Common Roots of Perception, Conception and Conscious Action

Nagarjuna G.
nagarjun@gnowledge.org
Homi Bhabha Centre for Science Education, TIFR
Mumbai, India.

February 3, 2009

1 Our ability to translate implicit modularized knowledge into explicit declarative knowledge is the root of perception, conception, conscious action, language and culture.

The main objective of this communication is to state that the underlying cause of human cognition, mind and social culture is one single ability. What we see is a butterfly effect.

1.1 Modulation of modules and modularization are the two fundamental processes of human cognitioin.

I will argue here that there are two main fundamental mechanisms in higher cognition that are inverse to each other. The two mechanisms are: (a) modulation of modules and (b) modularization. The popular *modularity of mind* view[7] gives us a static picture of an otherwise dynamic process called mind. The sense and reference of *modulation of modules* will be elaborated in this essay. The inverse process, *modularization*, will be alluded to and will not be elaborated here for two reasons. One: this view is well developed by Karmillof-Smith and others. (See [11] and [5].) Two: I think my main contribution to the debate is *modulation of modules*, and that is the main focus of this paper.

1.2 The mechanisms of perception, conception and thinking are same.

This is an argument for an ontological reduction of perception, conception and thinking, contrary to general understanding. I will be arguing against the view that conception and thinking are considered part of higher cognitive faculties while perception is considered a lower cognitive faculty or module concerning only with producing output for higher cognitive processes.(For example see [8].) The underlying mechanism is the modulation of modules. The following sections elaborate this mechanism.

2 The fundamental transition is from modular cognition to modularized cognition.

The central thesis will be developed by first identifying a transition in the cognitive development: from biologically rooted procedural knowledge to socially rooted declarative knowledge. Why is the transition from procedural knowledge to declarative knowledge important? In the current literature, sensory-motor intelligence is mostly assimilated into what is generally known as *procedural knowledge*, as against *declarative knowledge* [16]. During the cognitive development a child undergoes the transition from the modular, unconscious, non-verbal stage to non-modular, conscious, conceptual and verbal declarative knowledge. Since we do not begin with a display of verbal declarative knowledge soon after we are born, but develop them eventually, even nativist's must account for this transition, even though, strictly speaking, they are not developmentalist in their temperament. Ontologically, the problem is as fundamental as the transition from non-living matter to living matter.

Piaget's model of cognitive development aptly identifies this problem to be the focus of the transition from first stage to the second. He mentions that sensory-motor operations provide the early *schemes* for developing the corresponding concepts (*schemas*) associated to the schemes [24]. In his model, cognitive agents act on the objects, and this action is essential for learning. In this sense each subject *constructs* by acting on the experience. Piaget made a strict connection between motor competence and conceptual competence. Though he underestimated infants' cognitive abilities, and made sensory-motor stage pre-conceptual, his studies continue to be relevant till date, for his identification of the problem is arguably correct. Subsequent studies on infants showed that such a stage may not be more than a few months after birth, while nativists argued that conceptual knowledge and consciousness are innate [1]. In a recent work, Jean Mandler provides an account of how wrong Piaget was, based on the work of several other researchers, in assuming that infants during the first stage do not have declarative knowledge. Mandler argues, that both sensory-motor competence and conceptual competence develop almost at the same time and this happens very early, as early as six months after birth [16].

Karmiloff-Smith in her work on *Beyond Modularity* describes her theory of *representational redescription*, where she tries to reconcile the Fodor's nativist model [20] with that of Piaget's developmental model [23]. During the process of representational redescription, *implicit* procedural knowledge transforms into *explicit* declarative conceptual knowledge by a process of reencoding [10]. In *Origin of Modern Mind* Merlin Donald narrates with detailed substantiation of the evolution of modern humans from Apes, where he convincingly demonstrates the transition from the more primitive procedural to *episodic* memory, which inturn, over several thousand years, transitions into more recent and peculiarly human *externalized* memory, with the intermediary mimetic and mythical stages [3]. Though Donald is not talking about ontogeny, but phylogeny, the order of the transitions provides important clues to the possible way how a child might develop into externalized social being.[1] Peter Gärdenfors in his recent work *how Homo became sapiens* agrees with Donald and adds further weight to the *externalization* hypothesis, and underlines how a process of detachment could help in the transition, as well as characterize the peculiarly human cognition [9]. Keeping in view of the Vygotsky's emphasis on the role of social character of human mind [27], and Wittgenstein's strong argument against private language, and essentially social nature of language and thought [29], leeds us to expect very strong social and culturally rooted account of human mind. We may not be able to accept these apparently incompatible views, unless we can reconcile them by employing a sound conceptual base. In this essay I move towards such a reconciliation. If developmental psychologists' are correct in stating that during early ontogeny implicit knowledge metamorphoses into explicit knowledge, Wittgenstein's argument of impossibility of private language comes into trouble. Though Wittgenstein's arguments were intended against the empiricist epistemology, the same argument can be cast against developmentalists.

