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The Natural Sciences Meet Applied Linguistics:
The Brain and the Mind

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I have suggested that the symbolosphere may constitute, at least, part of the mind. There is general agreement that the brain is complex and far from fully understood. Therefore, it is mysterious, and it will require decades to unravel its structure, processes, and functions. On the other hand, there seems to be less mystery about the mind. The term is often used without any attempt to describe it. But whereas we know where the brain is, and we can point to it, where would we point if we wanted to indicate the location of the mind? I have colleagues who believe that the mind is the brain, so they would simply point to the head. But this wouldn't work for scholars who believe that the mind is not just what's inside the skull, but that

it also extends to the body and the environment, including interaction with other brains via a powerful symbolic communication system, language. In other words, the mind is at least, the physical brain, body, physiosphere, biosphere, and the symbolosphere.

The distinction between mind and brain is far from settled. A larger number of cognitive scientists now maintain that the brain is embodied and thus works in conjunction with the body through the autonomic nervous system, the musculoskeletal system, the endocrine system, the digestive system etc. In addition, this embodied brain is embedded in the world such that it functions in conjunction with aspects of the physiosphere, the biosphere, and the symbolosphere. In this paper, I propose that the human brain can create and process nonmaterial entities, and these entities are symbolic relationships in which signs (words) get their meaning from their relationship with other signs.

Extended Mind and the Bounded Brain

The hypothesis of the extended mind (EM) (Clark and Chalmers, 1998) was developed as an antidote to the notion of

the Bounded Brain (BB). This adjustment has required justification of the notion of "extended". The concept of the extended mind perhaps comes from making the implicit equation of the mind with the brain and then having to go beyond the brain. The problem might be ameliorated by making “MIND” the superordinate entity and then specifying its components. I would suggest that the mind is composed of the brain, the body, the parts of the inorganic physical world (the physiosphere), parts of the organic biological world, the (biosphere), non-material aspects of the symbolic world (the symbolosphere), and the material entities (e.g. artifacts, technologies) that have come out of this symbolic world. Now nothing has been extended. This mereological miracle creates one thing with several parts.

(The parity principle no longer has to apply.) Since the mind is not part of the brain, there is no reason why cognition that is external to the brain must be the same as what would occur internally and nor must it be performed in the same way it would be in the brain. Cognition outside the brain, however it is done, is cognition as produced by the MIND.

The extended mind seems to be the mind as embedded in the brain and then extended from it. Making the brain part of the mind eliminates the need for extension. The external components of the mind are mind; and an internal component of mind is the brain. But as my colleague Leon Somes says "no brain, no mind." Actually because of our symbolic abilities, the mind supervenes on the brain, but it remains true that if there is no brain there is no mind.

Robert Logan (2010, Mind and Language Architecture, The Open Neuroimaging Journal) has done some very important work on the relationship between mind and language. He conceptualizes mind as Brain + Language. Following McLuhan (1962), he distinguishes between percepts and concepts. In Logan's program, humans were initially only capable of percepts which are impressions of objects and events in the world made through the senses (vision, audition, olfaction, touch, and taste). The percepts are of concrete physical entities in the external world.

But as hominid life became more complex, percept-based cognition was inadequate, and there was a shift to conceptual thinking. This form of ideation allowed the formation of

superordinate categories for classes of percepts. Concepts developed that were abstractions over classes of perceptual entities and the relations among them.

Logan argues that concepts and language evolved simultaneously under pressure for a vehicle to express and share the concepts. Words were such vehicles and grammar emerged from efforts to combine words into larger meaning bearing utterances.

An important aspect of Logan's work is his framing of language evolution within a dynamic systems perspective. He sees the split between percept and concept thinking as a bifurcation resulting from punctuated equilibrium. Words become attractor states; indeed, they constitute strange attractors because the meanings of the words can differ in different contexts. Words have, "multiple, even ambiguous meanings, or multiple simultaneous perspectives" (p. 8). Mathematics tries to avoid such ambiguity by developing precise definitions and such mathematically-based scientific terms approach fixed-point attractors where much ambiguity is avoided, but not completely; a degree of fuzziness always remains. But word-based meanings used in the context of the social sciences and

in the humanities have much greater fuzziness by their very nature.

Logan argues that language and conceptual thought emerged as an autocatalytic process. In other words, they self organized as their interaction "catalyzed each other's existence" (p.4). Because of the processes involved in complex systems (autocatalysis, self organization, emergence), Logan argues that it is not necessary to postulate an innate basis for syntax.

It would appear that a remarkable thing about the human brain is that it is a physical organ that, in interaction with other human brains, can create a nonphysical environment, the symbolosphere, consisting of ideas, ideologies, idealizations, concepts, conceptualizations, theories, and unreal worlds. Some of these are nonexistent entities or fictions, but they are symbolic constructions as described in the symbolosphere, and they have effects on the physical brain and on the behavior of humans.

Thus, one of the characteristics of the physical human brain is that it has the ability to produce and process nonphysical entities. Words such as obedience, convenience, dominance,

patience, temperance, suspense, indifference, offense, are both abstract and refer to nonphysical concepts. These concepts seem to be abstract categories under which many different entities may fall. It would appear then that abstract nonphysical entities would not exist without language. As mentioned above, one way the brain, working with the language, generates nonphysical things is by naming individual entities, which may be physical or nonphysical, producing a lable for a superordinate category that refers to all of them. It then, of course, becomes possible to create labels for categories of categories. So the physical brain produces something nonphysical by abstracting from tokens of things to types of things. And as soon as we get to these abstractions we can leave the material world. Another way is to imagine nonexistent things and to label them (e.g. zombies, unicorns, ghosts, spirits, gods, dragons, and events such as mythical worlds, lands, life after death, superstitions etc).

It might be argued that, if it is the physical brain that creates and processes these entities, then those productions are physical. I would suggest that the brain physicalizes the entities, but that does not make them physical. Word forms and meanings will be nonmaterial, but when they are spoken, they are processed as articulatory gestures in the physical vocal

tract that have been processed previously in the physical brain and then processed in the brain of a hearer. This constitutes extensive physicalizing of the word and its meaning. But if the word does not have a physical referent in the world; (i.e., it is a nonphysical conceptualization which is frequently modified and passed from brain to brain) it is continually physicalized but never becomes physical.

