Muscularity of Mind: Towards an Explanation of the Transition from Unconscious to Conscious

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The title "Muscularity of Mind" indicates the point of view that is argued in this essay. I attempt to trace the roots of higher cognitive abilities to the physiological coupling that exists between neuro-sensory and muscular system. Most of the current discourses on the subject base their studies more on the nervous and sensory dimensions, neglecting the most crucial of all, *the role of voluntary muscles in shaping the higher cognitive abilities.* I make a claim that emancipation of voluntary muscles from the mandatory biological functions to take on the softer habits during the course of evolution played the crucial role in shaping the higher cognitive abilities. I undertake to explain the transition from procedural to declarative representation 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 objective of this essay is to indicate that the problem cannot be solved without attending to this nexus.

The Context

Cognitive science, particularly in the last three decades, witnessed several creative moments and innovative proposals on 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. This multi-disciplinary discourse, along the way, not only reenacted several traditional philosophical positions, but also exhibited considerable innovation in rephrasing the traditional questions

seemingly guided by a huge corpus of scientific findings from artificial intelligence, neurophysiology and pathology, evolution, and ingenious experiments on cognitive agents (both human and non-human subjects, including infants in the crib).

Some of the recent findings in cognitive science provide some very promising clues in understanding the uniqueness of human cognition. One of the first useful clue was from none other than Jean Piaget. While his stage theory, particularly the timings of the stages, has been contested, but his characterization of the transitions from one stage to the other continue to be relevant. For the purposes of this essay however, the first transition, from the stage of *sensory-motor intelligence* to the stage of *intuitive intelligence*, is crucial[13]. The problem of this essay is to explain this *transition* between the first two stages.

Why is this transition important? In the current literature, sensory-motor intelligence is mostly assimilated into what is generally known as *procedural knowledge*, as against *declarative knowledge*[11]. 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. Karmiloff-Smith in her work on *Beyond Modularity* proposed an ingenious theory of *representational redescription*, where she tries to reconcile the Fodor's modularity theory[5] with that of Piaget's developmental model. During the process of representational redescription, *implicit* procedural knowledge transforms into *explicit* declarative conceptual knowledge by a process of reencoding[8]. 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 *episodic* memory into more recent and peculiarly human *externalized* memory, with the intermediary mimetic and mythical stages[3]. Peter Gärdenfors in his recent work *how Homo became sapiens* agrees with Donald and adds further weight to the *externalization* hypothesis[7]. Keeping in view of the Vygotsky's emphasis on the role of social character of human mind[14], and Wittgenstein's strong argument against private language argument, and essentially social nature of language and thought[15], lead us to expect very strong social and culturally rooted account of human mind.

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 mind, it is important to understand the relation between 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 Jerry Fodor did not believe in developmental view of cognition, being a hard nativist, 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[5, 6].

It important to note that I am making an over generalization when I

clustered a large set of descriptions of the phase before and after transition. Such a grouping is not justifiable. We can and we must discern the subtle differences among them. It is enought here to highlight that the domain of transition approximately corresponds to those descriptions. I cannot make it more clearer at this time.

The engaging problem therefore is either to understand the *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 to agree with the developmentalists 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 nature.

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.

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 gener-

ate 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[9]. 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. This observation is supportive of my claim that emancipation of voluntary muscles from the mandatory biological functions to take on the softer habits during the course of evolution played the crucial role in shaping the higher cognitive abilities.

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.

Muscular Roots of Mind

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*.

Harder and Softer Motor Operations

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*.[1] 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.

Softer Motor Operations

Softer operations are all due to *emancipated* muscular operations. 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.

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

[1]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.

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.

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[10]. 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[10]. 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.

Cognitive Connection

In this section the central claim of the proposal is presented. 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[2], 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![3]

The crucial connection between modulating motor operations and conceptualization requires more attention, and I will eventually expand this section. Here, I will briefly indicate the connection: 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 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

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

[3]A detailed criticism of Fodor is presented in [12]. 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.

sense of the term.