While it is possible to discern subtle differences between the various positions mentioned above, what comes home is that, to understand the nature of human cognition, it is important to understand the relation be-

[1] No strict recapitulation of phylogeny in ontogeny is really possible, particularly due to the force of enculturation process as soon as the baby is born.

tween the hardwired, implicit, inaccessible, procedural knowledge rooted in *neuro-sensory motor mechanisms* on the one hand and explicit, verbal, symbolic, accessible, public, conceptual, declarative knowledge rooted in *socio-cultural mechanisms* on the other. Even though a nativist like Fodor did not believe in developmental view of cognition, he correctly identified that the harder problem of mind is to understand the relation between the modular and the non-modular components of the mind [20, 8], defining the scope of the fundamental problem of cognitive science.

It is important to note that I am making an over generalization when I clustered a large set of descriptions of the phase before and after the transition, in the above passage. Such a grouping is not justifiable. We may discern the subtle differences among them. The clustered description however will help us to confine broadly the domain of discourse that we are focusing in this essay.

The engaging problem therefore is either to understand the functional *relation* between modular and non-modular aspects of mind, as a nativist would like us to say, or the *transition* between procedural knowledge to declarative knowledge, as developmentalists would want us to say. I tend more towards the developmentalists, though I see a hope to reconcile, as Karmiloff-Smith did, and would want to grapple with the transition problem. Either way, it is clear that this is a non-trivial problem of cognitive science, and a solution to this problem will have serious implications in understanding human cognition.

For terminological convenience, I will call this *transition from harder to softer cognitive phenomena*. The choice of this terminology will become clearer below. In what follows I undertake to explain this transition by hypothesizing that *softer operations* that are peculiar to higher cognitive agents in the evolutionary order are rooted in the physiological nexus between neuro-sensory and muscular subsystems of the cognitive agent. The proposal can not only be worked out to be coherent with the conceptual and substantial insights of the authors mentioned above, but also paints a canvas that makes several of the scientific findings from biology, cognitive psychology and epistemology fall in place neatly.

3 Considering the genetic makeup of apes and humans is minor, the large size and asymmetry of human brain, social life, combinatorial ability, and motor dexterity stands in need of an explanation.

No significant differences exist in the genetic makeup between apes and human beings. One of the phenotypic differences is the well known fact: size of the brain of human beings is largest (about three times of the nearest primates) in relation to the rest of the body with about double the number of neurons. The large size is attributed to the increased size of neocortex (cerebral cortex) which contains three fourths of the neurons in the human brain, which are organized into the two hemispheres. Today we know that most of this area of the brain is responsible for the sensory-motor functions of the body, covering all the sense organs and voluntary muscles. This is the most striking and singular difference that must be explained by any theory that tries to explain the roots of higher cognition.

Stronger correlations between the formation of social groups in primates and the size of the neocortex is getting established[4]. *Encephalization* hypothesis, progressive increase in cognitive abilities are directly connected to progressive increase in the relative size of the neocortex, and *lateralization* of hemispheres with analytic left and synthetic right side, are two other important observations that also need to be explained. These phenomena are correlated to speech, language, and analytical abilities. There are evidences and counter evidences to the view that left hemisphere alone accounts for most of higher cognition. Whatever be the outcome of this ongoing research, there is sufficient evidence that asymmetry in the brain is one of the important developmental phenomena that needs to be accounted.

Chomsky's proposal that generativity, a combinatorial ability to generate compositions from some basic units, found some interesting empirical and theoretical support from the works of Kosslyn and Corballis[3]. Though the localization debate, whether left hemisphere is responsible for all the higher and peculiar cognitive functions of humans, as argued by Corballis, may be contested, the importance of explaining generativity is inescapable for any one interested in explaining the human cognitive phenomena.

Kimura's observation that *serial motor control*, an important ability of human body, is also localized on the left hemisphere, and must be a precondition for the eventual development of special communication skills of humans, mime and language, should not be lost sight of[12]. While the sophisticated motor control is localized to the left or right is an empirical question, the point that *motor control* is the root of higher cognitive abilities is an important observation.

We are so different from the other homonids, particularly in very highly developed cognitive and social world. Yet the absence of fundamental differences in our genetic makeup suggests that the difference cannot be radical and qualitative, but quantitative (a degree of difference). Our belief in evolutionary ethos is firmly rooted in the current intellectual atmosphere suggesting that this variation must be minor. However, a few minor variations can indeed produce ramified effects. The story of human cognitive evolution must be accountable on a few such minor variations. As indicated already, in what follows I provide an account of those minor variations that made the peculiar cognitive and social features of human being possible.

4 What is the minor variation that caused the cognitive butterfly effect?

Human body is the most flexible and dexterous of all the higher animals. We are not talking about gymnastic abilities which only a few humans develop, but the number of finely controlled muscles all humans have. Dogs and cattle, may have an ability to move their ears unlike humans, but they still don't have as many controllable muscles as we have.

Every animal has muscles. Cats and dogs have as many muscles and joints as we have, but the degree of freedom each of those joints have is far less. For example, we (and other primates) can move fingers more ways than other mammals. Our legs have far more degrees of freedom than other hominids, added to that is our flexible hip joints which helps us to stand erect as well. Point is not just this.