The nonphysical conceptualization is maintained in some form in spite of its extensive physicalizing (i.e. processed in physical brains). The physicalizing is a constraint on the nonphysical word meaning and provides it with some stability (unlike a dream), but still allows the meaning to evolve.

Non-reductive Physicalism

Does the notion of the symbolosphere that can be nonphysical and exist with the brain that is physical constitute dualism? In some circles it would appear that dualism is equivalent to an intellectual and moral deficit. I myself am not troubled by the idea (see Logan & Schumann, 2005) because you can't have the symbolosphere without the biosphere and the brain. But when the brain developed the capacity for symbolic reference and could produce nonmaterial entities, the change may have been

one aspect of the human spark, one aspect of humanity that makes us strikingly different from our primate relatives.

The philosophical concept , non-reductive physicalism, offers a way for us to understand how nonmaterial entities can have physical sources while at the same time not be reducible to physical structures (Murphy, 2013). The mind is composed of the brain, the body, the physiosphere (including the biosphere), and the symbolosphere. Life (the biosphere) came out of the physiosphere and the symbolosphere emerged from the biosphere when we became capable of symbolic reference and language (Deacon, 1997). The symbolosphere is, at least in part, composed of nonphysical concepts, conceptualizations, ideas, ideologies, and idealizations, and it can exert downward influence that affects physical and biological processes. Thus, the emergent structures of the symbolosphere can influence which physical processes will apply in a particular situation (Murphy, 2013).

An important aspect of non-reductive physicalism is the notion of complexity. As Diane Larsen Freeman (1997) has pointed out, complex systems can generate emergent properties with the ability to have downward influence on the physical

structures from which they come. We've argued that the symbolosphere emerged from the physiosphere and the biosphere when humans developed the ability for symbolic reference and language. And as was argued in the first part of the paper, the symbolic abilities allowed nonphysical entities to have descending influence on the brain and the body. So the mind can have nonphysical components that emerge from the physical but are not reducible to the physical. This framework is then philosophically situated within the school of non-reductive physicalism (Murphy, 2013). Thus to understand the mind, we have to move from notions of mechanisms and aggregates to relational properties of complex systems which can influence the physical components of the mind---the brain and the body (Murphy, 2013).

Another reason that the mind extends beyond the brain and cannot be reduced to the brain is that brains interact with other brains creating conceptualizations that cannot be assigned to an individual brain let alone to any area or circuit that brain. For example, suppose a scientist, scholar, comedian came up with the new concept, “loshpost”, and a neuroscientist was able to demonstrate that that word was processed in X area or Y circuit in the brain. Does that mean the concept came

from X the Y parts of the brain? It actually might mean the opposite. The concept may have become subserved by reusing a part of the brain which was previously the substrate for other entities. The concept may actually have gone into the brain rather than out of it.

Would the fact that this symbolic concept is processed by the brain make the concept physical? Is the firing of some neurons in X and/or Y the actual concept or is it the physical response of the brain to an environmental stimulus? Brains process all relevant features of their environments, and the human brain will respond to abstract nonphysical entities in the human's environment. One reason for this is that humans have language and can express symbolic relationships in an acoustic form to which related areas/circuits of the brain will respond. One might say that the responses in X and/or Y are physical vehicles for the concept, but not the concept itself (see Favareau below).

In an important extension of this idea, Gallagher (2013) argues that the extended mind is instantiated in various "mental institutions" (p.3). These are social/cultural institutions such as legal systems, educational systems, museums, and libraries.

Gallagher focuses on legal systems where interacting brains of many individuals develop principles that govern what is contained in various kinds of legal contracts. I would argue that the contract, typed and consigned, constitutes a physical entity. But the principles on which it is based are not physical. They are ideas/concepts that have been generated by multiple brains acting orally and in writing, often over generations. The contracts produced place constraints on how we can behave in relation to each other. These constraints emerge from many brains, and they influence the behaviors of many people.

The legal principles also constrain the ways our brains make judgments and decisions. Gallagher (2013) observes, "a judgment made in such contexts [a legal system] is a form of cognition that supervenes on a large and complex system without which it could not happen. Indeed, it's a cognitive practice that in principle could not happen just in the head" (p. 6). In terms of the position taken in this paper, the judgment is based on the "large and complex system" (p. 6) of legal principles that are not in the head and therefore not physical.

Deacon: Ententionals, Absentials, Constraints

Terrence Deacon, in two very important books, The Symbolic Species (1997) and Incomplete Nature (2012, 2013), characterizes how sign-sign relationships allow the construction of non-physical symbolic entities (Deacon, 1997), how the inorganic physical world produced the conditions for the organic biological world (life), and how the nonphysical aspects of mind emerged from these physical entities. In this work, he has introduced several concepts: ententional phenomena, absential phenomena, and constraints. The word “ententional” is derived from but is also distinct from the word "intentional". He defines “ententional as a generic adjective to describe all phenomena that are intrinsically incomplete in the sense of being in relationship to, constituted by, or organized to achieve something non-intrinsic" (27). It constitutes "a fundamental relationship to something absent"(27). The following list includes the sorts of entities that Deacon would consider absentials:

"A state of things not yet realized, a specific separate object of representation, a general type of property that may or may not exist, an abstract quality, and experience, and so forth – just not that which *is* actually present, an experience, a purpose not yet actualized, a quality of feeling, a functional value just

discovered (3), meanings, purposes, consciousness, value [having emotional or motivational significance] (2), function, something-not-there that permeates and organizes what is physically present (9), intended goal, any intentional and teleological properties (10), absent referents, unrealized goal, abstract values (11), something not-quite-realized, something not-quite-actual (19), a final cause, motivations (21, 22), something that is 'for-the-sake of' something else, desires, beliefs, sentience, reference, design, self, subjective experience, attributes often associated with mental states (38)".

A good example of Deacon's notion of absential is the concept "zero". Its meaning, "nothing," refers to a nonphysical entity. That entity can be physicalized by the numeral "0" or the word, "zero", but neither 0 nor the word is the concept, zero. The concept is nonmaterial, nonphysical. Another entity that is nonphysical is a unicorn. The unicorn is nonphysical because no such thing exists, but it can be physicalized by a drawing of a horse or a statue of a horse with a single horn in the middle of its forehead. All the Gods of the Greek pantheon are nonphysical because they didn't/don't exist, but they did have influence on how people thought and how they behaved. Indeed, for atheists God is nonmaterial because for them no

such entity exists. Even among believers, God (the Father) is a nonphysical spirit, but believers think and behave according to what they think God demands.

