OPINION AND PERSPECTIVES

Evolving Brain
Neuroanthropology, Emergence, and Cognitive Frontiers

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Abstract

Emergence is an interesting concept for explaining human evolution. An understanding of emergence enables us to define the role of novelty and creativity in human beings and their complex behavioural repertoire. Emergence merits a neuroscientific approach since the brain is a process of biological evolution, therefore, signifying the biological basis of human consciousness and experience. In this paper I outline three areas of emergence and the human brain which may further assist us in understanding the relationship between brain and culture.

Key Words: Neuroanthropology, emergence, and cognitive frontiers

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Introduction

This paper will examine the concept of emergence in relation to the human brain. The notion of emergence has been extensively examined in terms of cosmic and biological evolution. Alternately, there have been comparatively few studies on emergence and human evolution. The central thesis of emergence is that biological systems increase in their level of self organization and complexity. This is in a nut shell. In nature emergence is depicted in complex and multitudinous biological forms "of self-generating networks" (Capra 2002:13). Evolution is adumbrated by novel forms and adaptation strategies which increase the complexity of living organisms. For Maturana and Varela (1987), life forms exhibit autopoeisis, based on self organising principles. Emergence implies that in biological evolution certain features can be described as emergent due to the "increase in complexity from the physical components out of which it emerged" (Huyssteen 2006: 653). Clayton further notes: "When in addition internal changes in biological entities themselves become productive of complex behaviors, and in particular when they enhance the organism's prospects for survival and reproduction, we speak of them as purposive behaviors" (2004: 97). As organisms increase in their complexity they manifest a range of qualitatively complex and flexible behaviours which ultimately defines them as being markedly different (Clayton 2004:99). In other words, greater "complexity and flexibility" may posit the conditions for emergence in a specific species (Huyssteen 2006:653).

In human beings, the emergence of brain/mind must be examined through its evolutionary history from which brain has evolved. Understanding the relationship between brain/mind and between "consciousness and its neural correlates"—demands an understanding of the multilevel structure of nature (Huyssteen 2006:654). This

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is in itself is a demanding task, one in which neuroscience in conjunction with biological and behavioral sciences is exploring. According to Grof (1990:11), the neurophysical activities of the brain and its creative intelligence manifest the ingenious principles of nature. On this theme, the cybernetician Gregory Bateson expresses that the properties of mind are expressed throughout nature (1971). Bateson sums this up in the following: "If you want to understand mental process, look at biological evolution and conversely if you want to understand biological evolution, go look at mental process"(Manghi 2002, xi). If, then, the emergence of human consciousness is visible in evolution, how much more will it be evident in cultural evolution which is undoubtedly the hallmark of *Homo sapiens* (Huyssteen 2006: 655). Culture as a product of the brain's neuroplasticity is embedded in novelty and utmost flexibility due to its reliance on symbolic language. Unlike biological evolution, cultural evolution is rapid and incredibly novel. The efflorescence of culture has accelerated the brain's intelligence and ability to assess incredible amounts of information in a relatively short amount of time. Moreover, cultural transmission has been able to "codirect genetic evolution" (Laland et al 2000:132; Boyd & Richerson 1985).

This essay will locate the evolving brain and emergence in three areas: Brain evolution. Secondly, I provide a neurophysiological overview of ritual. The area of ritual and brain provides a fruitful area for understanding the emergence of novelty and its neural substrate. In the third section, I proffer new possible evolutionary directions of the brain due to the advent of nano-bio-information technologies.

Evolving Emergence

Numerous studies reveal that the *Homo sapien* brain has increased three times its size since the Pliocene period. Over the last five million years increases in the hominid brain have been paralleled by an increase in body size (Henneberg 1998:745). For example, the three fold increase in brain size over the past four million years has been from the Australopithecines (450 ml) to modern *Homo sapiens* (1350 ml) (Henneberg 1998:746). The evolution of brain encephalisation and complexity was probably prompted by the increasing social complexities of early hominid life. Sociality was an essential factor in neural development and informed social behaviour in such a way that it fostered the advent of culture. For the Russian neurophysiologist A. R. Luria, human consciousness was also contoured by a "rich net of essential relations" (Luria 1987).

