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Three Approaches to Human Cognitive Development: Neo-nativism, Neuroconstructivism, and Dynamic Enskillment

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ABSTRACT

In Section 1, I introduce three views that explain human cognitive development from different standpoints: Marcus's neo-nativism, standard neuroconstructivism, and neo-neuroconstructivism. In Section 2, I assess Marcus's attempt to reconcile nativism with developmental flexibility. In Section 3, I argue that in structurally reconfiguring nativism, Marcus ends up transforming it into an unrecognizable form, and I claim that his view (neo-nativism) could be accommodated within the more general framework provided by standard neuroconstructivism. In Section 4, I focus on recent empirical findings in neuropsychology and cultural/social neuroscience, and propose a friendly revision to standard neuroconstructivism, thus developing the neo-neuroconstructivist view. I conclude the article in Section 5 by analysing the implications of the results discussed in Section 4 for both neo-nativism and standard neuroconstructivism.

1 Introduction

In this article I discuss three views that aim to explain human cognitive and cortical development: (i) Gary Marcus's neo-nativism, (ii) standard neuroconstructivism, and (iii) neo-neuroconstructivism. I first distinguish how

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these theories are thought to relate in the mainstream literatures and then go on to analyse how I believe they actually relate. I argue that neo-nativism is not that distinct from standard neuroconstructivism (and could be accommodated within its richer theoretical framework) and that standard neuroconstructivism, in order to fully account for recent empirical findings, needs to be revised along the lines envisaged by what I call 'neo-neuroconstructivism'.

I begin this introduction by offering a short description for each of the three accounts at stake, providing some general philosophical background for each of the three positions.[1] Having done this, I analyse the links between them and summarize the arguments of the article.

(1) Neo-nativism, which I discuss in Section 2, is Marcus's theory that asserts that the cognitive structures with which we come to the world are 'prewired at birth' (Marcus [2004b]) and can (occasionally) be reprogrammed later in life by specific experience-dependent activities (appropriately mediated by the regulatory action of genes). This position draws from the conceptual palette developed by evolutionary psychologists (such as Barkow *et al.* [1992]; Pinker [1997]), but significantly differs from hardwired nativism (see Section 2 below for a discussion of the differences between hardwiring and prewiring)[2] because it doesn't posit the existence at birth of domain-specific, functionally specifiable modules.[3] Instead it accepts, at least in principle, the idea of rewiring as a way through which experience can alter and very partially reprogramme the inborn predispositions with which we come to the world. So, it is a strength of Marcus's view that in considering questions about the contribution of genes to development, he pays attention to the role of environmental

[1] I do not discuss standard nativism in this article, but rather a specific strand of nativism—Marcus's neo-nativism—in relation to standard neuroconstructivism and my own view, neo-neuroconstructivism. For critical discussion of standard nativism, see (Karmiloff-Smith [1992], [2009]).

[2] Hardwired nativism is a complex position that includes very different emphases and variants: (i) nativism about contents or concepts (Fodor [1975]); (ii) genetic determinism (Cronin [1991]); and (iii) nativism about cognitive architectures (Barkow *et al.* [1992]; Pinker [1997]). Since Marcus does not accept hardwired nativism, I set aside the goal of providing a critical exposition of this position and focus solely on his view.

[3] Jerry Fodor ([1983]) originally defined modules as 'functionally specialized cognitive systems' that have nine crucial features: (i) domain specificity, (ii) mandatory operation, (iii) limited central accessibility, (iv) fast processing, (v) informational encapsulation, (vi) shallow outputs, (vii) fixed neural architecture, (viii) characteristic and specific breakdown patterns, and (ix) characteristic ontogenetic pace and sequencing. Fodor later narrowed down the essential features of any module to two: domain specificity and information encapsulation (Fodor [2000]). In his view, modules can be found in peripheral processing but not in central processing. Evolutionary psychologists (such as Barkow *et al.* [1992]) have defined a module as a functionally specialized cognitive system that is domain specific. Modules, on their account, are the units of mental processing that have evolved in response to selection pressures and that contain innate knowledge about the class of information processed. Unlike Fodor, Cosmides and Tooby believe that quite often modules can be found in central processing and that they can perform a number of functions. Their thesis is, for this reason, known as 'the massive modularity hypothesis'. For some arguments in favour and against the massive modularity hypothesis, see (Buller [2005]; Prinz [2006]; Carruthers [2006]). For background interpretations of modularity, see (Coltheart [1999]).

activities in shaping human cognitive behaviour. However, it is important to note that, for Marcus, genes still maintain a special role in guiding development, as they possess a priority over environmental contributions (more on this later).

(2) Standard neuroconstructivism (Quartz and Sejnowski [1997]; Mareschal *et al*. [2007]; Karmiloff-Smith [2009]), addressed in Section 3, proposes a unifying framework for the study of cognition in neuroscience and aims at describing the way in which the brain progressively sculpts itself and gradually becomes specialized over developmental time, by deploying a number of different strategic cognitive tools, including phylogenetic developmental processes (such as gene–gene interaction or gene–environment interaction) and ontogenetic developmental processes (such as pre- and post-natal interactions). A central goal of standard neuroconstructivism is to understand how the neural substrates supporting mental representations are shaped. Standard neuroconstructivism explains the development of neural systems as 'heavily constrained by multiple interacting factors intrinsic and extrinsic to the developing organism' (Westermann *et al.* [2007], p. 75), so it focuses on the construction of representations in the developing brain and on the role that the environment plays in shaping the biological constraints with which we come to the world. According to standard neuroconstructivism, genetic activity is profoundly modified by neural, behavioural, and external environmental events, and all of these interactions play an au pair role in cognitive development. Thus, standard neuroconstructivism (unlike neo-nativism) acknowledges that the progressive specialization of neural structures is, to a large extent, driven by the environment and that both the genes and the environment play an equally important role (no ontological priority is given) in determining developmental outcomes. Furthermore, in the primary neuroconstructivist texts (Karmiloff-Smith [1992]; Elman *et al.* [1996]) there is a total, or near total, focus on brain plasticity in the early phases of development, at the expense of the plasticity found in later life. In fact, standard neuroconstructivism emphasizes 'the special role of the evolving social environment for the developing child' (Westermann *et al.* [2010], p. 724).