Our appendages (hands, legs and head) can turn back to our body. We see cats and dogs turning around with their flexible neck and lick their body with their tongue. We see cats and dogs using their hind limbs used for cleaning, and driving away insects. While our neck may not be as flexible as theirs, but our hands are. We can approach every part of our surface with our hands, particularly while taking bath, which is very unique. We will see later how this reflexive ability adds to the shaping of *manipulable auto-generated perceptual field*.

4.1 The distinction between harder and softer motor operations is the key to the cognitive transition.

Most animals use their body parts usually only when they have a *harder* biologically mandatory purpose. While we do a number of activities that are *softer* meaning *biologically emancipated*.[2] Harder operations are biologically necessary and are obligatory, while softer operations are fringe actions, and the animals' survival, in a medical sense, doesn't depend on them. Softer operations' adaptive role is not to be doubted here. Adaptation is a much broader question and is context dependent, while we can always conceptually distinguish a minimal sense of survival. Most important to note is that softer operations are *learnable* and are *voluntary*. Fetching food and eating are harder, while wagging a tail is softer. However, a fish's tail 'wagging' is harder. Walking and running are harder, while tapping feet, clapping, hand waving are softer.

No other animals' life is full of softer habits than human beings. All our childhood is spent learning and mastering softer habits, starting from thumb sucking, clapping to playing games, singing, dancing and talking. Our life is impossible without softer habits, we will be reduced to mere instinct driven beings without them. Softer habits and social habits are intimately related and give rise to the higher coginitive abilities of humans will become clearer below.

4.2 Softer operations are all due to *emancipated* motor actions.

They are emancipated because they are freed from the harder habits. Frederick Engels and others who speculated on the human evolution talked only about the emancipation of fore limbs due to erect posture. But my emphasis here is on a multitude of muscles of our body, though predominantly those of hands, mouth, and vocal chords, which are emancipated. I claim that such emancipated motor operations are the basis of higher levels of cognition that we developed, including language and culture.

Voluntary control is an essential character of all softer operations, for softer operations are only an extension of the already existing set of voluntary muscles, that are coordinated by the peripheral nervous system and central nervous system. It is the same skeletal muscles that were used for harder operations but were emancipated for a newer role. However we may ask, whether voluntary actions are the cause of emancipation or emancipation the cause of voluntary actions. A frog may never shoot her tongue just for fun, in the absence of any stimulus, but she does have control in shooting to the direction of the prey. This suggests that volition is a necessary condition for emancipation leading to softer habits, than vise versa.

[2]The choice of the terms 'harder' and 'softer', in place of 'hard' and 'soft' is to suggest that the distinction is relative and not categorical.

What is the nature of this emancipation? Most animals have a bilaterally symmetrical body organization. The organs and appendages also behave in a symmetric way for most functions. Emancipated operations are a result of *breaking* this symmetry in functionality. A well known case is that of *unimanual* skills observed mostly in primates. Peter Macneilage reviews this and aptly characterizes this as necessarily asymmetrical act[15]. Lot of literature both in human behavior studies and primate behavior studies can be found on preferences in handedness. It is well known that righthanded bias in human beings is attributed to its origin from the left hemisphere. These studies though are relevant, the central point I am making is not concerning only that of hands. Almost every voluntary muscle in our body is emancipated.

It is not only symmetry breaking, but also fine control of each muscle, aka dexterity. For example, each finger of our hand can be moved independent of others, though by training. Our ability to type and use of instruments like Piano are good examples of this skill. This is a modulation of each independent muscle. Most animals use the entire hand as a single unit, while in humans almost every joint of our hand can be independently manipulated. Our ability to speak, for example, is also due to such fine control of muscles that can release a sequence of fifteen consonants and vowels per second[15]. This soft operation may not appear like a break of symmetry, but an ability to make all the isolated muscles to work serially and independently of one another. Thus, although, human beings may have the same number of joints and muscles as any of the closer hominids, the main difference consists in human body's ability to modulate each of the muscles independent of the others. Human being therefore is most complex of all organisms—without taking into account the apparently non-biological features like language, intellect, social behavior—on the biological level alone. The large size of the human brain (encephalization) can be accounted for this fact alone without bringing in other behavioral complexities. I will argue that rest of the peculiar and higher faculties of human being are a result of this singular difference. However, it is important to note that this continues to be a degree of difference, for softer operations are seen in other higher animals too, but none as prolific as in humans. Therefore this variation can be accounted as per the regular evolutionary models and in this story there seems to be no break.

5 Rewriting mechanism can translate implicit declarative knowledge into explicit procedural knowledge.

Karmiloff-Smith proposed a theory of *representational redescription* to explain gradual and recurring reencoding of more or less inaccessible (encapsulated) implicit representations into explicit accessible representations leading to behavioral mastery[10]. As a model that explains the transitions during cognitive development, I find it important to relate it to the central idea of thiis paper.

Most important aspect of the transition that Karmiloff-Smith is explaining is from implicit to explicit, which during recurring reencodings becomes progressively more accessible. Karmiloff-Smith of course also talks about the inverse transition, of how modules develop when explicit knowledge transforms very often into implicit knowledge. When the operations were in the automated procedural domain, there is encapsulation. However, soon after the emergence of emancipated motor operations, the operations become conscious. But the conscious operations do not remain so after achieving behavioral mastery, they get modularized, and become another layer of procedural mastery, to disappear from the conscious gaze. Thus she explains, by reconciling Fodor and Piaget, the modular behavior of our linguistic mastery among others. I tend to agree with her, and see my proposal as one that fills more content into the mechanism of representational redescription (reencoding).