Word meanings are nonmaterial although they may refer to material entities. For example, the word "shovel" refers to something physical, but its meaning as captured in the dictionary definition of "shovel" is not physical (Deacon 2012, 2013) although the words in the definition have been physicalized in the printed words of the dictionary definition in the dictionary. A picture of a shovel is a physical representation of that tool, but it is not a shovel. Interestingly the definition of a shovel in the Webster's Seventh New Collegiate Dictionary (1972) is accompanied by pictures of shovels, probably with the realization that the words in the non-physical definition of shovel would not make it clear what a shovel is. A very clear case for the non-physicality of meanings comes from abstract words. For example, the concept "duty" is not material/physical. To understand the meaning, one may need many examples in many contexts or a definition that would be in words that refer to other words. These words are not "duty"; they are a set of signs that are necessary to explain the nonphysical concept. The same is true

for other abstract words such as "dignity," "interest," "salience," "freedom," etc. In Campbell (2012), Deacon explains that words can influence people's thinking and behavior, but "it's not because of anything physically or energetically there in words. It's actually about stuff that's not there. What will have an influence in the world is the meaning, the significance, the surprise value; all of these features that come with our talk, our words, our concepts, our thoughts (14)."

"I also don't think that thoughts are in the head. I think that neural activity is in the head, but I don't think that thoughts are, in the sense that there is some stuff or energy there. It's like words on a page; the words on a page are not what matters, the words on the page *convey* [my emphasis] what matters. (14)." He continues, "what matters is not something physical, chemical, energetic. What's so surprising is that, despite the fact that these kinds of things don't have the physical characteristics that should, according to our current theories, cause things to happen – they don't have those attributes – nevertheless they're remarkably powerful and important, once you get living and mental processes in the world (14)."

Symbol Grounding.

The biosemiotician, Donald Favareau (2015), further investigates the notion of symbol. He explains that icons that get associated with other icons become indexes indicating things in the world. For example, smoke can index fire, war, cigarettes, a dirty engine, cooking, or incense etc. Smoke as an index of fire can become an index of hell which gets its meaning from abstract concepts such as God, eternal damnation, punishment, suffering and hell becomes a symbol.

Favareau notes that icons and indexes relate to material objects in the world. Symbols relate to nonmaterial imputations: words that refer to other words for their meaning. For example, "motivation imputes (i.e., lays responsibility for, credits, attributes to, credits by transfer, grounds in) goals, motives, drives, rewards etc.

Favareau citing Deely (1990, 2001, 2015) notes that animals interpret objects and situations as desirable, undesirable, or safely ignored. But abstract symbols such as marriage or capitalism are "always simultaneously imputed to be desirable,

undesirable and safely ignored all at the same time." (p. 251). Thus, symbolic relations are grounded in imputation, indexes are grounded in association, and icons relate to qualities of an object.

Icons and indexes have their grounding in the physical qualities and facts of the world outside the brain, but symbols do not have a purely physical grounding. Human symbols are grounded in human interaction and are maintained by a community/culture. Individuals may vary in what they impute to a symbolic term. Let's take "communism". It is an abstract symbolic term that can take numerous different attributions. Favreau argues, "such is the case with almost all of our culturally embedded symbols: "God", "mind", "similarity", "friendship", "trust", "science", "beauty", "justice", "self", "good", "wrong", "again", "nothing", "being", "time" – all of which we can talk about with one another reasonably enough, without ever being able to converge upon a single predicated definition that captures their essential meaning, or ground." (p. 252). Thus, “the ‘ground’ of symbolic reference in a sense *depends* on such symbols never unilaterally resolving into a single, fixed, intellectual entity or concept.” (253). A symbol points to web of sign relations, not to an external referent.

The ground or grounding for a symbol is not a concrete entity from which the symbol develops. Symbols are in the minds of their interpretants in the form of propositions. Arguments about the propositions arise in communities of interpretatants, and they have a history. Brains interacting with other brains elaborate the symbol propositions, develop them, and carve them to fit different conceptualizations. This process allows symbols to grow into symbolplexes with the different understandings being maintained at one time (synchronically) and overtime periods (diachronically). This historical dimension permits symbols to develop and to potentially create new knowledge. But an ultimate interpretant may never emerge and indeed should never be expected. Final answers and final understandings are possible in the physiosphere and the biosphere, but they are not characteristic of the symbolosphere.

The brain and nonphysical entities.

Returning to the issue of physicalization, the question we have to understand is how the physical brain can produce nonphysical concepts. George Lakoff (2014) offers insight into

this question with his examination of Conceptual Metaphors (referred to above). He argues that

bodily experience in the world allows the production and understanding of conceptual metaphors. Love is an abstract entity. The brain construes it by associating it with physical aspects of the world. Following Lakoff, Evans (2015) discusses this in terms of primitive conceptual metaphors and complex conceptual metaphors that humans derive by way of our embodied brains' experience in the physical world. The "love" concept is understood in terms of three metaphors: the physical container metaphor (He is in love. Mary fell out of love.), the physical force metaphor (She couldn't resist his love. She refused his love.), and the physical journey metaphor (We're at a crossroads. We're stuck in a rut. Their relationship is on the rocks).

Lakoff (2014) argues, "the division between concrete and abstract thought is based on what can be observed from the outside. Physical entities, properties, and activities are "concrete." What is not visible is called "abstract:" emotions, purposes, ideas, and understandings of other non-visible things (freedom, time, social organization, systems of thought, and so on). From the perspective of the brain, each of these abstractions are (sic) physical, because all thought and

understanding is physical, carried out by neural circuitry. That puts ‘concrete’ and ‘abstract’ ideas on the same basis in the brain. " (p. 7).

So love is an abstract entity. The brain construes it by associating it with physical aspects of the world (container, force, journey). Humans derive these metaphors by way of our embodied brains' experience in the world. And the metaphors are produced and processed on neural circuitry. But does processing something on neural circuitry make that thing physical? As discussed above, another way of looking at the issue might be that the physical human brain creates, processes, and uses non-physical entities by physicalizing them, i.e. by construing them in terms of experience in the physical environment. When a nonphysical entity becomes physicalized, it does not mean that it has become physical; it has merely been redescribed or restructured using mental concepts that are metaphorically derived from the physical world. It would appear that language is required for this physicalization. By virtue of processing by the human brain which is integrated with a symbolic system, language, a nonphysical abstract entity becomes understood through the physical (love becomes a container, a journey, a force). Or a physical entity becomes an abstract nonphysical entity. Many

mental states which we experience physically get classified under a superordinate abstract word. For example, fear, happiness, depression, love, jealousy, envy, and passion, longing, are collectively labeled emotions.