According to one popular theory encapsulated by Diamond's phrase "The Great Leap Forward", there was an explosion in art, ritual, technology and social organization around 40,000 years ago (Diamond 1991). Numerous artifacts of this period support this cultural efflorescence. In comparison, Neanderthal tools show little innovation from 100,000-40,000 years ago (Diamond 1991:37). Diamond's thesis is interesting since it is apparently supported with modern scientific findings which show that two genes regulate brain growth – microcephalin and ASPM (abnormal spindle-like microcephaly associated). According to Nitzan et al (2005), the microcephaly allele in humans arose around 37,000 years ago, about the time of the hypothesized Great Leap Forward. The ASPM allele emerged around 5,800 years ago at the advent of the Second Great Leap Forward which saw the emergence of cities, complex social hierarchies, writing, improved technologies and sophisticated aesthetic awareness – the hallmarks of civilization. In addition, the recent ASPM selected variant suggests that the *Homo sapien* brain is still evolving, an aspect which I will discuss later on.

Intelligence and novelty was an ongoing process in the hominid line over millions of years and is not the sole property of *Homo sapiens*. For instance, the cranial impressions of the brain of *Homo habilis* (circa 2.2 mya) shows indications of developed Broca's and Wernicke's areas which may have given this early hominid the ability for rudimentary speech (Bradshaw 1997:38). Since there is little genetic variation between apes and humans, the growth of cortical areas was likely to have been influenced by "regulatory genes" over time (Bradshaw 1997:38). Furthermore, encephalisation of early hominid ancestors (*Homo rudolfensis*, *Homo habilis*, *Homo ergaster*, and *Homo erectus*) was coupled with cerebral reorganization and brain lateralisation (Arsuaga & Martinez 2006:126-127). Increases in the neo-cortex was probably prompted by the developments in social organization and the concomitant development of 'social intelligence' (Arsuaga & Martinez 2006:127). The hypothesis that social organisation was a driving force in early hominid encephalisation may have been advantageous in predicting changing social patterns and pressures which ensued novel social adaptations (Bradshaw 1997:163; Humphrey 1976). The fact that primate and Homo social organisation exhibits high complexity gives credence to this argument (Ehrlich 2000:113). As early hominid social organisation increased on several levels within the group and between other groups, this led to a positive feedback system which allowed individuals to become adept to the requirements of the changing social environment. These new environmental pressures fostered an array of adaptation strategies, further eliciting brain evolution (Ehrlich 2000:113). Thus, social intelligence became crucial to hominid behavioural repertoire. "Intense consciousness" may have concomitantly emerged with social intelligence and early hominids' "ability to generate ever better cognitive maps and internal representations or models of reality" (Bradshaw 1997:146). What is implicit is that the emergence of social intelligence in our early ancestors was associated by the enlarged pre-frontal cortex and heteromodal association cortex which occupies a quarter of the total cortical area in *Homo sapiens* (Bradshaw 1997: 168-169).