If there is any truth in this line of argument, the crux of everything depends on our ability to *encode* or in a lesser technical jargon *write*. Considering the symbolic character of conscious action and social behaviour, I would halt and press on this question: what is in our body or an embodied mind that makes *encoding* possible? This ability to encode seems to be the key action that makes implicit procedural knowledge explicit and declarative, so that the *private mind* is accessible to others. Therefore understanding this mechanism is vital for understanding how we communicate, how we make our internal thoughts explicit.

This process, I shall elaborate, happens due to proprioceptic soft motor actions.

6 There is no unconscious perception and all seeing is seeing as.

Most traditional and empiricist notion of perception supposes that first we get some input from experience, then we do abstraction. It is increasingly getting clearer, several empirical studies in cognitive science, that Kant was right and empiricists' wrong.[21] The question is where are the schemes? Do we get them by birth? Where are they located? Are they in the brain?

Dominant view is to locate all higher faculties of cognnition in the brain. Recently this view is under pressure. Embodied cognition view is gaining popularity.[14, 2] Merleu-Ponty and Gibson are often recalled. The location of mind is getting displaced from brain to body, and from body to external world and in some cases to society.

This shift of the central location of mind to an extended space of body, world and society can also be seen on philosophical debates about perception. In this narrative, one must mention Piaget, who focussed on the role of subject's *action* in cognitive development. He identified proprioception and linked to *conscious action*. Piaget's model has a unique place for sensory-motor operations for the early cognitive development, and he correctly mentions that motor operations are the early *schemes* for developing the corresponding concepts (*schemas*) associated to the schemes. In his model cognitive agents act on the objects, and this action is essential for learning. Piaget made a strict connection between motor competence and conceptual competence.

Thus the argument that softer self-reproducible and reflexive motor operations are necessary for cognition and consciousness is coherent, though not identical, with that of Piaget. Though he underestimated infants cognitive abilities, and made sensory-motor stage pre-conceptual his studies continue to be relevant till date. Subsequent studies on infants showed that such a stage may not be more than a few months after birth, while nativists argued that conceptual knowledge and consciousness are innate[1]. Several others who believed that *mind is in action* continued this approach.[22]

A very modern statement of Hanson's view—all seeing is *seeing as*—comes from Alva Noe's *Action in Perception.*[21] Noé He takes a radical view that perception is already thinking. I tend to agree with his views for two reasons: first his philosophy is based on sensorymotor action and is not brain centered, and second he uses proprioception of motor actions. I take off from his theory, and add an element of detail with regard to the close link between perception as conscious action and concept formation and encoding.

7 The cause of perception is conscious action.

This counter-intuitive assertion is the central thesis in this context. As mentioned already the traditional view wants us to believe that perception is *passive* and happens due to the existence of sense organs (modules in Fodorian jargon) and the output of these will be processed in the brain where interpretation happens.

I make this assumption that sense organs are indeed passive, they do produce output and not mind about interpreting them. However, the output cannot come into conscious attention unless the proprioceptive motor action mediates (filters). Best way to visualize this condition is: consider all sense organs are mounted on a moving organs of a body. When sensory output is generated, neglect (dump) it unless the proprioceptive moving organ (the mount) does not move. That is, consider only those outputs that are coming into the body stream only when the mount is moving. Since, the movement of the mount is known, the agent can make a direct *link* between the motion of the mount and the incoming signal.

Let us assume that different mounts are capable of different degrees of freedom, therefore different kinds of motion. The set of all possible motions of the mount, I propose, can be taken as the conceptual scheme. In computer science terminology, I call this a *datatype*. This datatype provides the *attributes* or *properties* that will be linked to the incoming signal (phenomena). The incoming signal becomes the *subject* of the 'proposition'. Thus, different proprioceptive mounts with varying degrees of freedom provide different conceptual schemes. The important point to note is that this is already *intentional* and *propositional*. This explains why all perceptions are conceptual from the root.

The assumption I am making, as may be noted, is that the mount is proprioceptive. One may say that the result is intentional because intentionality of the mount is already assumed, and to be intentional is to be conscious. Isn't it question begging? My reply to this possible objection is, proprioception is not difficult to fabricate. Robotics already uses this to economize on the required computation.[6] Proprioception can be understood as a transducer.[3] All that we need to fabricate a proprioceptive transducer (the mounts) is to build a transducer that informs displacement state (change of position) to a central processor. The input subsystem (again

[3] A transducer is any input subsystem that informs its change of state within a given range to a central processor. A haptic transducer will send tactile information, a photoreceptor will send visual inforamtion, etc. Physically a transducer transforms one form of energy into another.

a transducer) of any modality, say of heat, light, sound, touch, smell etc., will be mounted on a motion detector.

Considering that the identity of input subsystems, their modularity, and their implementability in artifacts as transducers is already well established, the central novelty of the above proposal is the idea of mounting sense organs on a muscle.

