolves the conflict above-mentioned in favour of vision and touch by generating the proprioceptive illusion. The brain therefore favours multimodal integration and represents “*the body both as the effector and as the goal of the action*”. [de Vignemont (2010), § 7].

Crucially, the result of this prediction is one that lets the rubber hand be experienced as a part of the subjects’ bodies. [Carruthers (2009)]. That is, “*the subject experiences a sense of ownership over the hand*”. [de Vignemont (2007), p. 438]. “*It is important to note however, that in this illusion the rubber hand is not experienced by the subjects as an addition to their bodies, rather the rubber hand is felt to become a part of their bodies*”. [Botvinick & Cohen (1998), p. 756]. The subjects do not feel the rubber hand as if they now possess an extra hand; rather they perceive that the bounds of their bodies have been transiently modified to include the rubber hand rather than their real hand. [Carruthers (2009), p.126]. In what remain of this chapter, I will try to use this crucial point as a leverage to develop my argument further.

Having quickly presented this multimodal understanding of the rubber hand illusion, I now try to develop analogous considerations for the cases of incorporation that I have mentioned earlier on in this chapter. In particular, I put forward the empirical hypothesis that says that when the brain predicts the sensory consequences of action with the tool, it is then able to predict inputs generated by it. This claim seems to be now much stronger and powerful than it was at the beginning of this chapter. Extrapolating from the rubber hand illusion in fact allows us to say that the model of the body that the brain produces to predict the inputs is precisely one that includes the tool, just as in the rubber hand illusion the model of the body was one that included the rubber hand itself.

I find further empirical evidence for this idea in recent experimental work conducted on

⁸² See also [Tsakiris and Haggard (2005) and Ehrsson (2009, 2004)].

brain-machine interface⁸³. [Nicolelis et al. (2003)]. This work undertaken on macaque monkeys has shed new light on the mechanisms underlying tool-incorporation [Crist and Lebedev (2008)], and demonstrated that “*primates can learn to reach and grasp virtual objects by controlling a robot arm through a closed-loop brain-machine interface*”. [Carmena et al. (2003), p.193].

In their most famous experiment Carmena and colleagues implanted a series of electrodes in the frontal and parietal lobes of a macaque monkey. These electrodes allowed a monitoring computer to track and record neural activity across multiple cortical units while the monkey was learning how to use a joystick to move a cursor across a screen. [Carmena et al. (2003), O’Doherty et al. (2009)]. In a second stage of the experiment, the joystick was disconnected. The macaque could however still display remarkable performances at controlling the movements of the cursor across the screen by using its neural activity opportunely guided by the intervening interface. [Clark (2008), ch.2]. In the third and final stage of the experiment, the original commands were transferred to a robot arm whose actions were converted into on-screen cursor movements. The experiment revealed that:

“after only a few days of playing with the robot in this way, the monkey suddenly realized that she didn't need to move her arm at all. Her arm muscles went completely quiet, she kept the arm at her side and she controlled the robot arm using only her brain and visual feedback.”. [Nicolelis, Science Daily, (2008)]⁸⁴.

Additionally, the analysis of the signals emitted by the macaques' brains while learning the new task showed that the onboard neural circuitry was progressively reorganizing to adapt to tool-use.

⁸³Brain-computer technology has received attention from many philosophers during the last decade. [See Clark (2008), Fenton and Alpert (2008); Walter (2009), Kyselo (2011); to name just a few].

⁸⁴Link available here; http://www.danshope.com/news/showarticle.php?article_id=10 (last accessed September 2011).

"It was extraordinary, Nicolelis continues, to see that when we switched the animal from joystick control to brain control, the physiological properties of the brain cells changed immediately. And when we switched the animal back to joystick control the very next day, the properties changed again". [Nicolelis, Science Daily, (2008)].

These findings have led the experimenters to conjecture that the dynamics of the brain-machine interface were incorporated into multiple motor and cortical representations of the monkey's body schema. On these grounds the experimenters have therefore claimed *"that the gradual increase in behavioural performance emerged as a consequence of a plastic reorganization whose main outcome was the assimilation of the dynamics of an artificial actuator into the physiological properties of fronto-parietal neurons"*. [Carmena et al. (2003), p. 205: also mentioned in Clark (2008), p.34]. This, once again, seems to imply that when the motor cortex is able to predict sensory consequences of motor commands sent to the robot arm it begins to treat the robot arm as something it can control; as a part of the monkey's body. *"Such findings therefore tell us that the brain is so amazingly adaptable that it can incorporate an external device into its own 'neuronal space' as a natural extension of the body"*. [Nicolelis, Science Daily].