(3) Neo-neuroconstructivism, which I discuss in Section 4, is an account of brain organization and cognitive development that retains a solid (standard) neuroconstructivist basis, but attempts to update and extend this basis in light of recent empirical findings in neuropsychology and cultural/social neuroscience.[4] Neo-neuroconstructivism is therefore an improved account of the role

[4] There are two important remarks to make about what I have called standard neuroconstructivism. The first point concerns the characterization of it I have given above. In particular, it concerns the last point (sensitive window of opportunity) that I introduced earlier on in this section. In the description I have provided above, there is no reference to the crucial role that evolving socio-cultural environments play in reorganizing and redirecting the functioning

of plasticity in development than appears in either standard neuroconstructivism or Marcus's neo-nativism. It takes on-board much of the standard neuroconstructivist conceptual palette, but introduces within it a much needed and genuinely innovative dimension, which I call 'dynamic enskillment' (see Section 4), that I believe standard neuroconstructivists have failed to take into account when they first formulated their framework. Dynamic enskillment, the central concept of the neo-neuroconstructivist view I am after, is a notion inspired by (but not fully coincident with) the patterned practices approach developed by Andreas Roepstorff and colleagues at the University of Aarhus (Roepstorff *et al.* [2010]). Dynamic enskillment is, roughly speaking, the idea that both brain organization and cortical development are heavily dependent on patterned practices and culture-sensitive activities throughout the entire lifespan.[5] Dynamic enskillment therefore aims at investigating lifespan changes in behaviour as a result of interactions, maturation, and learning, and tries to integrate empirical evidence across different domains (from behavioural to neural levels of analysis), while maximally acknowledging the dramatic power of brain plasticity and rewiring in an individual's lifetime (not only in early stages of life as standard neuroconstructivists have rightly pointed out). In doing so, dynamic enskillment affirms that adult entrenchment in different socio-cultural contexts can profoundly shape the functioning of the human mind and generate completely dissimilar neural responses (even among conspecifics) through embodiment and internalization, leading to structurally different, cognitively diverse, and deeply enculturated brains. Dynamic enskillment thus adds another element to the standard neuroconstructivist

of our brains during adulthood; rather, standard neuroconstructivists have only envisaged 'the special role of the evolving social environment for the developing child' (Westermann *et al.* [2010], p. 724). So, standard neuroconstructivists haven't put much emphasis on developmental issues throughout the lifespan, but rather have confined themselves to the influence of formative experiences and of experience-dependent activities in early childhood. This is part of the reason why in this article I propose a friendly revision, an update if you like, of this framework. The second point is related to the relevance and impact of the neuroconstructivist perspective in philosophy. Much of the philosophical enthusiasm for the developmentally based work of Elman ([1993]) and Karmiloff-Smith ([1992])—which culminated in the collaboration between Clark and Karmiloff-Smith ([1993]) and, more famously, in the publication of *Rethinking Innateness* (Elman *et al.* [1996])—hasn't been carried through to the present day. Neuroconstructivism, after receiving a lot of attention from philosophers in the early '90s, has more recently dropped off the philosophical radar (for example, the Philosophers' Index database lists only three articles on neuroconstructivism in the 2000s). I find this rather odd. In this article (and in other projects), by returning (as a philosopher) to standard neuroconstructivism, I attempt to bring it back to philosophy, and to make it the centre of a fresh and new theoretical debate.

5 The concept of patterned practices refers to the persistent participation of subjects in certain socio-cultural activities (for example, spending hours listening to and producing music). Participating in these socio-cultural activities and so taking part in a particular pattern of practice drives how subjects perform, and regulates how people perceive and act in particular group- and context-specific ways.

picture and aims at radicalizing it by proposing a friendly revision of its framework (what I call neo-neuroconstructivism).

In Section 2, I present Marcus's neo-nativism and assess his attempt to reconcile nativism with developmental plasticity. In Section 3, I argue that, in doing so, Marcus ends up reconfiguring nativism until it comes very close in all but jargon to standard neuroconstructivism. I also suggest that despite his more sophisticated nativism (one that claims to be able to account for both innateness and developmental plasticity), Marcus still significantly under-emphasizes the importance of neural plasticity and the relevance of constructive mechanisms of learning for the development of our cognitive functions.

According to Marcus, learning is guided by a tiny number of genes (Marcus [2004b]), which serve our brain as an ancillary tool for reprogramming both its configuration and cognitive responses in accordance with very minor (and restricted) critical environmental stimulation. Contra Marcus's neo-nativism, I argue that rather than a 'tiny number of genes', it is cortical plasticity that enables our distinctive intelligent behaviour to emerge from the enmeshing, on multiple timescales, of our on-board neural machineries with the wider world. I defend in Section 4 a view I label 'neo-neuroconstructivism', in which enskillment plays a crucial role, and which emphasizes the extraordinary power of our sociocultural/technological environs in moulding the functions and processes of our brains.

Congruent with standard neuroconstructivism, I therefore claim that although there might be some prewired, softly specialized circuits in place in the brain prior to birth (developmental bootstrapping precursors that become obsolete, rather than pre-established, permanent architecture for cognition), their organization, as well as their cognitive functions, can be continually altered and rewired through patterned practices (Roepstorff *et al.* [2010]) and culturally specific activities (Han and Northoff [2008]). Unlike standard neuroconstructivism, I emphasize that the constraints imposed on development by prior architectures in the early stages of life can be dramatically rewired throughout the teenage years due to a second, intense period of synaptic plasticity found in adolescence (Sowell *et al.* [1999]; Giedd *et al.* [2006]); and I stress the pivotal role that evolving socio-cultural environs play in influencing and re-directing the developmental path during adulthood. In other words, I take the second (dramatic) window of opportunity found in adolescence to point to the need for a friendly revision of the standard neuroconstructivist framework, especially in terms of its emphasis on the sensitive window for learning in infancy. I then argue that, besides this second window of opportunity, there is still a constant, obviously less dramatic though still quite remarkable, degree of rewiring (which has been neglected by both neo-nativism and standard neuroconstructivism), that goes on throughout the entire lifespan and that this rewiring is best explained by adding to the standard neuroconstructivist picture another dimension, namely, dynamic enskillment.[6] To corroborate this hypothesis, I present a number of crucial case studies in cultural and social neuroscience. I wrap up this article (Section 5) by showing how these findings shed light on the plastic and highly malleable nature of our minds and take them to undermine Marcus's version of nativism. From the analysis of these results, I also draw the conclusion that the original (standard) neuroconstructivist framework, in order to accommodate the role that evolving social environments play in adulthood (what I call the dynamic enskillment) and the second dramatic window of opportunity for learning, needs a friendly revision, and argue that the pay-off of this suggested update (the neo-neuroconstructivism view I am after) is highly desirable.