However, as a possible alternative theory, it is possible to dissociate my insistence that this modulation is motor based. In that kind of a model the above statement transforms into: consciously modulatable operations (suspending the belief that they are motor) are necessary for concept formation.

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[8]. As a model that explains the transitions during cognitive development, I find it important to relate it to the hypothesis. Most important aspect of the transition that Karmiloff-Smith is explaining is from implicit to explicit, which during recurring reencodings becomes progressively more accessible. When the operations were in the automated procedural domain within the passive perception, 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 the gap in the mechanism of representational redescription.

When lower animals produce sound *instinctively* (non-voluntarily) they do hear, but possibly not as their own. Unless the sound is modulated (that is emancipated from instinct) the above conscious loop is not possible. How do we know whether we are emancipated from the instinct? Play, practice and culture! Possibility of play is an index of softer operations. Normally, in lower animals, the motor operations are an effect of some external stimulus. This is the classical stimulus-response loop. If the response is produced without stimulus, it must be a softer operation. If you see a dog that is practicing how to bark, then that is a softer operation. If a dog barks without watching her parents and siblings, then that must be instinct, but if she cannot bark without her society, that is not only softer, but also culture. This kind of barking must be due to cultural inheritance, and not genetic inheritance. How and why this stimulus-response-loop breaks is an open question. But my claim is, this is the root of higher modes of cognition.

Non-reflexive softer operations are also cognitively significant, but they are significant only due to the extension of reflexive operations, by imposing our experience on them. Let me explain. An example of a non-reflexive softer operation is when we move closer and farther to the source of stimulus (say a source of sound), where we do manipulate the perceptual field by our movement. But here, in this mode of perception too the external source is effectively *modulated* without actually doing. External world cannot be modulated by us at this stage[4], but we can change our relation with

[4]However, during experimental manipulations, particularly in science, we do modulate ex-

it. Depth perception can also be explained in a similar way. This voluntarily introduced variation, though not reflexive, is good enough for conscious perception.

Jean Mandler argues that conscious awareness is the defining difference between procedural and declarative knowledge[11]. She convincingly demonstrates that prior to the arrival of conscious concepts, there exists knowledge of the procedural kind called *percepts*. I suggest that this transition from percepts to concepts happens by the softer operations.

Each conscious manipulation of perceptual field produces a *chunk*[5] in the input subsystem. Since there are a multitude of such chunks produced by the conscious motor modulation, we produce an *orchestra*. Such an orchestra of concurrent and sequential softer inputs generates an *episodic canvas*. This way the cognitive system transits to what Donald calls *episodic* phase from the *procedural* phase[3].

Since we assumed that the multitude of chunks are a result of the softer voluntary modulation of the perceptual space, with each kind of chunk belonging to one kind of input subsystem, we can assume that each chunk can be taken as a unit of combinatorial composition. The ability to form multi-part representations from basic canonical parts is what we need to explain for the *generative* character of the higher cognitive system. Generativity is understood to be a unique and advanced feature found in humans and is essential to cater to the development of language, and this is coherent with Chomsky's thesis. Kosslyn's observations on mental imagery also suggests the need for combinatorial operations among the unitary visual chunks. Generativity will give rise to analytical base and eventual semantic representations. I am aware that I am jumping too fast. The purpose of this proposal is to communicate the hypothesis, and how I see this could lead to different kinds of possible extensions explaining most of the higher cognitive functions.

Motor system is not usually considered as a part of the cognitive system. This is possibly one of the reasons why its *direct* role is not discussed in the context of cognition. Even when Kimura considers the ability of serial motor action as a very important condition of other higher cognitive abilities, it is only considered secondary in the dominant neuro-centric view. Since motor system can also be one of the input subsystems, because every voluntary motor action can also be perceived, it doubles up as one of the most unique systems of the body. With this unique property it becomes an extended processing organ. I believe that without understanding the central role of motor functions, particularly of the softer kind, the problem of cognition cannot be solved.

Motor system doubling up as an input subsystem very likely would solve another most important problem of cognition, namely, thought. *Subvocalization*, an inner speech, in our account will be a softer operation that can

ternal world.