In this picture, the muscle becomes the data processing engine. I think, this hypothesis when accommodated into the already existing views of embodied cognition we can see that the implications are promising. Let us take an example. The opening and closing of an eye lid, retracting and extending an arm, inward and outward movements of any appendage, etc. can not only provide the binary datatype (0 and 1), can also provide the various possible values between the 0 and 1 as a resolvable space. Thus various spacial metaphors (categories) can be generated. Lakkoff's *Philosophy of Flesh* contains several examples. It may not be difficult, I think, to work out these examples using the above idea.

The view presented can also be accommodated with the dynamical models of mind.[25, 26] After all, all motors and sensors (transducers) are made using dynamical principles applied in mechanical engineering.

The current computational approach, usually called information processing approach, focusses a lot on what happens in a CPU (central processing unit). Most scientists and philosophers always linked a CPU with central nervous system. I beg to differ here. As indicated in this proposal, the processing (encoding and decoding) happens in the sensory motor body and not in the circuit (the brain). Circuit is important, for connections between processors is vital for decoding (interpretation).

This brings us to another important idea called *cross representation*, originally proposed in criticism to Fodor's encapsulated character of cognitive modules.

8 Knowledge is differentiation of difference, and motor modulation of modules achieves this essential cognitive stage.

Let each input subsystem produce output in whatever format. Let us suppose that each subsystem is domain specific, meaning it is specific only to a kind of input and ignores others. Let us call each output thus produced a dimension. Each input subsystem thus produces a domain specific output as 'sound dimension', 'light dimension' etc.

Now let us suppose a cognitive agent that has only one input subsystem, therefore generates only one dimension. However sophisticated be the subsystem, as long as it is domain specific, such an agent with only one input system can not generate any bit of information. Why? Because, such a perceptual space is *blind*.[4] That will be like an undifferentiated ether or a super cooled liquid state. Information is a result of *differentiated difference,* which comes only by *interference* of another dimension. When two or more dimensions *cross* with each other, either concurrently or serially, a logical mark is possible in the undifferentiated space, for recognition needs an identifiable mark. This is very similar to the way a point is obtained by crossing two lines. It seems therefore impossible to think of individuating any *differentiated difference* without *cross-representations*.

Assuming that each dimension comes to us from an independent module, and information impinging on our mental 'screen', we may think that the story of perception ends. But it doesn't. We may be able to see changes in the screen, but how do we know what causes (constrains) each of these changes? Mere cross-representation is not enough, since we will never know if there is a cross, if it is invariant. We need to introduce a mechanism to control (modulate) the crossing too. Karmiloff-Smith's theory that representational redescription happens by reencoding cannot be the answer, though the line of argument is correct, because it is question begging. We still need to search for the mechanism of reencoding.

I am proposing that this happens by *modulation of modules* which introduces the required differentiation of *cross-representations*. Modulation of dimensions is a process where a cognitive agent introduces differences in some dimensions by keeping certain other things constant in the perceptual space. What I am suggesting is that the cognitive agent to begin with *consciously* performs certain actions (using proprioceptive motor action) that alter the perceptual space in a controlled way. For example, we move our eye muscles once on the window pane, and once on the distant trunk of the tree to perceive the depth. Once used to it, we do this unconsiously, but the fact that this can be done consciously explains why there is no encapsulation. The motor input system can affect the visual field. Since this operation is deliberate, we are possibly certain that the differences in the appearance are constrained by controlled motion. This way, the difference gets differentiated. I propose that *differentiation of difference* is the foundation of all conscious cognition, which happens by modulation. Differentiation of

[4]My allusion that perceptual space is blind may remind readers of the Kantian aphorism, that perceptions without conceptions are blind, and conceptions without perceptions are empty. Though insightful, my purpose here is to break this circle, and not depend on it.

difference produces the required cross-representation. One can see much of what I am proposing implicitly in Marr's theory, but what is missing is the requirement of *modulatory action by the agent* which introduces the constraint required for differentiation.

To see the causal connection between differences in the appearances, we need no higher form of inference like abduction, as Fodor thought. The constraints for inference are already available to the subject, since modulation is initiated by the subject, making the inference fast and direct, and therefore avoids frame problem. The assumption of proprietary database also serves the purpose of avoiding frame problem.[5] Since in the current proposal no proprietary database is assumed, one may think that the frame problem may arise. However, as mentioned above, modulation itself provides the required constraint for faster and direct inference. If we assume a loop between sensory subsystem and a modulation system, we do not need expensive computation to solve the problem. The nature of this loop is the conscious cross obtained between two or more modules, where voluntary muscles controlled by the central nervous system form a loop with sensory subsystems to generate the required self-modulation.

If this line of argument is valid, one thing is clear: knowledge is generated due to modulation of cross-representations, a sort of multi-dimensional/inter-modular interference or interaction. This mechanism then may be either innate or learned. I believe the potential to modulate is innate, while the context for modulation is culture. What seems the likely basis for concept formation is: loose physiological coupling, characterized by interactive and functional relations between different domain specific subsystems, rather than encapsulated modular structures.