Ritual, Emergence and Neurogenesis

The relationship between ritual and brain has been explored by a modern theory called biogenetic structuralism. This model was conceived by Eugene d'Aquilli and Charles Laughlin in the 1970's. Biogenetic structuralism conjoins the disciplines of neuroanatomy, psychology and anthropology. Its interdisciplinary approach is intended to transcend the Cartesian based sciences which still encourage a body/mind split. Both authors suggest such adherence to Cartesian dualism ignores the phenomenological aspect of human perception (Merleau-Ponty 1963). Both authors apply Levi-Strauss's and Chomsky's concepts of 'deep structure.' According to Levi-Strauss, the human brain orders the world into oppositional categories i.e. male/female, hot/cold/up/.down, right/left, raw/cooked. These oppositional categories reflect the binary structure of the brain (Levi-Strauss 1963, 1966). On this point, both authors mention that their structural model privileges the neuroplasticity of the brain and its massive neural matrix (Lipp 2000). Moreover, the brain is not limitless in its neuroplasticity but is regulated and constrained by a genetic precursor. The genetically predisposed neural model organises experience in particular ways – a process called neurogenesis (Laughlin et al 1979:8; Guthrie 2000). Laughlin and d'Aquilli insist that human behaviour is characterised by the interplay between "the central nervous system and the environment" (1974:195). While this idea is not new it does confirm the role of the neural substrate when engaging with the environment. The strength of the biogenetic structuralist theory lies in its ability to explain cognitive an structural elements by directing them to specific neural structures and functions (Laughlin & d'Aquilli 1974:14-15). This is an area in which anthropology and sociology have hitherto been reluctant to pursue.

A major role of biogenetic structuralism has been in elucidating the neurobiology of ritual. Ritual is an apt target for this model's exploration due to its universality and central place in human societies. In *Homo sapiens* ritual has become an intrinsic social adaptation in coordinating human behaviour. Ritual's onus on collective action is contingent on various communicative strategies which elicit prescribed behaviours (Laughlin et al 1979:28). In human societies rituals observe three criteria:

1. Rituals follow a structured pattern.
2. Rituals are characterised by repetitive and stereotypical behaviours within a time framework. Rituals often employ rhythmic and redundant patterns which can lead to a coordinated arousal of the cortical limbic system (Guthrie 2000).
3. Rituals manoeuvre participants towards a certain goal or formalised objective (Laughlin et al 1979:29).

The adequate adaptation to a ritual's symbolic milieu necessitates the incorporation of "sensory-neuroendocrine-motor subsystems" of a participant's central nervous system (Laughlin et al 1979:30). Therefore, appropriate responses within the ritualised environment requires "a balance between sympathetic and parasympathetic systems" (Laughlin et al 1979:30). Additionally, ritual and its aural correlate, myth, organise cognitive development and socialisation. Ritual provides a means for structuring and transforming "neuromotor subsystems in developing organisms" (Laughlin et al 1979:35).

According to Laughlin et al human beings have a drive towards creating and maintaining order in their environment. This "cognitive imperative" refers to the human drive in achieving a semblance of existential control in the life-world by unifying different elements and events into a unified whole (Laughlin et al 1979:10). The cognitive imperative emerges as a response to existential imbalances and the subsequent redressing of these. Either too much or too little novelty leads to cognitive imbalance (Laughlin et al 1979:10). What is certain is that human beings cannot live with uncertainty for a protracted period, and therefore, create rituals which order spatial and symbolic elements into systematic cognitive maps – ways of experiencing order and coherence in the face of indeterminacy (Jackson 1998).

Myth provides a mechanism for understanding the present and its tie with the past, as well as, the social and moral templates of human sociality. Ritual as the motor aspect of myth seeks to control antimonies apparent in life and resolving them. Victor Turner's theory of ritual is instrumental here. Turner, a la van Gennep (1909), divides ritual into three phases: separation, limen and reaggregation. The limen phase is the most significant since during this phase ritual participants are symbolically manoeuvred to experiencing "liminality" – a state "betwixt and between" social categories (Turner 1969, 1974). Turner contends that the symbolically indeterminate properties of liminality demand new ways for exploring the self. In this way, creative novelty is emergent in liminality. Liminality's amorphous structure stimulates variations in human behaviour which correlates with mutation in organic evolution (Turner 1983:237). The ludic recombinations of familiar elements in unfamiliar patterns experienced during liminality are rooted in the dialectic between the brain's right and left hemispheres and their corresponding ergotropic and trophotropic systems (Turner 1983:237).

