

Layers in the Fabric of Mind: A Critical Review of Cognitive Ontogeny

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Cognitive science, particularly in the last three decades, witnessed several creative moments and innovative proposals on several issues related to cognition – the nature of mind, naturalized epistemology, cognitive development, biological roots of cognition, and an attempt to understand what is it to be distinctively human, scientific, theoretical, and socio-cultural. Encouraging leads to the underlying biological roots of cognition also came from neuro-physiological investigations as well as theoretical biology. Cognitive architectures based on information processing approaches are gaining strength and becoming popular and getting closer to being accepted as the received view on the subject. This multi-disciplinary discourse, along the way, not only reenacted several traditional philosophical positions, but also exhibited considerable innovation in rephrasing the traditional questions guided by a huge corpus of scientific findings from AI, physiology and pathology, and ingenious experiments on cognitive agents (both non-human and human subjects, including infants in the crib). While taking note of the achievements thus far, I wish to identify some conceptual and foundational problems in the dominant trends of current cognitive science. Given this vast multi-dimensional canvas, a single essay cannot do justice to critically review the area. I will therefore

focus here on what I consider as fundamental issues that must have a bearing on cognitive science and science education as a whole. Approaching these problems as an epistemologist I will focus on the issues closer to naturalized epistemology and architecture of mind than on empirical cognitive psychology.

It is celebration time for rationalists and constructivists. Gone are the days when mentalese was more or less forbidden in academic departments. Cognitive phenomena does not constitute merely the behavioral (stimulus-response) patterns of a ‘black-box’. Constitutive reality (both form and substance) of the cognitive agent is today considered highly relevant for the scientific study of mind. There are predominantly two kinds of camps: those who believe that cognitive faculties are completely specified by the innate biological reality (Noam Chomsky, Jerry Fodor), and those who believe that they develop during ontogeny based on incompletely specified ‘embryological’ reality (Karmiloff-Smith, Susan Carey, Alison Gopnik). While it is possible to identify other positions that are in neither of the camps, a significant point to note is, almost none of the modern views are of the traditional rationalist or empiricist variety. Most of the current pundits reformulate the older questions so as to make them addressable

by scientific means: towards a naturalized (more or less genetic) epistemology. According to the current trend, Piaget's theory of across the domain mechanism of cognitive development found no experimental support. Instead they painstakingly studied the developmental patterns that are 'general' enough only within specific domains (Spelke, Mandler, Karmiloff-Smith, Gopnik, Hirschfeld, Gelman). A striking observation made by cognitive developmental psychologists who did ingenious experiments with infants in the crib was that quite a few concepts that were supposed by Piaget as products of a lengthy process of cognitive development were demonstrated to be either more or less innate or develop very soon after the post-natal ontogeny. Chomsky's and Fodor's rationalist philosophy forms a supportive framework of these studies dismissing empiricist, associationist and behaviorist beliefs on one hand and Piaget's (aka Kantian) empty schemas on the other. Most notable among these studies are those that demonstrate and argue that *language is instinctive and peculiarly human*.

In the last half-a-century, developments in computer science, particularly AI, have contributed several enlightening metaphors to cognitive science without which the discipline remains impoverished. The most significant contribution from AI has been in the area of knowledge representation and memory, drawing mostly from the centuries of deliberations on epistemology and logic. Today these remain the least controversial among the proposals on the architecture of mind based on the information processing approaches. Most notable and highly relevant to the current review are the concepts of *modularity* and *encapsulation*, borrowed from object oriented abstractions of procedural and declarative data modeling. Fodor's highly influential architecture of mind proposed that the mind is composed of peripheral (perceptual), domain-specific, dissociable functional sub-systems that are mandatory, swift, and involuntary processing units, wholly determined by evolutionarily selected genetic endowment. However, the high-level central cognitive systems that are involved in belief, creativity, reasoning etc., according to Fodor, are amodular and non-encapsulated. A group of scholars disagree with Fodor and attempt to modularize almost every cognitive faculty of mind making it massively (entirely) modular. In this context I will argue against the notion of informational encapsulation, by proposing that *cross-representation* of cognitive dimensions, which is impossible with encapsulation, is *essential* for the formation of concepts of any kind. Mandlers' observations suggest that percepts and concepts should be carefully distinguished. I shall further explain this distinction and the transformation of the former into latter using cross-representations. Further evidence from parallel distributed processing ap-

proaches used in simulating the process of concept formation, the traditional arguments of associationism, and the individuation argument, will be used support of this claim. The observations that prompted the hypothesis of informational encapsulation can be explained by invoking *selectively sensitive* sub-systems and/or anatomical constraints.

A leading developmental psychologist Karmiloff-Smith rather convincingly demonstrates that some behavioral (cognitive) modules actually are culminations of developmental process and not entirely innate. A brilliant theory of *representational redescription* (RR) was proposed by her to explain gradual and recurring reencoding of more or less inaccessible (encapsulated) implicit representations into explicit accessible representations leading to behavioral mastery. While Karmiloff-Smith's observation that modules must be culminations of a developmental process is reasonable, we need to distinguish between the modules that develop during embryogenesis (pre-natal ontogeny: **Layer 1**) and those that develop after birth (post-natal ontogeny). The former is ontologically and physiologically rooted in *biological* being, while the latter *cognitive* development is formal (relational), symbolic and epiphenomenal in nature. The post-natal cognitive development, I will argue, should be further differentiated into three layers: perceptual/conceptual (**Layer 2**), socially mediated folklore (**Layer 3**), and the counter-intuitive, rule based, explicitly constructed formal knowledge (**Layer 4**), the last two being peculiarly human. Most Fodorian modules (with the exception of the language module) are actually the *result* of pre-natal-embryogenesis, and not post-natal cognitive development. Though both pre and post-natal modules are part of the ontogeny of a single cognitive agent, they do not, so to speak, lie on the same path of development. In the case of human beings, the post-natal development is highly complex, making the distance between humans and apes almost unbridgeable. Karmiloff-Smith correctly argues that RR is peculiarly human. However, Fodorian modules and the peculiarly human behavioral 'modules' belong to different layers of ontogeny mediated by another layer of conceptual cognition. I will argue that RR occurs in post-conceptual ontogeny and not during the formation of conceptions. While holding that cognition is entirely biologically rooted, cognitive scientists must realize that biologically enabled 'social-physiology' as against biochemical neuro-physiology are distinguishable layers of ontogeny.