Consequently, we, at least human beings, are not abandoned to take what the input subsystem have to offer. We have the ability to differentiate the differences caused by the input systems. It is this *freedom* that makes us *reflect*, and thus begets the thought. Other animals may also be getting deceived from appearances, but due to our freedom to modulate perceptual field we resolve several of those deceptions. Thus the mechanism for perception, conception and thinking are not ontologically different.

[5] See the discussion by Weiskopf on modularity and frame problem [28].

9 Softer operations are cognitively significant because they modulate perceptual field by self-reproduction of perceptions, and also become the basis of the symbolic life.

We don't percieve only what happens outside our body in the world around, we also produce variations in the objects of perceptions and then feel them. A human baby learns about it during early infancy by kicking around, thumb sucking etc. We can create a feeling of touch by another part of our own body, though usually by hands. This unique *self-reflexive softer motor operations* form the basis of concept formation, for they produce self-generated manipulable perceptions. The self-generated variations in the perceptual field and the corresponding voluntary softer-motor operations become the *signifier* and the *sign* respectively. Since the sign is reproducible[6], and externally encoded it is already capable of becoming a representation for the self-generated perceptual variation, the concept.

When we hear a sound from a source outside our body, we do perceive it, but passively, since the source of the sound is outside the body. An organism at this level can *know* the world around only by behaviorist conditionings. But when our own vocal chords produce the sound, and then we hear using our own sensory input subsystem, we are employing a reflexive softer operation. We can voluntarily introduce variations in the object of perception and feel them too. This loop is the genesis of *conscious* experience. It is important to realize that in this loop we have three important subsystems: the central nervous subsystem that controls the voluntary operation, the motor subsystem, and the sensory input subsystem. Thus the role of the motor system of the body is to act as an intermediary in the conscious cognitive loop. So to speak, the so called encapsulated Fodorian module (sensory input subsystem) is 'accessed' by the neuro-motor subsystem, when the harder operations emancipate to softer. Harder operations are indeed encapsulated, but after emancipation into softer form the input that goes into the input subsystem and its output both get modulated, and thus get a partial access. No additional non-modular central processing unit is required in this model. Such a thing doesn't exist, time to apply Occam's Razor![7]

[6] It is more than reproducible, since it is self-reproducible.

[7] A detailed criticism of Fodor is presented in [19]. I have argued there that modularization cannot lead to conceptualization. My line of argument there is that modular input subsystems cannot produce concepts since meaning of a concept cannot be stated independent of other concepts, so a chemistry or a network of concepts is necessary. This means the input-subsystems must have intricate, but modulatable, interactions. Since interactions cannot be prior to the formation of the sub-systems, concepts also cannot be innate.

The crucial connection between modulating motor operations and conceptualization requires more attention. As we saw in the previous section, each modulated perceptual field will produce an aspect (dimension) of perceptual experience; This isolation of an aspect from a complex picture helps us to see what is differentiable from the picture. This act of *differentiation of difference* is the root of concept formation. Since this differentiation is due to the voluntary (proprioceptic) modulation, it is conscious, but may become unconscious over time. What is differentiable or not, depends on the genetic character of what is modulatable or not. So this potential I assume is 'innate' in the genetic sense of the term. We also saw how the existence of Kantian schemas within motor organization in a previous section.

10 Modulation of modules produces externalizes the internalized knowledge, and produces multi-layered inter-subjective space.

I argued above that domain specific modules can be modulated, and this process has the potential to explain concept formation. In the process the implicit procedural 'knowledge' transforms into explicit declarative knowledge. By demonstrating that modules can be modulated by the agent's actions, modules become Piaget's *schemes*. This reconciliation of nativism and Piaget is different from that of Karmiloff-Smith's. In her account, modules are the product of post-natal development. I am suggesting that input subsystems are hardwired and biologically given. However, to remain consistent with a developmental account, they are also products of a developmental process. But this process is embryological, and therefore purely biological. Biological ontogeny in the form of maturation continues even after birth, and this process may enhance the sensory-motor potential, but remains biological nevertheless. This developmental process remains the bedrock for other layers in the story, forming the **Layer 1**: biological ontogeny.

Cognitive development essentially begins after birth. New born child is like a cognitive 'ovum', gets 'fertilized' by experience of both the cultural world and the 'natural' world. This onsets the development of the **Layer 2**: *subjective cognitive ontogeny*. This process also continues to develop, though reaches maturation (meaning modularization) very fast. The character of representations that are produced at this stage are *cross-representations*. These representations are a result of the subjective cognitive ontogeny, and remain *procedural*. This corresponds to the nature of knowledge generated during sensory-motor stage in Piaget, and percepts of Mandler. Let me clarify here that this account is not a stage theory, it is the character of knowledge generated that corresponds to the Piaget's sensory-motor stage and not the stage to the Layer 2. One important difference is that these layers continue to exist and develop, and they don't stop or transform into another at any time. Subjective experience doesn't cease when we tend to become inter-subjective or objective. This layer produces the mandatory appearances that sometimes result in the illusions we discussed in the previous section. Most of animal cognition remains at this stage, since the process that generates the other cognitive layers, modulation of cross-representations, doesn't seem to be available to them. Karmiloff-Smith's representational redescription, for the same reason is also not available to them. This corresponds to 'Implicit' level in Karmiloff-Smith's theory.