2 Marcus's Neo-nativism

In *The Birth of The Mind* ([2004a]),[7] Gary Marcus reconfigures the hardwired nativist position, according to which our minds come to experience the world fully equipped with pre-specified knowledge and endowed with a set of inborn mechanisms, which are 'innate' and hardwired into the brain at birth.[8] These mechanisms are thought to be the result of dedicated and specialized cognitive mechanisms tailored by natural selection over evolutionary time (Barkow *et al.* [1992]; Pinker [1997]). To fulfil his goal, Marcus makes two crucial moves. First, he abandons strong genetic determinism,[9] the view that describes the genome as being shaped by natural selection to become the blueprint for development and instead conceives of genetic activity in terms of 'cascades'

[6] Explaining why some rewiring throughout a lifetime is incompatible with neo-nativism and with standard neuroconstructivism is going to take some doing, but I shall make the argument for this claim below.

[7] In this article, I focus on Marcus's ([2004a]) book (although it is a popular one) because it represents a sort of watershed in his academic career. It summarizes many of Marcus's previous ideas about connectionism, constructivism (Marcus [1998]), and brain plasticity (Marcus [2001]); at the same time, it points to the development of his thought into new fields (for example, Marcus [2012]).

[8] Innateness is one of the central concepts in cognitive science, but also one of the most puzzling and, as Griffiths ([2002]) has noticed, a source of considerable confusion. Mameli and Bateson ([2006], pp. 177–8) have helpfully distinguished twenty-six definitions of innateness in the scientific literature. More recently, Griffiths and colleagues ([2009]) have systematized these definitions along three core dimensions. However, a growing consensus in the literature holds that in light of all this ambiguity, the very concept of innateness is a misguided folk concept. So, as an anonymous reviewer rightly pointed out, 'if this concept is so imprecise, what hangs on whether we label Marcus as a nativist or not?'. I emphasize in this article (despite the ambiguity of the notion of innateness) that I am trying to identify one important strand (neo-nativism) within the complex range of nativist positions and that this strand is the one at stake here.

[9] In the context of natural selection, strong genetic determinism attempts to describe evolution through the differential survival of competing genes: those genes whose phenotypic effects effectively promote the reproductive success of the organism throughout generations will be favourably selected to the detriment to their competitors. Thus, proponents of this approach argue that genes are the driving force of evolution, which exclusively takes place by change in their frequency.

or 'self-regulating recipes' (Marcus [2004b], p. 169). Second, he renounces the hardwiring account of psychological development and with it the existence at birth of domain-specific, functionally specifiable modules. Rather, Marcus endorses a 'prewiring' understanding of the evolution of our cognitive behaviour, according to which some of our brain structures possess prewired patterns (independently of learning and experience), but learning and experience can impact on these patterns by partially reprogramming and redirecting their functions in later stages of development. In this section I discuss Marcus's approach, focusing in particular on his idea of prewiring. Before I describe how Marcus's notion of prewiring informs his neo-nativism, let me quickly look at the way he understands genetic activity, as this provides him with the conceptual palette necessary to develop his positive proposal.

In his book, Marcus attacks strong genetic determinism and, in place of the hardwired psychological nativism related to it, he defends a more liberal account of the development of our cognitive functions, one that emphasizes the power of gene cascades in regulating (or better 'controlling' (p. 163) and 'supervising' (p. 168), to use Marcus's terminology) the multi-branched construction of phenotypic structures.[10] The idea is that 'each gene contributes to many phenotypic structures and each phenotypic structure depends on many genes' (Mameli and Papineau [2006], p. 560). 'Without genes', Marcus claims, 'learning would not exist' (Marcus [2004b], p. 170). So, cascades of genes create the complexities of human thought by being actively involved in processes of learning—that is, by supporting, changing, and modifying the neural structures that underlie our cognitive architectures. Learning, on Marcus's account, consists of several different sets of distinctly and uniquely specialized subtasks, each supported by a specific bit of neural activity fine-tuned by experiences that have been appropriately mediated by the regulatory action of a relatively 'tiny' number of genes (p. 105). Thus, learning is facilitated by (i) genetic activity (p. 109), and (ii) a moderate amount of experience-dependent mechanisms used to tune the modules and the connections between them (p. 105).

Marcus also emphasizes the 'electrical nature' of learning and repeatedly asserts that learning often requires some sort of electrical activity to be triggered in the brain. He discusses a series of interesting studies on synaptic strengthening and shows that the electrical activity underlying processes of synaptic activation is necessary to trigger cascades of genes that result in the production of actions that are in the long term instrumental for learning. Cascades of genes and the electrical activity of the synapses, he argues,

[10] Because a gene can trigger the action of another gene, which in turn might trigger the action of several others, and so on, it is customary to call the process by virtue of which these complex activations are realized 'gene cascades'. With the expression 'gene cascades', biologists describe the gene regulatory networks, whose actions provide a way for evolutionary novelty to emerge.

work in parallel and are in most cases entangled and deeply interwoven. So, for Marcus, the electrical impulses generated by the synapses, and the interaction between external environment and sensory apparatuses mediated by the regulatory power of genes are essential for the fine-tuning of our cognitive capacities. Marcus uses this idea of gene-driven development as a conceptual palette for his prewired neo-nativism, according to which the prewired configuration of our brain can only be reprogrammed by the action of cascades of genes in conjunction with restricted environmental exposure. In what remains of this section, I describe Marcus's notion of 'prewiring' and finish up by showing how it fits in his account of brain development.

Marcus distinguishes between 'hardwiring' and 'prewiring'. Certain skills or abilities are hardwired if they are built in the brain prior to birth, that is, if their development is predetermined by the genome and they develop through rigid, domain-specific mechanisms of learning. Marcus doesn't believe that hardwired nativism is the right way to think about psychological development and, on the grounds of both theoretical considerations concerning the complexities of genetic expression and experimental evidence pointing to a crucial role of sustained experiences in the development and organization of our cognitive functions, he rejects it. He argues instead for a more sophisticated form of nativism, one that puts the idea of prewiring at the core of his proposal. As Mameli and Papineau ([2006], p. 563) put it, for Marcus something is prewired if 'there is a default setting that gets inscribed prior to learning, but which can later be rewired by subsequent sensory experience'. Thus, for Marcus, there is no one-to-one mapping between genes and neurons:

> The role of individual genes is not so much to give pixelwise portraits of finished products as to provide something far more subtle: an *environmentally sensitive* set of instructions for constructing (and maintaining) organisms. (Marcus [2009], p. 149)

Therefore, there is no conflict between prewiring and rewiring on his account: 'If the human mind is neither rigid and fixed nor arbitrarily malleable, it is precisely because genes are conditional recipes rather than blueprints' (Marcus [2009], p.151).