The central nervous system comprises the sympathetic (arousal) system (SNS), and the parasympathetic (quiescent) system (PNS). The former is connected to the adrenal glands and the amygdala and is arouses the left hemisphere (Guthrie 2000). Its interaction is called ergotropic (Greek: 'ergo' = 'to work'). The latter is connected to the endocrine glands, thalamus and hypothalamus and arouses the right hemisphere. Its interaction is termed trophotropic (Greek: 'trophos' = 'to nourish') (Guthrie 2000; d'Aquilli 1979). The arousal of the ergotropic system during ritual behaviour excites the trophotropic system, leading to "hyperarousal and hyperquiescent states" stimulating the limbic system (Guthrie 2000). The switching back and forth between the two systems often triggers altered or non-ordinary states of consciousness. From this perspective multiple stimulations provided by the interacting systems ensues a reduction in ambiguity and increases uniformity among ritual participants (Lex 1979:120).

> Ergotropic response consists of augmented sympathetic discharges, increased muscle tonus, and excitation in the cerebral cortex manifested as "desynchronised" resting rhythms; the trophotropic pattern includes heightened parasympathetic discharges, relaeased skeletal muscles, and synchronized cortical rhythms (Lex 1979:135; Gellhorn & Kiely 1972).

This interaction between binary systems is stated by Newberg et al (2002) in relation to attaining transcendental states of awareness culminating in a state referred to as Absolute Unitary Being; a *Unio Mystica*, characterised by the dissolution of self. What these authors privilege is the collective emotional synchrony of ritual in achieving transcendental states. Similarly, Turner cites that the intense emotions that are aroused during ritual can lead participants to experiencing *communitas* – a state characterised by feelings of equality, egalitarianism and unity between participants (Turner 1969, 1974). According to Myerhoff (1974), *communitas* may also include unity between participants and the cosmos as expressed by the Huichol pilgrimage to Wirrikuta (the creation point of the Huichol cosmology and home of their deities) in the south-west United States. Having entered Wirrkuta, the Huichol incorporate the psychotropic plant peyote in to their rituals which aids in inducing cosmic *communitas*. *Communitas* in this sense can be suggested to be prompted by ritual activities which are intimately linked to cortical structures such as the limbic and autonomic systems (Newberg et al 2002:59). Since *communitas* type rituals are found in many societies across the globe implies the importance of altered states of being in relation to myth and ritual.

Studies of the hemispheric dialectic suggest that rhythmic and repetitive movements such as dancing, clapping, and body swaying engage the right hemisphere, whereas repetitive chanting such as Hindu and Buddhist mantra monopolises the verbal logical left hemisphere, enabling “the right hemisphere to function freely” (Lex 1979:126; Ornstein 1972, d’Aquili and Newberg 1999). Thus, it can be shown how ritual behaviour as a symbolic complex stimulates the autonomic nervous system. The dynamic interplay between the sympathetic nervous system and parasympathetic nervous system tends to strive towards an internal equilibrium which is different for each participant (Lex 1979:132-133).

Here, John Teske’s neuromythology is relevant. Narrative forms such as myth act as a mnemonic device, combining symbols in order to heighten emotion (Teske 2006). Since myths are multileveled, that is, they provide various social and psychological functions, so their engagement organises human actions that are both rational and immersed in mythical power, such as the construction of virtual realities or the sacred retrieval of a mythical past (Teske 2006: 187; Eliade 1954). Rites of passage are a poignant example of myth’s narrative quality. During a passage rite the initiate enters the ritual world which symbolically and spatially demarcates from the ordinary world. At the same time, the initiate must be provided with a new worldview – a cognitive model for understanding self and its new place in the social world (McManus 1979: 238). During the liminal phase previous cognitive models collapse – the initiate enters into an entropic state and is forced to make sense of his/her situation (McManus 1979: 239). As previously discussed, apart from promoting anxiety, liminality may also foster the emergence of new and novel ways of thinking which are reintegrated into the initiate’s new prescribed cognitive model (McManus 1979: 238). This process is ontogenetic; upon re-entry into the ordinary world the initiate’s past is discarded, their new psycho-social identity is emerged (Turner 1969, 1974). A ritual’s mythic content, invested with sacred meaning and authority recoordinates “the neural and cognitive apparati in the new mode,” thereby directing the transformation process (McManus 1979: 240). In addition the power of ritual lies in its putative ability to alter reality such as the distortion of temporal ordering in which time and space are dissolved (Newberg and Lee 2005:484). According to Newberg and Lee “time and duration are not absolutes”. I would contend that this sense of timelessness which participants experience during meditative states is a source of creative insight and leads to the emergence of mythic genre, and is akin to Eliade’s formulations of myths as pointing to an eternal return, an *illud tempus*, the origin of existence.