Evans (2015) presents an illustrative vignette about the frustrations of a computer user. The computer is physical. The user is physical. But the qualia of this frustration (an emotion), and the concept of "frustration" itself, are felt by the biophysical body and brain, the concept itself is not physical. If the user recognizes that the feeling is what his society calls frustration, then he is processing an abstract construct which is derived from his physical experience, conceptualized by a culture, encoded in language. It is thus a nonphysical entity that is underpinned at every step of the way by a physical body and brain, but not reducable to the physical.

One might argue, that the entity/phenomenon discussed here is so dependent on the physical world, why don't we simply consider it physical? Well, if we want to understand how humans are different from other animal species, including our closest relatives, the apes, then the human ability to derive nonphysical entities from the physical brain, body, and world may be one of the dozens of ways that we differ from animals. Understanding our brain's ability to produce and to process

nonphysical entities may help us understand humanity, and it may help us understand (rather than dismiss) the humanities and the arts that make up so much of the human world.

How does the brain produce nonphysical entities?

Neural Reuse

A candidate theory for how the brain produces nonphysical entities comes from the notions of neural reuse. Neural reuse theory (Anderson, 2010, 2015) maintains that regions and networks in the brain are reused, redeployed, recycled, exploited, and colonized to subserve new functions. These processes lead to massive interconnection and overlap of neural structures. Reuse continues even after the original and subsequent functions are established, and the result is that one-to-one mapping between neural structure and function is rare. Anderson (2010) argues that there is overwhelming evidence that neural reuse is a characteristic of brain structure, but how the reuse is actually implemented in the brain is still very much an open question. One possibility might be that when the brain needs an abstract structure, say a higher order subordinate term, it searches itself for a region or network that

serves a related function and then exploits that network by redeploying it to support the more abstract entity. To put it in reentrant selection terms, the original network selects the concept, and the new concept selects the original network. As Anderson (2010, 2015) points out (see below), a highly abstract concept (e.g. love) may later become grounded (i.e., physicalized) metaphorically (Love is a journey.). Thus, as discussed above, conceptual metaphors allow us to reground a concept in physical terms. One important function of conceptual metaphors is to take abstract concepts and reformulate them in in physical terms, i.e., to physicalize them, but, of course, physicalizing them does not make them physical.

Biological processes in neural reuse.

It is the general case that neurons communicate at synapses. But another form of neural communication involves volume transmission (VT), also known as non-synaptic neurotransmission. In this process, neurochemicals are released into extracellular space. Depending on the particular chemical milieu, the VT signal can be up regulated or down regulated, and then this signal can up or down regulate the synapse and alter the action of a circuit without connecting

two cells via a synapse. In this way, a single circuit or network can produce several outputs. The neurochemicals can diffuse in different directions (ansiotropy) depending on the structures they encounter. The chemicals can easily affect glial cells which operate via extra synaptic communication.

Anderson (2014) suggests that VT may facilitate the search process that occurs when an environment presents a challenge for the brain to find candidate networks for possible reuse to subserve a new function. He also suggests that VT might potentiate learning by the formation of "temporary coalitions of neural partnerships" (69).

Axonal-dendritic overlap

Another process that may contribute to neural reuse is through axonal-dendritic overlap (Ascoli, 2015). Ascoli argues that the Hebbian adage that neurons that fire together wire together may be implemented where an axon of a neuron is in close proximity to the dendrite of another neuron and the functions of the two neurons are related, a connection may form between the axon and the dendrite. The area of overlap is called a potential synapse. Ascoli, who is interested in the neurobiology of learning, notes that such overlaps are very common and constitute an efficient way of forming new

connections. He suggests that the overlap constitutes background knowledge that facilitates learning, and the synapse formation produces the actual learning. I would suggest that perhaps the overlap could also facilitate reuse. One can imagine that extracellular neurochemicals in the region of an axonal-dendritic overlap might produce a non-synaptic communication between the neurons at the overlap thus creating a "neural partnership" (69) that could subserve reuse.

Friedemann Puvermuller (2013) and his colleagues have been exploring the neural basis of word meanings. In general, they will found that there is a strong tendency for the words to be processed in areas of the brain related to the word's semantic reference: actions, objects, sounds, the numbers, number concepts, color, form and the motion. Pulvermuller suggests that concrete words like "hand" and "eye" have clear embodied referents, but many abstract words maintain a much less direct connection to the body and its action. For example, the abstract words "perception" and "infinity" are only weakly tied to action in the body, and therefore are disembodied abstract words. Abstract words may become detached (or be

unattached) from bodily schemas, and therefore, rather than activating body-related circuits, they may link to multimodal prefrontal parietal and temporal convergence zones. In addition, it might be imagined that some words have embodied and/or embedded links at one time in their history, but these links may become weakened overtime. Then the words may have to be learned via dictionary meanings and etymologies. This would be a classic case of Deaconian symbolic reference whereby words get their meanings by association with other words.

Pulvermuller also argues that the association between the abstract concept of an emotion (e.g. sad) and the abstract word /saed/ is acquired through language socialization in which adults identify for the child the appropriate behaviors (i.e., emotion-expressing actions) associated with an internal state of sadness. This position parallels Barrett's (2009) notion that emotions, as we have will named them, are psychological constructions or, from a semiotic perspective, they would be considered symbolic constructions.

Since nonphysical entities are frequently products of what we refer to as human imagination, the neurobiology of imagination

is an important candidate for the physical systems that support the generation of nonphysical/nonmaterial entities.

The neurobiological dynamics of the imagination, John Kaag, Phenomenological Cognitive Science, DOI 10. 1007/s 11097-008-9106-2

Kaag suggests four processes that that may underlie the human ability for imagination: plasticity, experiential selection, reentry, and degeneracy. With respect to plasticity, he notes that brain areas that respond to bodily and spatial orientations also respond to linguistic cues that refer to these orientations. This indicates that abstract grammatical concepts carried by linguistic elements such as prepositions, articles, particles, and other forms conveying grammatical information can be adapted to areas and circuits that subserve bodily actions.