In other words, to be 'prewired' is not to be utterly unmalleable, but rather to be organized in advance of experience. Just because something is preprogramed at birth, Marcus notes, it doesn't necessarily mean that it cannot be reprogrammed later in life. However, since reprogramming via learning is costly and evolutionarily demanding, Marcus argues that this cannot be the general norm. Rather, normally development is driven from within the organism by 'internally self-generated experiences' (Marcus [2004b], p. 106). An interesting example that Marcus discusses to highlight the power of this internally self-generated activity concerns the way in which primates develop stereo vision (for more details see section 'autodidact' in (Marcus [2004b], p. 108)). Many species of monkeys develop stereo vision by fine-tuning their ocular dominance columns[11] in a darkened womb,[12] without the influence of any external input—that is, by spontaneously generating their own experience via specific internal molecular cues. The idea is that normal development is just like development in these monkeys, the product of internally generated activity (mostly) regulated by the power of gene cascades (Marcus [2004b], p. 109).[13] When cortical structures do get reprogrammed later in life, by being rewired in accordance to environmentally generated patterns, learning (the electrical process triggered by synaptic activation in conjunction with the regulatory activity of cascades of genes) does not proceed by overriding the internally generated structures, but rather improves upon them, repurposing their distinctive functions. Prewiring thus becomes the keystone of Marcus's neo-nativism: it allows him to explain developmental flexibility and the plasticity of our cognitive functions, while hanging on to a nativist stance about the nature and structure of our minds.

With this discussion of genetic activity and prewiring in place, Marcus develops a reasonable middle-ground position that is capable of accounting (even experimentally) for both innateness and developmental plasticity. Marcus can do this, so he claims at least, because he believes that a number of cognitive structures are inborn, emphasizes the importance of gene cascades in guiding and directing the developmental process, acknowledges the role of developmental plasticity in both brain organization and cognitive development, thinks that (in principle at least) everything can be rewired, and so recognizes the role of very specific environmental exposure in moulding, forging, and sculpting the functioning of our brain.

[11] Ocular dominance columns are clusters of neurons present in the striate cortex of many mammals (including humans) that are particularly sensitive to inputs from one eye or the other.

[12] Analogous findings have been observed in turtles and mice. Scientists have consistently demonstrated that embryonic vertebrate brains instinctively produce neurons before their senses can enter into contact with the world (Coppinger and Coppinger [2001]), and that this self-generated activity enables those brains to refine their own pre-existing wiring (Wickett *et al.* [2000]).

[13] Here I would like to hint at a possible criticism of Marcus's view. Hochman ([2013]) has recently argued that a phylogeny fallacy (Lickliter and Berry [1990]) is committed when what looks like a proximate explanation is given as an evolutionary explanation in disguise. Though there is not enough room in this article to come to a conclusion on this issue, it is interesting to ask whether Marcus commits this fallacy here. When Marcus says that it makes (evolutionarily) sense to use prewired, genetically driven developmental strategies without describing the proximate biology/neurology related to it, he may be committing the phylogeny fallacy. That is, he might be giving an evolutionary explanation that looks like it has proximate science supporting it, when it in fact does not. Thanks to an anonymous reviewer for the helpful suggestion.

Marcus is right in many ways: He is right when he attacks strong instructionism and the hardwired account of psychological development related to it.[14] He is right when he asserts that genetic activity is designed to respond to environmental cues in the course of natural development. He is right when he accepts the existence of a degree of plasticity in our brain. He is right when he affirms that the environment can play a role in reprogramming our prewired brains. However, there are some elements (on which more below) that are missing from his proposal. Moreover, a fundamental question arises when we look at his neo-nativism: can the approach he is proposing still be considered as a form of nativism? There seems to be many points of contacts and very few important differences (as we shall see in the next section) between Marcus's neo-nativism and moderate anti-nativist positions (standard neuroconstructivism, for instance). In reconfiguring hardwired nativism, perhaps Marcus has pushed the nativist position a little bit too far and comes close in all but jargon to standard neuroconstructivism. In the next section, I explain why.

3 Is Marcus's Neo-nativism Really a Form of Nativism?

Standard neuroconstructivism, as we have seen in the brief preview in Section 2, proposes a unifying framework for the study of cognition in neuroscience. It explains the emergence of our cognitive architecture as by-products of the progressive organization that our brain structures undergo in response to both internal and external contingencies. Westermann *et al.* ([2010]) helpfully describe standard neuroconstructivism as characterizing 'development as a trajectory that is shaped by multiple interacting biological and environmental constraints' (p. 724), whose guiding principle is the idea of context-dependent learning, within and between levels of organization. One of the fundamental aspects of (standard) neuroconstructivism is the acknowledgement that cortical activity, affected by environment, behavioural patterns, and a host of other influences, can profoundly alter our cognitive architectures. Thus, neuroconstructivism, unlike traditional nativism, does not prescribe the ontological priority of a specific level of analysis over another, but rather calls for 'consistency between the neural and cognitive levels in characterizing developmental trajectories' (Westermann *et al.* [2007], p. 76). Standard neuroconstructivists posit the interrelatedness (on multiple timescales) of brain,

[14] Strong instructionism, according to Wheeler ([2007]), '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 is the view that the genotype is the blueprint for the organism, the holy grail of biology, the recipe for development.

body, and world, and argue that the interweaving of all these factors is equally important for brain development.[15]

So, standard neuroconstructivists do not embrace a reductionist standpoint in which cognitive change can be explained solely in terms of neural adaptation; rather, they describe cortical specialization as the results of an intricate process in which constrained mental representations get reshaped via learning and experience-dependent activities. Crucial in this respect is the debt that standard neuroconstructivism owes to Piaget's ([1953]) theory of cognitive development, according to which intellectual development goes through four fundamental stages (sensorimotor, preoperational, concrete operational, and formal operational), and knowledge is the result of a progressive reorganization of mental processes that is determined by biological maturation and specific environmental experience. Thus, standard neuroconstructivists strongly emphasize the role of developmental plasticity and specific environmental exposure in the unfolding of our cognitive behaviour. Having presented the conceptual palette on which standard neuroconstructivists rely, I now want to investigate the relationship between standard neuroconstructivism and Marcus's neo-nativism. Let me begin by looking at how they diverge. I will then turn to the points of contact and will argue that neo-nativism can be accommodated within the richer framework provided by standard neuroconstructivism.