The first two layers now become the foundation for the **Layer 3**: *inter-subjective cognitive ontogeny*. In some of the higher cognitive agents, particularly human beings, the implicit procedural knowledge transits to explicit declarative knowledge by modulation of cross-representations, leading to representational redescription, generating explicit representations. This is what we called the fundamental cognitive transition. Cognitive agent for the first time in cognitive ontogeny begins to develop a *detachment* between *sign* and *signifier*, where the former is publicly (inter-subjectively) accessible. This is when percepts become concepts. This layer is sufficiently complex and amenable for further layers within. Karmiloff-Smith distinguishes three 'levels' of this Layer 3, Explicit 1 (E1), Explicit 2 (E2), and Explicit 3 (E3). E1 is explicit but not accessible for consciousness, E2 is explicit and accessible for consciousness, and E3 is accessible, conscious, and verbally reportable [10, p.20]. Though there is no strict matching with our account, Donald's three stages during the phylogeny of modern human also fall in Layer 3. He identifies during the phylogeny a stage of episodic representations to begin with leading to semantic externalized representations, mediated by mimetic and mythic layers [3]. It is during this process the most unique human character, language module develops. This view is unlike Chomsky and Fodor, who argued for an innate language module/s. While I disagree with them on this, language is mostly 'hereditary' in the sense that is almost entirely due to cultural inheritence. Behaviorally, lot of play, practice and enculturation (training) are responsible for this layer to develop. 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.

Thought and imagination too are due to *detached* processing of representations, but happening in the subjective space—internal modulations. Layer 3 is too rich to capture in a paragraph. To sum up, what happens in this layer is that implicit procedural representations transform into explicit declarative knowledge by 'rewriting'. This proccess is the hub of all eventual higher cognitive functions. Layer 3 has all the necessary paraphernalia for developing the peculiar socio-cultural human life. It culminates to produce folklore.

The three layers thus formed become the foundation for the exclusively human **Layer 4**: *formal cognitive ontogeny*. This layer develops by transformation from folklore of Layer 3. Declarative knowledge of folklore in this new layer gets redescribed in formal operations. In this layer, no assumptions remain implicitly. Knowledge of Layer 3 depends a lot on the implicit and subjectively available experience. All the knowledge is stated as a declarative representation. During the formal cognitive ontogeny, concepts are artificially and operationally *represented* without a direct bearing on experience. They may be idealizations of Layer 3 concepts. The concepts that form the basis of formal knowledge may or may not have observational basis, but operational basis. By operational I mean rule based construction based on definitions. Since definitions state the conditions explicitly, confining to a constructed conceptual space, this makes these new constructions completely *detached* from perceptual experience. Scientific knowledge, for example, 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. They 'touch' the real world here and there. By this I mean the logical space of possible world extends beyond the actual space of real world. This constructed form of knowledge results into formal, mathematical and scientific knowledge. By formal I do not mean only mathematical or algebraic. A knowledge becomes formal, when any representation—the symbols, the rules of combining them, relations between them, etc.—are fully made explicit. This requires that knowledge be re-represented in an entirely artificial language. One may see what I am saying comes closer to some branches of science like physics, but the view may be rejected for other sciences such as biology, economics and social science. The possibility of reconstructing an artificial language by using mostly available vocabulary from folklore, masks us see the essentially formal nature of the latter sciences. Just as the folklore notions of force, energy and work do not just extend into the scientific notions by the same names, the notion of heart and species of folklore do not extend into biological space. If this view, that science is not part of the Layer 3, is true, then it will have serious implications for science education. Most science education practices assume that science is an extension of common sense. The view I am arguing for demands an epistemic break from common sense. I do not have space to provide a complete argument here. Please see "From Folklore to Science" for a complete statement of this position [18], where a demarcation criterion in the form of conditions that make the transition from folklore to science is presented.

Before I close this section, a few lines on the nature of the layers would be relevant. What is the relationship between the layers? The top layers depend on the bottom layers. This dependence is substantial. Just as living layer of the world depends on the physical non-living layer, formal layer depends on folk layer, and folk layer depends on the biological. Top layers, once developed, do not replace the bottom layers, they only cover them. This view is different from that of Thomas Kuhn who argued that revolutions replace the former body of knowledge [13]. Kuhn's view is the most outlandish, and unfortunately the most influential, view from an otherwise a very careful historian of science. I argued in [17] that he confuses psychological (ontogenic) replacement that *may* happen in a believer with historical (phylogentic) replacement. Top layers emerge due to changes in the functional relationship of the underlying ontological layer. Substantially there exists only one ontological world, the distinctions of the layers are methodological helping us to theorize. Thus this position can be characterized as ontological monism and epistemological pluralism.

A question also arises naturally regarding the relation of the layered view with that of Piaget's stage theory. Stage view suggests that the cognitive being transits from one kind to another. Layered view suggests that the being develops an additional layer without loosing the earlier base. Metaphorically it is more like a few threads of the fabric of the bottom layers *escape* to form the latter layers. In the layers in the fabric of mind, for each *thread* of development, it is possible to provide a stage theory, but not for the cognitive being as a whole.