Kaag cites Edelman's (1987, 1989, 1992, Schumann et al, 2004) notions of developmental selection and experiential selection as contributors to neural plasticity. Edelman explained that genes do not specify the targets of all neurons. Instead, they control the expression of adhesion molecules that cause cells to bind together and move along certain trajectories. These

processes are largely stochastic and depend on the local mechanicochemical milieu in the embryo. A cell's ultimate location and connectivity are thus the result of the activity of the adhesion molecules and the chemical influences on the cell's history. This activity, called developmental selection, leads to brains that are similar in overall construction but which vary considerably at the level of microstructure (i.e. circuitry formed among neurons, axons and dendrites).

A third source of variation is experiential selection. Developmental selection establishes a "primary repertoire" which consists of neuronal groups whose connections, and thus basics circuitry, are formed by the activity of adhesion molecules during embryology. Postnatally, as the infant interacts with the environment, certain of these circuits match or resonate with the environmental input, and their synapses become strengthened. So in a very real sense, in the process of experiential selection, the environment selects the neural circuits in the brain that will subserve a particular signal or set of signals. Because each individual's environmental experience is different, experiential selection operating on the variation in the primary repertoire generates brains that, at the level of microanatomy, are even more different from one another. (The

material in this section is reproduced from Schumann et al, 2004).

It is my sense that Kaag is arguing that plasticity in the life of the individual and the species operates, at least in part, through forms of experiential selection. When the species acquires a new trait such as oral language and when an individual learns a new skill such as reading, the trait or the skill selects regions or networks with which it resonates and then the substrate which involved for other reasons is reused for the new knowledge. (See the discussion of neural reuse, p.23ff).

Kaag argues that the selection process involves the Hebbian notion that neurons that fire together form synaptic connections. In the light of experiential selection, the environmental inputs to various parts of the brain become associated as they reuse previously formed circuits to support the new task or skill. Thus new circuits are constructed by borrowing neural structures that have the plasticity to become the neural basis for the new knowledge. In other words, the plasticity provided by Hebbian synapses facilitates neural reuse for new environmental inputs.

Reentry is a characteristic of neural structure in which reciprocal/bidirectional connections between neural maps allows the selection and correlation of different areas and thus mediates the " ‘emergence of complex sensory and conceptual meanings.’ “(p. 8). These reentrant connections are heteromodal and coordinate many functional maps allowing processes such as categorization, abstract concept formation, and feelings that are not reducible to the neural activity that generates them. Reentry allows creative imagination by integrating separate neural maps that bring different information together in new patterns thus past patterns integrate with novel current activations coordinating the past with the present.

Kaag suggests that additional contributors to the neural basis of imagination are mirror neuron systems. When a person performs an action, certain neurons fire, and when a person watches someone else perform that action, neurons of the mirror neuron system also fire. Indeed these neurons become active when the individual simply hears an action performed or only observes a small part of the action. The alignment and

intersubjectivity that may be fostered by these systems may also underlie the ability to imagine.

Degeneracy, once again, refers to the situation in which to structurally different areas or networks in the brain can produce the same or similar outputs. Kaag argues that this ability provides flexibility to produce more adaptations. In sum, if my understanding is correct, Kaag suggests that these four processes (plasticity, reentry, mirror neurons, and degeneracy) each and together support the creativity the processes of imagination.

Agnati et al. (2013) propose a possible neural substrate for imagination. They begin by distinguishing between imagery and imagination. Imagery involves recovering from memory representations (images) of entities previously experienced visually, auditory, or motorically, but that are not currently present. Imagination is the ability to create images of objects, actions, and events that have not previously been experienced. It includes unreal scenarios, plans and visions for the future, nonexistent worlds, hypothetical constructs, ideas etc. These entities are constructed from stored images and created images, and they are not necessarily tied to the material-

physical world. Both imagery and imagined entities can affect the brain and the body in the same way that the external physical environment does.

Agnati et al. (2013) suggest that even the brain has imagery neuron systems (INS) that have been exapted from extant systems (e.g., mirror neuron systems) that are put to a new use. This process, they argue, is compatible with notions of reuse or redeployment (Anderson et al., 2012) made possible by the interaction-dominant dynamics of the neural systems that generate plasticity by massive interconnections among neural areas. (It is this interconnection and interaction that, as we argued, make it difficult to assign unique functions to regions). The authors hypothesize that imagination was exapted from pre-existing neural circuits for imagery and self awareness that we may also share with other animals, especially apes. The system they propose consists of a hierarchy of nested functional modules (FM) (as in Russian dolls) that exist at the network, synaptic cluster, synaptic, and molecular levels. The FMs can assemble as needed and communicate with each other either via wiring transmission with actual physical connections or via volume transmission in which interaction is achieved through the expression of

neurotransmitters into extracellular space (ECS) where they also interact with astrocytes and help to define the boundaries of the FMs and facilitate the construction of synaptic clusters within them. The researchers speculate that there may be modifiers between the signal from the environment and its target within the FM and between FMs. The modifiers operate in either a pass mode or an interrupt mode, which open or close the pathways through the ECS. The authors suggest that this structure creates opportunities for a large number of transient integrative processes that could subserve creative reuse of circuits and regions that evolved for other purposes.

The authors then suggest that the imagination system (INS) may operate within the Default Mode Network that "includes ventral-medial prefrontal cortex (VMPFC), posterior cingulate cortex (PCC), lateral parietal cortices, and the hippocampal/parahippocampal cortices." (p. 11). This network is hypothesized to create and control the pathways through the VT of the neurochemicals in the ECS.

WHY?

When I share these ideas about the nonphysical aspects of the mind with colleagues, I generally get two types of reactions. The first is that they say they always have assumed that the world contained nonphysical entities and wondered why I felt it necessary to point this out. Some of these people were comfortable because their religious beliefs included entities such as the "Holy Spirit", "Grace", and "heaven". But others had always assumed that ideas, concepts, and thoughts were nonmaterial, but that they were the generated and supported by physical brains.