It is obvious that there are some differences between Marcus's view and standard neuroconstructivism. Even if both Marcus and standard neuroconstructivists broadly agree that in the context of brain development everything can in principle be 'rewirable', they fundamentally disagree on the importance of developmental processes in generating our cognitive architectures. More specifically, Marcus believes (i) that certain (quite a few) fundamental cognitive and anatomical structures are the result of domain-specific learning (although there is room for domain-general learning on his account, and this is how Marcus differs from hardwired nativism); (ii) that these structures remain as almost-intact prewirings in the mature brain; and (iii) that gene cascades is what really matters in explaining their development. Standard neuroconstructivists, by contrast, think (i) that learning is essentially domain-general; (ii) that only a very restricted number of cognitive functions develop independently of learning and experience; (iii) that nearly all prewired modules present in the brain at birth get rewired during the developmental process;

[15] There is a strong analogy between the neuroconstructivist idea of brain development and the concept of interactive constructionism (on which more in Section 5 below) as proposed by developmental systems theorists (for example, Shea [2011]; Oyama *et al.* [2001]) in evolutionary biology.

and (iv) that gene-environment cascades, rather than just gene cascades, are crucial to understand the developmental process. These differences lead us to the real source of disagreement between these two accounts, that is, the extent to which learning and experience are believed to impact on the development of the brain. So, the main difference between these two approaches is essentially quantitative, involving the proportion of cases in which there is a key role for learning.[16] For Marcus, it makes sense (evolutionarily) to use prewired, genetically driven developmental strategies (strategies that do not rely too much on learning, because learning is costly and demanding) to guide and direct the development of our cognitive behaviour. For standard neuroconstructivists, on the other hand, it seems perfectly legitimate to affirm that the experience can play a major role in the developmental process because learning makes brain development more sensitive and adaptable to local conditions.

Despite the disagreement on this critical issue, it nevertheless seems that when we look at both accounts on a broader scale, neo-nativism and standard neuroconstructivism also share many important assumptions. First, both Marcus and standard neuroconstructivists recognize the existence of inborn mechanisms and predispositions, that is, both acknowledge the presence of cognitive constraints on development at birth. Second, both recognize (to a different degree) the role of learning and experience in the developing of our cognitive behaviour. Third, both accounts believe in rewiring. Fourth, both think of genes as crucial for brain development. Fifth, both approaches emphasize the crucial contribution of environments and talk of gene–environment cascades. Sixth, both renounce hardwired (strong) nativism. Seventh, both views agree that the developmental data cannot be ignored. Eighth, both acknowledge the role of cortical plasticity in moulding our cognitive functions. Thus, both Marcus and the standard neuroconstructivists draw on a similar conceptual palette.

This, however, leaves us with an important question: do these approaches really belong to different, antithetical traditions?[17] It seems to me, given the many similarities listed in the previous paragraph, that these views could be

[16] It is important to note that one of the insights that could be attributed to neuroconstructivists is that there are all sorts of developmentally important experiences that would not at all be construed as 'learning' in the traditional sense. To pick just one example, perceiving patterned light binocularly has important effects on brain structure, but such perception would not ordinarily be considered a form of 'learning'. Thanks to an anonymous reviewer for pressing this point.

[17] This question has both an historical and a conceptual reading. The two approaches belong to very different, antithetic traditions in terms of their history (and maybe sociology). However, I am arguing that, despite this, they are (surprisingly) conceptually close. Thanks to John Sutton for pointing out this distinction.

compatible overall, and that the differences one can find between them are due to a degree of emphasis, and are thus comparable to those one might find within two different approaches belonging to the same research paradigm. This entails another, perhaps more important question: how can two explicitly divergent proposals (one nativist, the other anti-nativist) converge so as to share that many conceptual assumptions? I think there is a reason for this anomalous convergence: Marcus's neo-nativism (despite his attempt to magnify the differences) doesn't differ that much from moderate anti-nativist (standard neuroconstructivist) claims, and I believe it could be accommodated within its richer theoretical framework. Marcus claims to be a nativist in public: 'I've always been closer to the nativist side, thinking that there probably are sophisticated mechanisms built in. I've been persuaded by scientists like Chomsky and Pinker that we start with something interesting in the mind. We don't just start with a blank slate' (Marcus [2004a]).[18] In truth, however, little of a traditional nativist position (except the label) is left in his own proposal. Marcus's commitment to the biology of neurological development and his acknowledgment of the importance of developmental variation forces him into necessary compromises, which bring him close in all but jargon to a standard neuroconstructivist account. Thus, I find no compelling reason to classify his account within the nativist tradition, and rather think that it can be inscribed within the richer, more encompassing, and better suited (standard) neuroconstructivist framework.

So far, we have seen that Marcus and standard neuroconstructivists hold similar (though obviously not identical) positions and share many assumptions. On these grounds, I have argued that Marcus's neo-nativism could be accommodated within the richer theoretical framework provided by standard neuroconstructivism. Having claimed this, I now want to turn to the second main goal of this essay—the friendly revision of standard neuroconstructivism—and present my positive proposal in more detail. In the next section of this article, I will concentrate on what I shall call 'dynamic enskillment', the combination of developmental plasticity and constructive mechanisms of learning, with socio-cultural activities and patterned practices. By adding these elements to the standard neuroconstructivist framework presented earlier and, in particular, by focusing on the idea that differently wired brains are the result of engagement in different practices, I want to argue for a view (neo-neuroconstructivism) that acknowledges all forms of possible construction throughout the lifespan.

[18] It is important to note that this is a straw man version of the critics of nativism. Neuroconstructivists certainly do not believe that we begin life with a blank slate.