[5]I borrow this nice term from John Anderson.

be consciously modulated. That is, thought can be explained as a process of modulating vocal chords sans the movement of lips, tongue, and production of explicit sound.

Somehow thought is taken as something non-material, intangible thing. If that were so, no energy should be spent when we think. For my argument, however, it is not essential that the thought operations be visible skeletal muscles. They can be at a subcellular microtubules or some such motor proteins. But we know that motor operations can come under conscious gaze. So why not hypothesize on this plausible model? Further thought operations should be physically instantiable operations (events) (even if they are anamolous)[2]. As a biologist I see nothing physical in the biological space apart from microtubule kind of proteins that can produce operations, which anyway are the basis of all muscular tissue. Thus I see some chance of reviving motor theory of thought.

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 above proposal 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].

No theory of mind can be complete without accounting for memory. I do not want to fill this essay with more hunches than those which already exist. I will wait for another occassion to write on this, but for one comment. In this account, the distinction between procedural, episodic and semantic memory is very important. However, I suspect that only procedural and episodic are biologically localizable, while the semantic memory is external. But every semantic memory does map onto the former kind. This amounts to saying that our body biologically stores only procedural and episodic memory, while the semantic memory is stored in the external social space. This brings us to the relation between human being's social character cognition and external memory.[6]

Socialization and Externalization

Human beings are abandoned to be social due to miserable dependent human infant. But this misery is turned into strength. A child lying on the back has more opportunity to engage in reflexive activities than a puppy

[6]Merlin Donald's highly dependable account on this topic is more extensive. See [3].

that begins to run soon after birth. We do see that infants in the crib indeed reflexively begin their life with thumb sucking (actually also the toes). Even in these early softer operations, there is a break of symmetry. Soon the social *feeding* begins. It is important to notice that the culturation process fully depends on softer operations. They begin as conscious, and after reaching behavioral mastery they tend to get modularized. This recursive process, as Karmiloff-Smith explains, helps in progressive externalizing. More and more of our representations get symbolized in external spaces, beginning from mimetic gestures to books and cyberspace[3, 7].

Vygotsky rooted mind in society[14]. Human child left in a non-social context will not survive. That is why we are abandoned to be social. A whole gamut of cultural resources, (language, tools, institutions, roles etc.) that had centuries of phylogeny must be hurriedly transmitted in a truncated ontogeny of our childhood. Except for the ability to engage in softer operations and save the memories within and outside our body, most of it indeed comes from the cultural inheritance. The peculiarly human character, whatever that be, mostly comes from *memes* and not from *genes*.

But, think of human life without the softer motor operations. It is as good as life devoid of society and language. Wittgenstein linked language and society so tightly that he denied the existence of a private language[15]. There surely are no private *semantic* representations, in other words, all of semantic memory is external. But there are private *procedural* and *episodic* representations. Human beings are coronated by semantic memory, but the procedural and episodic memory did not vanish. Wittgenstein did not accept the idea of private representations. We have today enough evidence that percepts (procedural memory) are the only basis of most animal behavior. We cannot explain their behavior without supposing the existence of procedural representations, contra Wittgenstein. By interpreting Wittgenstein's argument as applying only to semantic memory and not episodic, I suggest a transformation mechanism in terms of harder to softer operations resulting in representational redescription, which explains one of the mechanisms involved in learning and discovery, where the transition is towards semantic representations.

Conclusion

I did not intend to achieve much in this essay, except possibly indicating a line of engagement. Things seem to be falling in place, but we need to rigorously establish each claim made. Making a conceptual distinction seems easier than operationalizing and testing the hypothesis. But, I suppose that the criteria formulated for the softer operations are clearer. However, the recurring modularization of behavior, and adaptive nature of most behavior, most likely may make it very difficult to distinguish clearly what is softer and what is harder. But the claim at the biological level, that we have a largest number of modulatable softer motor actions than any other

being, appears true at its face value, explaining the phenotypic differences.

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