Future Cognitive Evolution

While the architecture of the brain is genetically determined its neuronal connectivity is subject to adaptation and change as a result of cultural factors. As Geertz (1973), points out, human brains without culture exist in an inescapable vacuum. At present, researchers have mixed responses as to whether bigger brains will equate to further intelligence in *Homo sapiens*. For thinkers such as the renowned physicist Stephen Hawking, the human brain has reached and evolutionary impasse. He argues that our present level of intelligence isn’t advanced enough to voyage to the stars. Consequently, we need to be more intelligent. Hawking’s answer is to provide an external and simulated uterine medium for developing foetuses. Such an environment would extend the gestation period of the foetus, whereby increasing the size of its cranium and brain. One may query whether the absence of the maternal uterine environment may pose unbeknown neuro-developmental problems and conditions to the developing foetus. This is because the uterus is an important site for the transmission of necessary growth hormones and other chemical properties to the foetus. Whether a simulated uterus can perform a similar bio-chemical function is problematic given the significance of the interplay between mother and foetus, such as the foetal responsiveness to the maternal cardiac rhythm. It could be argued that a foetuses' reposeful response to the rhythmic maternal cardiac cycle may be indicative of a nascent parasympathetic reaction which is aroused during ritual. If this is the case, future foetuses being deprived of the maternal uterine environment could have compromised subcortical responses in the trophotropic system which would create an imbalance between the ergotropic and trophotropic systems and their corresponding neural substrates.

Possibly, Hawking's way of dealing with the intelligence issue is awkward considering that human intelligence is not posited on encephalisation alone. This can certainly be challenged. As Bradshaw (1997:155) claims, the human brain has a lot of spare room, not the opposite. He points out that hemidecortication (a consequence of Rasmussen's encephalitis) if performed in the formative years of human life may result in the individual functioning without apparent loss of cortical function (1997:155). The bigger brain hypothesis leads us to further problems. The comparative anatomist Henneberg cites that the size of the "human cranial capacity" has decreased by approximately 10% (100-150ml) from "the late Pleistocence period until the early 20th century" (Henneberg 1998:747). It should be noted that this micro-cranialization has appeared at a time of advanced technological and cultural progress by *Homo Sapiens*. In this case, decrease in brain size is the result of the proportional decline in the musculoskeletal system. The latter's decline coincides with the evolution of agriculture, technology, science, writing systems, and urbanisation (Henneberg 1998:747). Taking up from Henneberg, the special qualities of human intelligence may not be due to either its size or anatomical structure (1998:748). On this note, it might be more beneficial to explore brain in terms of the distribution of its neuronal network rather than by any empirical study of its neuroanatomy (Adkins-Regan 2006).

This does not mean that *Homo sapiens* are evolving to be less intelligent. This is apparently not the case. What I propose is that the human brain is on the verge of a unique evolution via the emergence of nano-biotechnologies which will expedite and enhance cortical functions in the future. Recent literature on the nano-brain interface is both promising and visionary. Away from the sci-fi Drexlerian visions of nano constituted brains, the strength of nanobiotechnologies may in the near future come in the form of various implants in selected Brodman's areas to enhance memory and sensory perceptions (Garcia-Rill 2003:228). Brain-machine interfaces (BMIs) would be based on a feedback mechanism between neural circuits and bio-chips which would be driven by the electrical impulses of neurons (Nicolelis 2003:252). BMIs could provide various applications from restoration of motor functions in quadriplegics to complex sequence training by trainees in virtual reality environments (Nicolelis 2003:253).