4 Neo-neuroconstructivism and Dynamic Enskillment

Before I go on to describe my positive proposal in more detail, let me briefly remind the reader of the overall aim and dialectic of this article. The view I am endorsing (neo-neuroconstructivism) is not meant to constitute an attack on standard neuroconstructivism; rather, it is an attempt to revise it in light of a number of recent empirical findings in neuropsychology and cultural/social neuroscience. So, my proposal simply aims at adding another dimension (the dynamic enskillment) to the standard neuroconstructivist framework. In other words, there is nothing about the view I want to endorse that is hostile to standard neuroconstructivism—quite the opposite. A genuine (standard) constructivist should like my view and especially its focus on dynamic enskillment.

Standard 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. This increase in representational complexity is realized through a progressive elaboration of functional cortical structures, which are not selected from a constrained juvenile stock, but rather emerge in an experience-dependent way. Standard neuroconstructivists argue for progressive elaboration of neural structures. There is a sensitive period for learning and it is only if the early structures are in place that the later structures will develop since these build on what has occurred during the short phase-sensitive windows of opportunity that characterize childhood. This doesn't imply that the brain can't continue to change itself through learning at later stages, just that the ways in which it can change itself—the new structures it can build—are severely constrained by experience-dependent activities undergone in early stages of life (Mareschal *et al.* [2007]). Thus, learning is (for standard neuroconstructivists) a constructive mechanism, realized by means of continuous changes operated on constrained cortical structures in the early stages of life by experience dependent activities. This notion of learning lies at the very heart of the standard neuroconstructivist framework and it is absolutely paramount to understand it.

While fundamentally agreeing with standard neuroconstructivists on their characterization of learning as a constructive process, I nevertheless disagree with them on the extent to which learning is taken to be constrained by experience-dependent activities undergone in early stages of life. In other words, I do agree with standard neuroconstructivists that early experiences constrain development; however, I disagree with them on the implications of their assumption that the constrained and rewired cortical structures acquired in early stages of infancy cannot be themselves dramatically rewired and (re-)constrained later in life. Evidence supporting my criticism comes from the work carried out by Jay Giedd and colleagues ([2006], [2009]), who recently demonstrated the existence of a second period of synaptic over-production (followed by relative pruning of redundant connections) during puberty. This second wave of synaptic over-production (in all respects analogous to the one that takes place in early childhood) constitutes a second window of opportunity for the developing child. It is characterized by an extremely high degree of cortical plasticity and, more importantly, allows the developing adolescent to re-mould and re-forge the constrained cognitive structures acquired during infancy, preparing the adolescent's brain to take on the challenges that lie in the adult years of adulthood. According to Giedd, the structural changes that rewire the adolescent brain take place in many different brain regions, but there are three areas that are consistently remoulded: the nucleus accumbens (mainly responsible for reward-seeking behaviour), the amygdalae (mainly responsible for memory and emotional reactions), and the prefrontal cortex (mainly responsible for decision making, personality expression, and social behaviour).

Giedd's work provides good empirical evidence for adult neurogenesis, for a second period of synaptic plasticity during puberty, and more importantly for the possibility of rewiring already rewired and constrained cortical structures (the very same structures that were sculpted by experience-dependent activities during infancy) in adolescence. Giedd's research confirmed other results found by neuroscientists (such as Sowell *et al.* [1999]) at the beginning of the 2000s. Sowell and colleagues ([1999]) used an MRI to compare the brains of twelve- to sixteen-year-olds to those of people in their twenties. They found that the frontal lobes—the areas of the brain that are responsible for crucial executive functions (such as self-control, judgement, emotional regulation, organization, and planning)—undergo the greatest change between puberty and young adulthood, growing considerably and reaching their peak at ten for girls and twelve for boys. Sowell *et al.* also found that the temporal lobes—areas of the brain devoted to emotional control, processing of sensory inputs, and language comprehension—do not reach their grey-matter peak until age sixteen. But there is more: Giedd's findings not only confirm previous results, they were also extensively replicated by other researchers (such as Paus [2005] and Toga *et al.* [2006]), who pushed the grey-matter peak well into the twenties. More recently, Lebel and Beaulieu ([2011]) also claimed that 'the body of the corpus callosum, cingulum, and inferior longitudinal fasciculus demonstrate prolonged increases, confirming post-adolescent maturation' (Lebel and Beaulieu [2011], p. 10946). Together, these results show that the brain undergoes dramatic dynamic changes much later than we originally thought; beyond childhood, the brain manifests dramatic degrees of malleability, peaking during adolescence and continuing well into early adulthood. Thus, maturity isn't simply a matter of slipping software (learning) into existing equipment. On the contrary, the hardware profoundly changes and these changes reflect signals from the environment. Adolescent plasticity, then, can be understood as a period of profound change in the both the structural and functional organization of the brain (Choudhury [2010]).

These findings offer some empirical evidence for the friendly revision of the standard neuroconstructivist framework I suggested at the beginning of my article. These results profoundly undermine the idea of hard constraints imposed on development by sustained experiences in the early stages of life as well as the standard neuroconstructivist assumption of a unique, phase-sensitive window of opportunity confined to childhood.

More direct evidence for the neo-neuroconstructivism view I am after can be found in a series of neuroscientific studies in cultural and social neuroscience that have highlighted the need to add another dimension—the dynamic enskillment—to the standard neuroconstructivist framework outlined in precedence. It is to these studies that I now want to turn.

Draganski *et al.* ([2004]) used brain magnetic resonance imaging to visualize learning-induced plasticity in the brains of trained volunteers who, over a period of three months, had learned to juggle from scratch for approximately sixty seconds without dropping the ball (Draganski *et al.* [2004], p. 311). In undergoing their experiment, the team conducted two scans on the subjects involved. First, the participants' brains were scanned without prior juggling skills. Then they were scanned again after three months of intense and continuous practice. At this stage researchers were looking for changes in the distribution of brain matter as the jugglers learned their new skill. Using a specific quantitative measurement technique (morphometry), Draganski and co-workers then compared the brain scans obtained from the trained jugglers with scans from non-juggling control subjects. The experimenters found significant changes in the volume of grey and white matter in the brain of the jugglers, which displayed a remarkable increase in the grey matter in brain area V5 in particular (a region typically devoted to the processing of visual movement). These results were later confirmed in a follow-up study conducted by the same research group (Driemeyer *et al.* [2008]), who found an increase in the grey matter in the occipital temporal cortex with juggling practice, and that this increase in grey matter density was transient, progressively disappearing after a period (between two and four months) of failing to practice. These findings are particularly instructive because they reveal the direct correlation (even on a short-scale period) between skills and patterned practices (juggling skills in this case) on the one hand, and adult brain structural organization, on the other.