This brings us to the important question of what makes us peculiarly human. There are very few scholars who believe that cognition is only human, but it is often argued that the so called higher modes of cognition such as self-consciousness, theory of mind, fabrication

of tools, language, scientific knowledge, etc., must be peculiar and defining characteristics of human nature. Very absorbing discussions of Daniel Dennet's levels of intentionality, Merlin Donald's three stages in the evolution of culture and cognition, and Peter Gardenfors's account of how Homo became Sapiens, provide a fruitful intellectual context to critically review the various proposals on this interesting question. The bundle of peculiarly human characteristics are strongly correlated to the social fabric of human life rather than genetic, neuro-physiological domain. Evidence is gradually accumulating to suggest that the larger size of human brain (encephalization) has mostly to do with the new found socio-cultural context during phylogeny. The fact that the genetic and anatomical differences between apes and humans is so marginal indicates that this problem is unlikely to be answered by gene and brain-centric view-points. Socialization and language go hand in hand, for they are not possible without each other. It seems therefore plausible to hypothesize that representational redescription is an *essential* mechanism in producing *external* memory space helping to enhance much needed memory capacity for storing cultural heritage, and also for *detached* processing of information: explaining thinking. Taking clues from Karmiloff-Smith and Merlin Donald, I think, it is possible to explain much of the peculiarly human features using this mechanism. Coherent with the above argument favoring a delineation of the biological development from the cognitive development, I shall argue that there are two *inter-dependent* but *superveniently* evolving inheritance mechanisms: biological and social. The nature of human beings cannot be understood without delineating the two. We have abundant evidence to support the point that the evolution of culture and higher forms of cognition are correlated.

Many leading cognitive psychologists (e.g., Alison Gopnik) today believe in a strong working hypothesis called: theory-theory. According to this view no knowledge worth the name can be non-theoretical, and the basic mechanism (or methodology) of knowledge formation and evaluation happens by theory change, and this mechanism is universal. By demonstrating that even infants in the crib are little theoreticians, they argue that the mechanism that makes us know the world around is the same as the one that makes science. While agreeing with them that there are general cognitive mechanisms (or methodologies), it is necessary to make certain finer distinctions which weaken the strong form of theory-theory. First of all, we need to make a clear distinction between conceptual and analogical: the former is a result of cross-representation while the latter is a result of *'across'-representation* drawing in similarities across domains based mostly on relational knowledge. Further, all theories are not of the same

nature, particularly the model driven, counter-intuitive scientific theories. While folklore is also sufficiently theoretical (analogical) and non-inductive, a form of knowledge belonging to another layer of cognitive ontogeny—mostly but not necessarily identical to scientific—can be clearly distinguished: let us call this *formal*. Formal knowledge is an *explicitly constructed* form of knowledge in the sense that the rules of construction are overtly specified. This form of possible world construction creates an idealized description of the actual world that describes indirectly (mediated by models) the phenomenal world. Only in this form of construction can we find *invariant relativistic descriptions* of various flavors of scientific theories. Contrary to the claims of theory-theory proponents, I suggest that transformation from the cognitive layer of folklore to explicitly constructed knowledge cannot happen without formal instruction, necessitating social institutions like schools. This argument, if it is valid, can have profound practical implications in the context of science education. Needless to say, my position goes against the views in philosophy of science that theory-theory finds support in.

The four layers of cognitive ontogeny, that helped us to critically appraise the current popular models of cognition, clearly correspond to developmental *stages*, but are not strictly identical to Piaget's. Firstly, cognitive development is supervenient on the physical development, and not a continuation of the same line of development. Secondly, the layers are distinguished by a bundle of features that go hand in hand and are not strictly age-dependent and may happen in different phases in each domain depending on environmental pressures. Thirdly, the four layers recapitulate phylogeny supporting Piaget's claim of cognitive version of biogenetic principle.

Based on the above critical exposition, a few comments I think are in order on the perspectives and prospects of cognitive science. While arguing against the behaviorist model we tended to be excessively 'inward' looking in our search to describe human nature. If my arguments have any weight, we should be looking mostly at what is publicly accessible to understand what is peculiarly human. This reminds us of one of the most brilliant philosophical arguments in the history of philosophy: Wittgenstein's private language argument, where he argued against the possibility of private representations. Neuro-physiology can inform us of the manner of encoding episodic memory, but possibly none of semantic memory, an essential form of human cognition. It is highly likely that semantic memory is stored exclusively in the externalized public socio-cultural mind-space. Scientific knowledge is necessarily and undoubtedly located in the inter-subjective space. A few of our scientists have 'gut' reactions against science

having a socio-cultural foundation. But, I think, this does not by any means make it less objective, since externalizing by reencoding is the only means of making private subjective knowledge public and potentially objective. By interpreting Wittgenstein's argument as it applies only to semantic memory and not episodic, I suggest a transformation mechanism in terms of representational redescription, which explains one of the mechanisms involved in learning and discovery. A cogent and complete understanding of learning and discovery cannot be accomplished without responding to Wittgenstein's challenge.

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