Why is it important to understand the brain's ability to create and process non-physical entities. In the following section, I will discuss this issue from the perspective of the importance of the nonmaterial symbolic world and the importance of the uncertainty that it creates. An enormous amount of the symbolosphere consists of fictional stories, novels, movies, and plays. These are objects of study in the humanities, and as Siri Hustvedt (2016) notes, "examining the dynamic brain

processes involved in fictional experience is important, and if the right questions are asked, it may lead to further understanding of the ways in which fictions of all kinds are related, the ones we read in books, but also of the fictional aspects of memory and imagination in general." (451).

Some years ago when I told my daughter who is now an author and a professor of creative writing about the unreal worlds of the symbolosphere, she said, "I get it dad, it's what we call fiction." She often writes within the framework of magical realism in which characters inhabit a "physical world", but neither the characters nor the world is constrained by the laws of physics. These worlds are nonmaterial, and they are described in physical terms but at the same time, they are not limited by the laws of the physical world.

Harari (2015) along with other scholars, suggests that about 70,000 years ago there was a change in the way Homo sapiens could conceptualize. Unlike other apes, they began to cooperate in large numbers. Hariri proposes that what made this possible was their ability to produce fiction. "Large numbers of strangers can cooperate by believing in common

myths." (27). The general idea is that the beliefs in the same myths, religions, laws, customs and behavior (i.e., the symbolosphere) mediate and facilitate cooperation beyond family and kin. But this cooperation required the ability for symbolic reference (sign-sign relationships) and a powerful communication system (language) to communicate the fictions that motivate cooperation. Further, we needed the symbolic abilities to create fictional (irrealis) worlds in order to eventually invent science and to understand the physical world. Harari refers to this as the cognitive revolution, but in terms developed in this paper, we could understand it as the revolution of symbolic reference or the symbolic revolution. Harari believes that since this revolution occurred, humans have been living in a dual reality – the material reality of the physiosphere and biosphere and the nonmaterial symbolic reality which we have called, the symbolosphere (religions, constitutions, nations, philosophies etc.). He states, "the ability to create an imagined reality out of words enabled large numbers of strangers to cooperate effectively," (32) in other words our ability for symbolic construction. He suggests that “without an ability to compose fiction, Neanderthals were unable to cooperate effectively in large numbers, nor could they adapt their social behavior to rapidly changing

challenges." (34) The human ability for symbolic reference allowed us to produce nonmaterial entities that gave us minds that go beyond biology while remaining integrated with it. With a shared mythology, large numbers of people could unite behind gods, totems, spirits, rituals, and, in general, shared beliefs (even if they were only in fictional entities) and thus to cooperate with individuals beyond the immediate family. This provided a platform for the creation of "imagined orders" (102ff) which were formalized in documents such as the Code of Hammurabi and the American declaration of Independence. People believed in the tenets of these documents and cooperated to achieve them. Dissenters, of course, existed, but there were always enforcer institutions (armies, police forces etc.) where individuals cooperated to convince or silence the dissenters. If these institutions were unsuccessful, new orders were always possible. For example, the ideas that "all men are created equal, that they are endowed by their Creator With certain unalienable rights, that among these are life, liberty, and the pursuit of happiness," constitute fictional symbolic conceptualizations that generations of Americans have decided to believe in. Such imagined orders are intersubjective and are shared in the brains of members of a society. (117)

Fictions of all kinds served to establish and maintain hominid life; they engaged the nonphysical, unreal and imagined entities. But as chronicled in Literary Wonderlands: A Journey through the Greatest Fictional Worlds Ever Created, the imagined, the unreal, and the nonphysical continue to profoundly engage our species (Miller, ed., 2016). Miller's survey covers works of Ancient Myth and Legend (up to 1700) such as The Epic of Gilgamesh (c 1750 BC) with imaginary landscapes in exotic places, works of Science and Romanticism such as Jonathan Swift's Gulliver's Travels (1726) which portrays the 6 inch high inhabitants of Lilliput, the 70 foot high people of Brobdingnag, and the struldbrugs of the kingdom Luggnagg who are immortal but senile, and the intelligent horses and uneducatable Yahoos encountered on his fourth voyage, the stories of the Golden Age of Fantasy (1901-1945) is such as J. M. Barrie's, Peter Pan in Kensington Gardens (1906) and Peter Pan, or the Boy Who Wouldn't Grow Up (1904), books of the New World Order (1946-1980) such as the great dystopia of George Orwell, Nineteen Eighty-four (1949) which is being invoked even today to anticipate where we may be headed in the age of Trump, and books of The Computer Age (1981-Present) such as Stephen King's The

Dark Tower series (1982-2012) and which Miller describes as "one of the largest fantasy worlds ever created" (p. 238).

The nonphysical symbolosphere and the nonphysical ideas and concepts that it maintains have become our environmental niche, and like all niches, they have impacts on the brains that inhabit them. They can change these brains and the brains of whole groups of people. Because they are nonphysical and depend on the use of symbolic relations, as Favareau points out, they may never have a final interpretant, interpretation, or answer. They are always subject to revision, and unlike the entities in the physiosphere and the biosphere, they may defy closure. As a result, an epistemology and methodology for the natural sciences may not always be appropriate for the symbolosphere – it might be like trying to describe a rock's DNA. The considerations for empirical rigor in the natural sciences may be wasted in the nonphysical world, and the hope for clear ultimate understandings may be sadly misplaced.

In the book, *The Existentialist Café*, the author notes how Sartre never seemed to finish his projects. He never came to final

conclusions about ethics in *Being and Nothingness* or freedom in *Road of Freedom*. The author argues that this tendency was not because of loss of interest in the issue; it was because he was always changing his mind about these issues.

From the point of view of this paper, I would suggest that a deeper reason is that the symbolosphere, where one works with nonmaterial concepts, there is very little room for finality on issues such as ethics and freedom. The political, economic, and social milieu after World War II and the occupation of France (all of which were part of the symbolosphere for the existentialists) all, interacted with symbolic conceptions of freedom and ethics and caused Sartre's thinking to shift, to recalibrate, and perhaps in some cases start over. But I would suggest that we should expect these changes of mind in our symbolic world.