Cultural and social activities, however, not only determine structural modifications in our brains, but also affect the way they process relevant information. We know that there is evidence for dissociated digit and letter processing in our brains (see Jonides and Gleitman [1972] for instance). Despite this strong evidence, Polk and Farah ([1998]) designed an experiment to determine whether or not (extensive and repetitive) socio-cultural activities undertaken in adulthood could have an effect on this dissociation. They tested Canadian postal workers who spend eight hours on alternate days sorting mail by postal code. Unlike many other countries, Canadian postal codes are comprised of both letters and numbers (for example L6Y 2N4). This made these subjects perfect for the purpose of this study. The results the researchers found were fascinating: in comparison to their fellow postal workers who do not sort mail, Canadian mail sorters show significantly less behavioural evidence for segregated letter and digit processing (Polk and Farah [1998]). What we learn from this study is that culture and social practises can deeply and profoundly affect neurocognitive processing, impacting on the functioning of our brains, and continually rewiring any alleged pre-determined developmental outcome.

Further evidence attesting to the effects of skills and abilities on the recruitment and functioning of our cognitive architectures can be found in recent neuroimaging studies conducted on musicians. Ohnishi and colleagues ([2001]) in particular compared the brain activation of expert musicians with that of non-musicians and found that while listening to the same piece of music (namely, Bach's *Italian Concerto*), musicians and non-musicians displayed different areas of brain activation. In particular, subjects who were unfamiliar with classical music showed significant brain activity in the secondary auditory association area in the right temporal cortex, whereas the musicians showed brain activity in the auditory association area in the left temporal cortex and in the left posterior dorsolateral prefrontal cortex—the brain regions dedicated to the processing of language and working memory, respectively (Ohnishi *et al.* [2001]). This study once again reveals the power of rewiring, and how specific skills and abilities can affect the processing and the functioning of our brains, determining very different (mostly culturally driven) neural responses.

Similar results were also found in jazz musicians. Vuust *et al.* ([2005]) demonstrated that 'pre-attentive brain responses recorded with magnetoencephalography to rhythmic incongruence are left-lateralized in expert jazz musicians and right-lateralized in musically inept non-musicians' (Vuust *et al.* [2005], p. 560). The authors, in particular, interpreted this left lateralization as reflecting the functional adaptation of the musicians' brain to a particular communication task (the production of music) that, for the musicians, was very much like a language.[19] Vuust *et al.* ([2009]) subsequently observed that

[19] We know that the left hemisphere of the brain is responsible for language and speech production. It is probably this that has provided the authors with the analogy between music and language production.

jazz musicians, when compared to non-musicians, exhibit a larger and earlier MMNm response to unanticipated deviations in rhythmic presentations.[20] This much larger and earlier response is probably due to the fact that these unanticipated rhythmical deviations are key elements in mediating communication when jazz musicians improvise (Vuust and Roepstorff [2008]; Roepstorff *et al.* [2010]). So, it looks like the brains of professional jazz musicians react to rhythmic deviations more significantly and in a shorter period of time than the brains of non-musicians, and that this happens because jazz musicians (as opposed to non-musicians) are routinely engaged in musical practices that continually involve these deviations and improvisations, and thus consistently redeploy the same neuronal patterns to make sense of them. Again, this confirms the crucial role that cultural practices and social activities play in redirecting the development of our cognitive functions, even in adulthood.

Where do all these findings leave us? Before I look at the relevance of these results for the views I presented earlier on in the article, let me briefly connect them with the existing philosophical literature. I believe the notion of dynamic enskillment goes rather well with recent work conducted on cultural scaffolding in that philosophy of biology (Sterelny [2003]) and especially with the apprentice learning model developed by Sterelny ([2012]). The apprentice learning model highlights the role of adaptations in contexts of learning and teaching. For Sterelny, human evolution is not driven by domain-specific modules—pre-determined responses to problems raised by the environment—rather, it is driven by social cooperation, hybrid learning, communication skills, foraging strategies, and depends on planning, development, and intergenerational transmission of local expertise and technology. Thus, the apprentice learning proposal explains the development of human cognitive capital via high-volume, high-fidelity, large scale, reliable processes of cultural learning, and through cross-generation information pooling. A crucial role in the apprentice model is played by cultural inheritance: the generation-by-generation accumulation of information. Cultural inheritance is the result of the interaction of cultural learning and information pooling. Humans of one generation scaffold and transform (via developmental plasticity) the learning environment of the next generation, thereby creating (via positive feedback loops) a trans-generational exchanging of skills and practices. This can turbo boost their 'turbo boost' survival capacity and fitness in the long

[20] The mismatch negativity (MMN) is a brain response to violations of a rule, established by a sequence of sensory stimuli (Näätänen [1992]). It can occur in any sensory system, but is typically studied for audition and vision. In the case of auditory stimulation, the MMN occurs after a sporadic change in a frequent and repetitive series of sounds. For instance, a deviant and infrequent (p) sound can be interspersed among a sequence of frequent and repetitive (d) sounds (for example, *dddddddddddd-p-ddddddddd-p-ddddddd-p-ddddddd*...).

run. Thus, in combining (via cognitive re-engineering) information from the social world with information from the bio-physical realm, the apprentice learning model configures itself as a process of learning (and rewiring) by doing (Farina [2012]).

Understood within the philosophical framework provided by the apprentice learning model, those results from experiments exploring dynamic enskillment provide strong empirical evidence for the intimate dependence of human cognition (even in adulthood) on both socio-cultural environments and patterned practices. These results also highlight the power of brain plasticity in enabling the nervous system to successfully respond to environmental pressures, physiological changes, and personal experiences during both early adolescence and adulthood. These findings invite us to partially reconsider the framework proposed by standard neuroconstructivism (Westermann *et al.* [2010]) and also to rethink the idea of a unique, phase-sensitive period for learning. Although standard neuroconstructivists are right in asserting that the pre-specifications with which we come to the world are shaped and rewired in the early stages of our lives by experience-dependent activities and (normally) cannot be very easily changed thereafter because these early experiences constrain subsequent development, it nevertheless seems that these constraints on development shouldn't be understood as final: both social and cultural practices can still dramatically redirect both the development of our cognitive capacities and the functional organization of our brains in later stages of life. Culture and society, together with the brain and via cortical plasticity, provide the lifeblood for constructive mechanisms of learning, and these mechanisms are spread throughout our entire lifespan. In other words, developmental windows are not just developmentally determined in early childhood, but rather are culturally, socially, and interactively co-constructed throughout an entire lifetime.