References

[1] Susan Carey and Rachel Gelman, editors. 1991, *The Epigenesis of Mind: Essays on Biology and Cognition*. Erlbaum, Hillsdale, New Jersey.

[2] Anyd Clark. 1997, *Being There*. The MIT Press.

[3] Merlin Donald. 1991, *Origins of the Modern Mind: Three Stages in the Evolution of Culture and Cognition*. Harward University Press, Cambridge, Massachusetts.

[4] Robin I. M. Dunbar. 2000, Causal reasoning, mental rehearsal, and the evolution of primate cognition. In Cecelia Heyes and Ludwig Huber, editors, *Evolution of Cognition*. MIT Press.

[5] Jeffrey L. Elman, Elizabeth A. Bates, Mark H. Johnson, Annette Karmiloff-Smith, Domenico Parisi, and Kim Plunkett. 1996, *Rethinking Innateness: A Connectionist Perspective on Development*. The MIT Press.

[6] Paul Fitzpatrick, Giorgio Metta, Lorenza Natale, Sajit Rao, and Guilio Sandini. Learning about objects through action - initial steps towards artificial cognition. 2003, In *Proceedings of the IEEE International Conference on Robotics and Automation (ICRA)*, Taipei, Taiwan, 2003.

[7] Jerry A. Fodor. 1983, *Modularity of Mind*. MIT Press, Massachusetts.

[8] Jerry A. Fodor. 2000, *The Mind Doesn't Work that Way: The Scope and Limits of Computational Psychology*. The MIT Press, Massachusetts.

[9] Peter Gärdenfors. 2003, *How Homo became Sapiens?: On the Evolution of Thinking*. Oxford University Press, Oxford.

[10] Annette Karmiloff-Smith. 1995, *Beyond Modularity — A Developmental Perspective on Cognitive Science*. A Bradford Book, MIT Press, England.

[11] Annette Karmiloff-Smith. 1995, *Beyond Modularity: A Developmental Perspective on Cognitive Science*. The MIT Press, Cambridge, Massachusetts.

[12] Doreen Kimura. 1993, *Neuromotor Mechanisms in Human Communication*. Oxford University Press, New York.

[13] T. S. Kuhn. 1970, *The Structure of Scientific Revolutions*. Chicago University Press, Chicago.

[14] George Lakoff and Mark Johnson. December 1998, *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*. Basic Books.

[15] Peter F. Macneilage. 1998, Evolution of the mechanism of language output: Comparative neurobiology of vocal and manual communication. In James R. Hurford, Michael Studdert-Kennedy, and Chris Knight, editors, *Approaches to the Evolution of Language*, pages 222–241. Cambridge University Press, Cambridge.

[16] Jean Matter Mandler. 2004, *The Foundations of Mind: Origins of Conceptual Thought*. Oxford University Press, Oxford.

[17] Nagarjuna G. *The Role of Inversion in the Genesis, Development and the Structure of Scientific Knowledge*. PhD thesis, Indian Institute of Technology, Kanpur, INDIA, 1994.

[18] Nagarjuna G. From folklore to science. Presented in the International History, Philosophy, Sociology and Science Teaching Conference, Leeds, during 15th - 18th July 2005., 2005.

[19] Nagarjuna G. Layers in the fabric of mind: A critical review of cognitive ontogeny. 2005, In Jayashree Ramadas and Sugra Chunawala, editors, *epiSTEME 1: Review of Research on Science, Technology and Mathematics Education*. Homi Bhabha Centre for Science Education. Forthcoming.

[20] Nagarjuna G. Muscularity of mind: Towards an explanation of the transition from unconscious to conscious knowledge. Paper presented at the Annual Conference of European Society for Philosophy and Psychology (ESPS), in Lund, Sweden, http://cogprints.org/4352/, August 2005.

[21] Alva Noë. 2004, *Action in Perception*. The MIT Press.

[22] Willis F. Overton, Ulrich Müller, and Judith L. Newman, editors. 2008, *Developmental Perspectives on Embodiment and Consciousness*. Lawrence Erlbaum Associates.

[23] Jean Piaget. 1968, *Six Psychological Studies*. Vintage Books, New York. Translated from French by Anita Tenzer.

[24] Jean Piaget. 1970, *Carmichael's Manual of Child Psychology*, volume I, chapter Piaget's Theory, pages 703–732. J. Wiley, New York, 3 edition.

[25] Robert F. Port and Tim van Gelder. 1995, *Mind as Motion: Explorations in the Dynamics of Cognition*. The MIT Press.

[26] T. van Gelder. October 1998, The dynamical hypothesis in cognitive science. *Behav Brain Sci*, 21(5).

[27] Leo S. Vygotsky. 1978, *Mind and Society*. Harvard University Press, Cambridge, Massachusetts.

[28] Daniel A. Weiskopf. 2002, A critical review of jerry a. fodor's *the mind doesn't work that way*. *Philosophical Psychology*, 15(4):551–562.

[29] Ludwig Wittgenstein. 1953, *Philosophical Investigations*. New York: The Macmillan Company, New York.