My colleague Robert Logan has been writing extensively over the last several years about the symbolosphere and has made valuable proposals that develop the notion. In "The propagation of extra-somatic organization in the semester: an enquiry", he examines technology, science, governance, and economy as

aspects of the symbolosphere. He does so from the perspectives of complex adaptive systems, the extended mind, language and culture as symbolic organisms that have evolved and continue to evolve through the processes of abiotic natural selection, emergence, the propagation of organization, catalytic closure, and the adjacent possible. In another paper (Neo-dualism and the bifurcation of the sembolosphere into the mediasphere and the human mind, Logan proposes that the mind "consists of the human mind and its abstract symbolic thoughts, language, culture, concepts and memes" (p.). He suggests that the mediasphere be considered "those products of abstract thought that are instantiated or mediated in the physiosphere … and [that] would include all expressions of spoken and written language, mathematics, science, computing, the Internet and its contents, tools, technology, buildings and structures, all forms of visual art, music, dance and any human artifact or physical expression of culture all of which is a product of abstract thought." (1,2). Logan sums up this conceptualization of the symbolic or with the formula: symbolosphere = Mind and mediasphere.

In the future, I would expect that there will be many other suggestions for how symbolosphere. From my perspective, the

question is not which is the correct cleaving, but rather is the which cleaving is useful for the person who does it and perhaps others as well?

I would suggest, there will never be a final conceptualization of the mind. The mind is not an iconic or an indexical entity. This is because the symbolosphere is a major feature of the mind and the symbolosphere is largely composed of nonphysical/nonmaterial symbolic entities that are malleable, with fuzzy boundaries that inevitably generate ambiguity and uncertainty. These symbolic constructs then are necessarily and importantly amenable to subjectivity, interpretation, and revision. As new mental concepts, conceptualizations, ideas, idealizations, ideologies and research technologies are developed, new perspectives on mental life will cause the mind to be depicted differently. We cannot hold the mind in some indexical relationship in which one could point to it; it is essentially a symbolic notion with no material essence, and even though it involves the brain one can't point to it.

Lisa Feldman Barrett (2006, 2009, 2012, 2015) and colleagues have developed a perspective on emotion called Psychological Construction Theory (PCT). They consider emotions to be psychological constructions, not biological entities. They argue that the brain has several domain general core systems for functions such as memory, affect, attention, categorization, and language. They consider these core systems to be the basic ingredients of human emotions. From the perspective of PCT, emotions do not have dedicated neural regions or networks. They are not observer independent entities such as things in the physical and biological worlds (e.g., trees, water, rocks, soil, plants, animals, humans). Emotions exist only when they are interpreted as such, and thus they are observer dependent. In technical terms they are not natural kinds, that is they don't exist independently in the world. Nor are our emotions the changes that take place in the body (in the autonomic nervous system, endocrine system, and musculoskeletal system) when an emotion is experienced. Different emotions may have the same bodily changes, and in different individuals the same emotion may be associated with different bodily systems. In addition, there is no one-to-one relationship between an emotion and behavior. Every emotion category (happiness, sadness, fear, disgust, etc) is composed of instances that vary in

their physical characteristic. The emotion we call "fear" may be experienced as " worry, concern, panic, distress" etc. Emotion category labels are generated by society/culture, and children are socialized to them through the language that conspecifics use to identify emotion categories in themselves and in others. According to Barrett, an emotion is highly dependent on context such that emotions are category labels for particular states of the body in relation to the current states of the world that the individual is experiencing.

From the perspective developed in this paper, we might consider psychological constructions to be one type of symbolic construction. An emotional category then would be a nonmaterial symbolic element of meaning which is used to associate a particular body state with the current context/situation in one's physical and symbolic world. To explain human emotions then, we have to understand how the human minds (i.e., brains, bodies, and the physical and symbolic worlds) create nonphysical ontologically subjective categories. This is extremely important. If the physical human brain can create nonphysical entities (symbolic constructions) then the mind is, in part, nonmaterial, whereas the brain is entirely physical.

In the first part of this paper, we discussed motivation. I would consider motivations to be conceptual acts and symbolic constructions. Whereas emotion categories are generated by society/culture and are acquired through socialization, enculturation and education, motivational categories are developed among researchers interested in motivation. Children are not socialized to recognize various motivations (instrumental, integrative, etc.).

Psychology is a field created by conceptual acts. The categories that constitute a cognitive/psychological ontology are the result of categorizations made by psychologists attempting to understand mental processes and mental states. They are conceptualizations; they are not natural kinds or perceiver independent entities; they are not dedicated regions or networks in the brain. They are nonphysical/nonmaterial symbolic constructions, but they are real and cannot be reduced to biological entities. Thus, Barrett's notion of psychological constructions appears to fall within the framework of non-reductive physicalism. Her idea of psychological constructions that are real but not biological (and therefore not physical) illustrates the wonderful "betweeness" of psychology's physical/biological roots and it's

symbolic formulations, without conflating the two or dismissing the biological.

Eric Kandel (2016) argues that abstract artists used reduction in their work to stimulate imagination and curiosity and thus to generate emotional, expressive, and conceptual responses and interpretations on the part of viewers. They encouraged individual interpretation, subjectivity, personal affective, cognitive and visuomotoric responses. The artists did this through the use of geometric shapes, color, line, and light. But we have to remember that their works were not just academic studies of form, color, line and light. They were also attempts to produce something beautiful, something artistic that would transcend the basic components of the work. It would appear that there may be an element of emergence in abstract art. By focusing on the basics of form, line, color, and light, the artists were striving to produce something that would transcend the basics and that would be aesthetically valued by viewers with diverse interpretations.

The brain scientist, on the other hand, has a different goal. The scientist wants to discover the biological mechanisms that subserve various functions. Kandel's goals were to discover the biological substrates for memory and learning. Thus the reductionism in brain science, particularly through the use of rigorous experimental procedures, is engaged in order to learn the structure and function of mechanisms at the molecular, synaptic, and neuronal levels, in order to find (illuminate) universal facts, not personal responses and subjective understandings.

Thus abstract art presents the artist's subjective vision and state of mind. It generates a mental state in the viewer and allows personal understandings by that viewer. But in brain science the researcher does not try to represent his or her inner vision if it can't be shown to conform to physical reality.

It is interesting that "reductionism" is used for two different and opposite purposes in brain science and an art: In brain science the researchers seek facts, objectivity, unambiguous answers where personal interpretation should not be unnecessary. In abstract art, the artist is seeking and encouraging subjectivity personal interpretation,

indeterminate perspectives, emotions, spirituality, and transcendence. Why is reductionism successful in art? Kandel argues that "abstract artists of the New York School succeeded in REDUCING the complex visual world around us to its essence of form, line, color, and light." We might paraphrase this in the following new way. Abstract artists succeeded in ABSTRACTING the visual world around us to the essence of form, line, color, and light. But note that here we move into a semiotic distinction between reduction and abstraction.