The conclusion I draw from the two sets of findings mentioned above is the following: Standard neuroconstructivism remains valid overall as a framework for the study of cognition in neuroscience. However, it needs to be stretched further to fully account for the kind of plasticity found in adolescence and for the second window of opportunity observed in adulthood. More specifically, these results indicate that the constructivism of standard neuroconstructivism is not just (or only) a product of the nervous system's immaturity, but constitutes the longer-term potential of the system—including cultural, developmental, and social elements.

5 Conclusion

In this final section, I would like to look more specifically at the implications of the previous results for both neo-nativism and standard neuroconstructivism. How do the findings reported above inform Marcus's neo-nativism?[21]

The apprentice learning model and the concept of interactive constructionism as developed within developmental systems theory (Oyama *et al.* [2001]) are interesting and powerful philosophical tools to pair with what we know about enskillment. Interactive constructionism is the idea that biological development and evolution are driven by au-pair interactions between various resources (genes, environments, and epigenetic factors) without any one interactant being the locus of control. By pairing this notion of interactive constructionism with the findings analysed in the previous section on neo-neuroconstructivism, we gain a better glimpse into the evolution of our cognitive behaviour than if we were to rely exclusively on Marcus's neo-nativist approach where, recall, genes retain priority over other developmental factors. In embracing this truly developmental perspective, we understand that the environments in which we live has a huge and profound (and by no means secondary) influence on the initiation and orchestration of specific physiological processes, and in anatomically and functionally organizing our cognitive architectures. Although the anatomical structures and the cognitive architectures that characterize our brains develop through a common developmental path, they continually interact with one another and with their environment to change each other's functions—as in a cascading waterfall, where the water changes the stream bed and the stream bed affects the speed and path that the water takes. From these studies, we also understand that Marcus's idea of prewiring is problematic and should be replaced with a broader understanding that emphasizes the power of plasticity and rewiring throughout the entire lifespan. Sociocultural-based activities profoundly affect our mature cognitive architectures and what is pre-wired at birth is massively rewired (via patterned practices, culturally specific activities, and social engagements) later on.

But how do the findings presented above inform standard neuroconstructivism? Standard neuroconstructivism is indeed sympathetic with the notion of interactive constructionism. However, as discussed above, standard neuroconstructivism has failed to fully take into account the importance of plasticity, enculturation, and dynamic enskillment throughout the lifespan. The research on enskillment suggests that standard neuroconstructivists need to revise their framework so as to accommodate the second window of op-

[21] Although I have argued that Marcus's neo-nativism could be accommodated within the richer theoretical framework provided by standard neuroconstructivism, I haven't actually claimed that the two views are coincident; I believe it is appropriate to analyse these approaches separately in this final section.

portunity for learning, and the dramatic role that cultural practices and social activities play, not only in early childhood, but also throughout the entire lifespan. So, the findings discussed in Section 4 suggest a friendly restyling of the standard neuroconstructivist palette.

However, standard neuroconstructivists could resist this conclusion and object: The point about the second sensitivity window is a good one, which we failed to take into account (I grant you that); but it is just an empirical point in developmental neuroscience. How is this point philosophically relevant to our framework? In other words, what is there in the theory or in the conclusions that are drawn from the theory that is altered once we extend the sensitivity window? Couldn't the second window of opportunity and the findings reported in favour of the neo-neuroconstructivist view (and, in particular, dynamic enskillment) be accommodated by just a minor tweak to the standard neuroconstructivist theory?

This is a good objection, but there are ways to resist it. The theoretical framework to which these two research paradigms appeal is very different. One (the standard neuroconstructivist) looks at early infancy as the period in which the crucial learning takes place; the other (neo-neuroconstructivism) with dynamic enskillment proposes to investigate the effect of patterned practices and environmentally driven (cultural and social) activities throughout the entire lifetime, and challenges the existence of a unique sensitive window for learning. Modularity theorists such as Marcus ([2004b]) have tried to appropriate constructivist ideas to account for the role of development. In particular, they have taken the existence of a unique sensitive period for learning to be fully compatible with the assumption that the innate predispositions with which we come to the world will fully mature in early infancy, in response to experience-dependent activities. Thanks to these experience-dependent activities, it is claimed, the modules' functions are tuned up and fixed in stone so that they don't change, or change to a very limited extent, later in life. But here there is a question that needs to be answered: how can the nativists account for the existence of a second massive and dramatic window of opportunity in early adolescence? If those modules had fully matured in early infancy, realizing their function through positive interactions with the environment, will they now need to mature once more? Saying so would sound like an *ad hoc* hypothesis generated to rescue theoretical claims and to account for negative counter-evidence. Of course, such a hypothesis could still be made, but then there would be other concerns to worry about. For instance, how many maturation periods should we expect to explain the development of our cognitive behaviour? None (as the original nativists envisaged), one (as everyone is prone to concede now), or two or more (constant rewiring, as dynamic enskillment envisages)? And for how long does this maturation continue in our life? It seems the price to pay for accepting the second window of opportunity and the dynamic enskillment within the nativist framework would be too high for the nativist; it would cause a collapse of the original nativist position, leaving a much softer, non-nativist understanding. What would be left (if not the label) of the original nativist position when we push rewiring and development so well into adulthood?

So, to answer the standard neuroconstructivist objection, the empirical point about the second window of opportunity, and the impact of skills and cultural engagements throughout the lifespan, is relevant to the standard neuroconstructivist framework. It is essential to: (i) pose an original (yet unanswered) challenge to neo-nativist accounts of brain development; (ii) move the focus of the literature in a new direction, beyond mere 'pre-wiring' and towards 'rewiring'; and (iii) encourage attention on previously neglected life-stages of plasticity, which in turn provide significant evidence for the implausibility of neo-nativism. For these reasons, it seems fair to suggest a friendly revision of the standard neuroconstructivist framework along the lines envisaged by neo-neuroconstructivism and dynamic enskillment. That is, standard neuroconstructivism should recognize all forms of possible scaffolding and construction across the lifespan and not merely focus on (and privilege) one developmental phase.

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