Another possible area in which nanobiotech may converge with the brain is in measuring the levels of human 'sensory gating' via a helmet incorporating P50 midlateracy recording electrodes (Garcia-Rill 2003:230). The nanotech helmet would have a range of self monitoring and therapeutic functions such as ascertaining the level of blood flow to the frontal cortex. Insufficient ability to sensory gate may derive from decreased blood flow to the frontal cortex called hypofrontality. Hypofrontality is evident in various neurodegenerative and psychiatric disorders such as Alzheimer's and Huntington's diseases and Schizophrenia (Garcia-Rill 2003:231).

Hypothetically, the long term application of neural prosthetic devices could spurn the emergence of cognitively enhanced human beings, thus, altering neural organization over time. This may come about via nanobots (nanotechnological robots) which may in part simulate neurons (Kurzweil 1999). If in the future, computational systems are based on the principles of the nervous system this would provide a more informed knowledge on the neuro/machine interactivity (Cauller & Penz 2003:256). From an evolutionary viewpoint, nano-neuro fusion may provide novel neural organizational patterns which we cannot foresee. This is because of the neuroplasticity of the brain which allows for "the continuous refinement of neural functions" (Cauller & Penz 2003:257). Intrasomatic biofeedback which enables individuals to control physiological functions such as heart rate, blood flow to skin, and muscle tension via the conditioning "of autonomic and brainwave signals" could over a period of time induce biological changes to the human body (Pope 2003:268).

Conclusion

This article has proposed various areas in the study of emergence and the human brain. The concept of emergence is a productive area for neuroscientific research given that the brain is still evolving. From the social scientific approach, emergence is a significant area since human neurological connectivity is dependent on cultural evolution. The domain of cultural evolution needs to be addressed more by neuroscientists, particularly in the area of "cultural selection processes" (Knudsen & Hodgson 2006). For example, ideas are more than evolutionary units, and social organizations are more than gene like simulations (Knudsen & Hodgson 2006). In other words, an organismic approach to cultural evolution fails to elaborate on our intense consciousness as meaning makers. Emergence not only embodies human complexity but defines our unique evolution. Here, the human brain exemplifies an autopoietic network in that it is self organizing and self regulating and engages in symbolic conceptualisation which forms the basis of human consciousness and experience (Nelson 1999:48). Lipp (2000:156), contends that "rapid evolutionary adaptation" might be produced by environmental changes. An interesting issue here is "how fast genetic adaptation and speciation can occur" given the possible influence of microcephalin and ASPM genes have had on the brain in our previous evolution (Lipp 2000:156). It seems likely that emergence as a novel form of evolutionary adaptation may either "accelerate or decelerate" future human evolution (Laland et al 2000:140). Laland et al claim that it was advantageous for early human ancestors to pass on more information to their offspring, as this increased human capacity to control and regulate the cultural and physical environment (Laland et 2000:142). In other words, more information enabled for greater cultural novelty in creating new forms of information which led to greater control. It can be hypothesised that the present information age explosion may lead to different kinds of mutualisms which are evident in nascent cyber space interactions. If the brain is posited on a modular model as evolutionary psychology professes then algorithms are central to the brain's input. This being the case, algorithms may themselves be open to change as individuals learn new knowledge (since inputs modify the brain's wiring) (Aunger 2000:147). On this theme, I conclude by citing Cohen (2005) who states:

> It remains to be seen whether the prefrontal cortex (and associated structures) has the capacity to meet the challenges that its appearance seems to have introduced, or whether evolution has truly taken a bite of Eden's apple.

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