Clark (2008) has indeed used these results to argue that brain-computer interfaces are transparent bodily extensions that get factored and incorporated into the monkey's body.

To the extent that this work suggests assimilation or better incorporation of the robot arm into the monkey's body, it also contributes to undermine Rupert's embedded criticism of EMT. It does so in fact, by showing that even if a prediction is required in order to trigger motor cognition, this doesn't yet preclude incorporation from happening; as this process seems to occur via forms of deep cortical sensorimotor integration. So, even if there is an emulator circuit in place when the brain predicts the consequences of an action while using a tool; the brain gradually starts treating the tool as a part of its own body and as a result, the tool becomes enmeshed into the properties of our onboard neural machinery.

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Closing Summary

In this dissertation I have tried to defend the extended mind thesis. I started by locating EMT within the framework provided by the situated cognition movement and have then pinpointed its crucial tenets. In reviewing the most crucial arguments that advocates and opponents have formulated to argue for and against the idea of cognitive extension, I have acknowledged a stalemate in which the debate between extended and embedded has fallen. Rather than fighting the battle for the extended mind thesis on a functionalist turf, I have proposed to focus on a second strand of thinking about EMT that is concerned with Complementarity. Complementarity is the idea that different components of a softly-assembled system can play quite different roles and have different properties while nevertheless combining to make different but complementary contributions that enable flexible thinking and acting. I have argued that second-wave approaches, in exploiting the fine-grained functional differences between internal and external, can help to decide the debate in favour of EMT. I have therefore set up a defence of EMT on the grounds of Complementarity considerations involving the individual and its cognitive developmental niche. In particular I have focused on both the ontogeny and the phylogeny of cognitive systems.

In exploiting the work conducted on neuroconstructivism I have tried to show the profound dovetailing, the symbiotic and complementary partnership, that characterises the relationship between brain and world. In particular, I have argued that both functional specialisation and at least some of our higher cognitive functions are experience-dependent and that brain plasticity is a pre-condition for EMT. Brain plasticity is the capacity of the brain to change structurally and functionally in response to environmental stimulation. I have claimed that brain plasticity is a pre-condition for extended cognition because it enables human beings to incorporate environmentally located resources into their problem solving routines. By changing our very own neural machineries, cortical plasticity gets us something new that we wouldn't otherwise get. This in my view is supposed to break the tie between embedded and extended.

I have then tried to broaden these considerations by looking at the phylogeny of cognitive systems. I have drawn a parallel between gene-centric accounts of evolution and intracranialist understandings of cognition. In attacking the former on the grounds of empirical research drawn from evolutionary biology I have made a case against the latter by showing the complementary way in which brain and culture intermingle and become instrumental for organisms to achieve biological fitness in the long run. I have then argued that our cognitive abilities are fleshy, deeply embodied and developmentally plastic and that our biological nature is gradually co-opted, again via plasticity, by the trappings and effects of culture and society.

In what remains of this closing summary I would like to point to some open questions, whose significance for my research has become clearer after the discussion with my examiners. Addressing these pressing concerns shall be one of the main tasks of my doctoral studies. It is therefore with these open questions that I would like to conclude this dissertation:

- 1) What is the relationship between Parity-based, functionalist defences of EMT and the Complementarity approach? That is, are Parity-style arguments and Complementarity considerations in tension or do they rather complement each other to make the case for EMT even stronger?
- 2) Can we use developmental considerations to make a case for EMT? That is, is development sufficient to establish synchronic extensions or does it merely deliver diachronic explanations. In other words, does development just give you the causal dependence of the internal cognitive processes on the cultural environs or does it rather establish metaphysical claims about constitution?
- 3) Do we need a mark of the cognitive to discriminate between what is cognitive and what is not? In particular, do Complementarity defences of EMT need to be armed with one to break the deadlock?