Kandel also notes that such abstract art can induce a "sense of spirituality." Is spirituality material? Here, in Kandel's terms, spirituality is generated by a viewer's brain when beholding the physical painting. So the spirituality comes out of two physical sources--the brain and the painting. Does that make spirituality material OR does it simply describe what the human brain can do – produce immateriality from physicality.

Based on Kendel's observations, we might argue that abstract art has the ability to elicit the nonmaterial. Of Pollock's work, he says the action in painting doesn't require an EXTERNAL framework of knowledge. Could we also say that it doesn't require a MATERIAL framework of knowledge. It requires

movement, action, paint, and a talented artist. On these things, the viewers can project their " own impressions, memories, aspirations, and feelings onto the canvas" and sometimes experience a spiritual uplifting. All this is done by physical entities, but is the spiritual uplifting more than simply the senses and relevant brain processes? Is spirituality material/physical? Wikipedia offers the following:

Surveys of the definition of the term, as used in scholarly research, show a broad range of definitions[10] ranging from very narrow and uni-dimensional definitions such as a personal belief in a supernatural realm[5] to broader concepts such as a quest for an ultimate/sacred meaning,[7] transcending the base/material aspects of life, and/or a sense of awe/wonderment and reverence toward the universe.

"A personal belief in the supernatural realm" and "a quest for an ultimate/sacred meaning, transcending the base/material aspects of life." are two aspects that seem to include the nonmaterial/the nonphysical. "A sense of awe/wonderment and reverence towards the universe" might be considered a reference to the material/physical universe.

We are left to interpret Kandel's use of the word "spirituality" in the same way we are left to interpret abstract art. Kandel, by

considering brain science and art together, creatively integrates the symbolosphere and the biosphere, and in the process the biosphere inherits some of the ambiguity of the symbolosphere. This is a non-reductionist creative move that is needed in order to "bridge the two cultures".

Kandel discusses the default network in brain processing and suggests that this network is related to the issues of self and identity [and therefore may be relevant to second-language acquisition]. One might also speculate that the default network may contribute to our brains ability to create and process abstract nonphysical entities. Our identity is protean.

We often project ourselves into the future and imagine an identity at that time. In Deacon's terms, the future self is an absential and to the extent that absentials can be nonmaterial, one's self identity in the future is nonmaterial/nonphysical, but this absent non-physical entity can influence our brain, body and behavior with respect to achieving that identity.

Kandel cites the New York art critic, Nancy Princenthal, in a discussion of abstract art as saying, "To be abstracted is to be at some distance from the MATERIAL [my emphasis] world." (185) This suggests some abstractions may not be material.

The work, the products of abstraction in the art of abstract artists, may refer to the nonmaterial world via the material painting.

A Return the Two Cultures

Kandell notes (p. 187) that in the 1950s, after the discovery of the structure of DNA, the unification was begun among the fields of biochemistry, genetics, immunology, development, cell biology, cancer biology, and molecular neurobiology. He would like to see a similar unification among brain science, art, and the humanities. He believes a dialogue is already possible and, indeed, is underway by a people interested in the integration of these three areas.

But we should take into account the fact that the arts and humanities are in the world of the symbolosphere, and they work differently the biosphere and the physiosphere.

This biosphere is a universe of sign-sign and symbol-symbol relationships. Words (as is signs) get the meaning through their referential relationships with other signs. Symbols (in the

Piercean sense) do not refer to things in the world (as icons and indexes do). They refer to other signs (e.g. words) in great waves of words.

The brain is degenerate in the sense that many structurally different regions and networks can produce the same output. The lexicons of human languages are also degenerate. They contain synonyms that are words that are spelled differently but have the same or similar meaning. The brain is also pluri-potential; the same region or network can produce a very different outputs. In language, words can be polysymous; the same word can have different meanings (Schumann, 2017). This situation introduces a great deal of ambiguity and imprecision into language, and this fact is recently being confronted by neuroscientists.

Additionally, as Kandel has shown in his book, abstract art, and we might say, the arts and the humanities in general bring forth and encourage interpretation, subjectivity, speculation, and personal appraisal based on variation in cultural values and individual temperament. The sciences, of course, are interested in precision, fact, universal truths, irrefutable evidence and conclusions.

I don't believe these differences will go away or be resolved through the process of conflict and resolution. The human ability for symbolic reference has allowed the physical brain to create and process nonphysical ideas, idealizations, ideologies, concepts, and conceptualizations. In order to bring about a unification between brain science and the arts and humanities, we have to recognize the symbolosphere as a separate entity from the biosphere and the physiosphere from which it comes. This symbosphere has to be understood in its own terms. We have to understand how the symbolosphere was generated by biological human brain interacting with languages that are, in many ways, imprecise, ambiguous and, at the same time, flexible and extremely efficient and effective for communication and thought.

We can't see the arts and humanities as simply quaint remnants of a prescientific world that now must yield to science the role of discovering the truths of the universe. At the same time, we have to recognize that, in some way, which is not fully understood, the arts and the humanities come out of human brains and have never lost their connection to them. Like Kandel, we have to understand these connections to fully

understand the arts and the humanities. At the same time, we can't expect to achieve an eliminative reductionism in which understanding the neural basis for the arts and humanities will be sufficient. Even when we come to completely know the neural basis for love, love stories will continue to be written.

Reductionism in Art and Brain Science is a wonderful book. Like the arts and humanities, it is designed to make one think. Kandel's association between abstract art and reduction in science makes a basic association between two highly symbolic signs “abstraction" and “reduction”. The question now is not whether this association is correct or wrong. The question is what the association has opened up for us. Kendell has painted a picture. If we were to hang it in a gallery with other paintings, would we ask which one is correct? I don't think so. The question would be “How is this painting relevant to me? “

There are several avenues for future study of the neural basis for the production of the nonphysical symbolic world. An alternative, of course, is just to dismiss the notion that there is anything nonmaterial in the world, but we would want to be certain that such a strong physicalist approach is not just an ideological stipulation based on a preference. The only way to

do that is to maintain and explore the possibility of a nonphysical sphere of our existence.

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