The man who mistook his brain for his Self…

…and other tales of the Self from neuroscience

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Publishing history

First published in Direction, Vol. 3, no. 4, 2005, pp.19-26, Edited by Paul Cook

ASO versions listed on the article web-page.

Abstract

To act (move) requires the whole self: brain and body engaged with environment and task. For F.M. Alexander, this was a pivotal concept in developing his ideas of psychophysical unity and the 'use of the self.' Over the latter part of the 20th century, neuroscientists have investigated the experience of self as an emergent phenomenon in brain function. Advances in imaging technology (brain mapping studies in particular) have afforded inroads into understanding how the brain generates a singular, stable reference called "self" out of variable neural patterns. Rather than the experience of self being localized to any one part of the brain, however, neuroscientists rather are finding that it is "use-dependent," dynamically constructed through "use," through activity. This article reviews current concepts of neural plasticity -- that is, how the brain is constantly shaping and being shaped by our actions. The research cited here points towards complementarity between the neurological construction of the self and Alexander's discoveries

"Indeed, human consciousness may arise not just from some novel feature of human brains, but by way of the body's "awareness" of itself through its exteroceptive and proprioceptive senses." Jay Seitz[1]

"Talk about a man's individuality and character: it's the way he uses himself." F. M. Alexander[2]

Introduction

The use of the Self is a fundamental tenet of the Alexander Technique. FM's choice of the word "Self" (with a capital S) appears to be a prescient shorthand for a state of embodiment (psychophysical unity) and a vehicle (the means whereby) for achieving poised thought and action. An astute observer of human behavior, Alexander argued not for Self as fixture, but as a process by which human beings could optimize their relationships. Both "owner"[3] and "agent,"[4] the Self is unto itself and in relationship, being and belonging, whether habitually oblivious or self-aware and intentional.

Over the last decade particularly, neuroscientists have been intrigued by the topic of self. Neuroscientists Oliver Sacks, Antonio Damasio (*The Feeling for What Happens*), Joseph LeDoux (*The Synaptic Self*), and V.S. Ramachandran (*The Phantom Brain*), have popularized the phenomenon of self. Advances in imaging technology have afforded neuroscientists inroads into understanding how the brain generates a singular, stable reference called "self" out of the constantly changing and infinite variation of neural patterns. How do humans form a stable body schema for both continuing awareness of body homeostasis while operating flexibly and adaptively in the world?[5] Rather than localized to any one part of the brain, neuroscientists are finding that the self is "use-dependent," dynamically constructed through activity. Research supporting some of Alexander's discoveries is discussed in this article.

Psychophysical unity of the self

Our brain generates a mental image of the whole body from myriads of sensory impressions. This dynamic integration of sensory input is called the "body schema" or "body image, "[6] a multi-modal composite that forms the basis of corporeal awareness. This corporeal "self" gives us a sense of ownership of our being, and distinguishes self from others.[7] The neural process(es) for creating a "schema" for self recognition must be dynamic and adaptive, enabling us to have some sense of a stable body image under changing conditions.

We function not only as "owner" of a body, but also as "agent." The body schema underlies attention and intention, providing us with several vantage points from which to orient, name, evaluate, and act. Two vantage points have been identified both in science and somatics: first person egocentrism (I, me, subject) constituting the internal, lived experience, and third person ex-centrism (he, she, other, objective) for naming and judging.[7,8]

Far less examined is the realm of first person experience that F.M. called "habit," the "manifestation of a constant," and its counterpart, the dynamic relationship of the primary control.[9] Habit is the state of unconscious oblivion to the bodily self, automatic pilot, or the "elusive obvious."[10] The neural nature of consciousness is far too complex a subject to tackle here, but suffice to say that neuroscientists recognize a "default state" of self-referential mental activity.[11] Positron Emission Tomography (PET) scans show a relative increase in blood flow in portions of the medial prefrontal cortex during resting baseline conditions in this "default state," implying that when the brain is not attending to external stimuli, consciousness naturally turns inward, reflecting upon internal states and oblivious to the outside world.

The capability of our brain to represent the human body is possibly a genetic endowment. Minutes after birth, babies can imitate the faces adults make at them. Awareness of body structure must be intact enough at birth for babies to identify and replicate these actions. A deceptively simple act, facial imitation requires complex interactions between many sensory inputs and motor outputs in the brain, enabling babies to form a mental construct and dynamically organize themselves to move.[12]

Conscious body (self) awareness relies upon a large and intricate neural network of the entire nervous system (see Figure 1). Certain areas of the brain appear to play crucial roles, however, in the formation and maintenance of a stabilized body schema and conscious awareness of self, distinguishing self from other. These areas include the somatosensory cortex, posterior parietal lobe and the deeper structures (insular cortex, limbic system).[13] Studies of people with stroke (central nervous system lesions) and of persons post-amputation (central effects of peripheral lesions) have helped neuroscientists have some insight into how the body is represented in the brain.

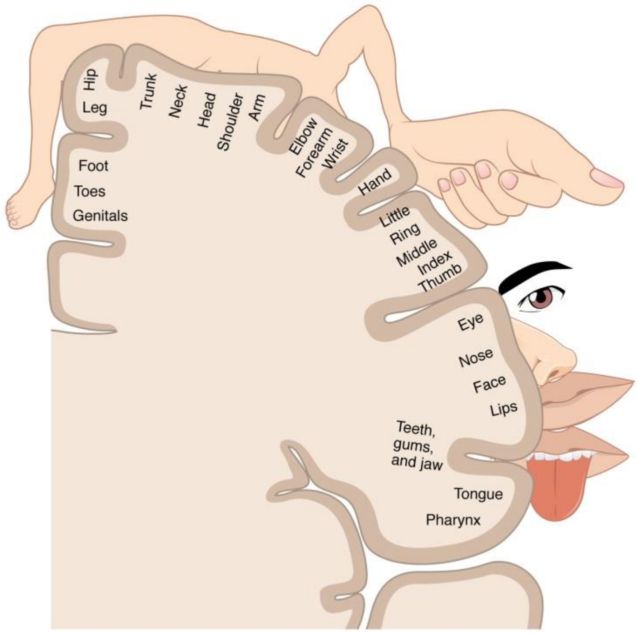

Figure 1: Sensory homunculus

I think, therefore I move

Perception of biological motion is a basic evolutionary endowment that enables humans to distinguish self from other.[3] Movement enables us to know we are alive and living in relationship to self and world. Metaphorically, movement "feeds" off the nervous system – like food – nourishing ongoing existence. If you stay still too long, you go "brain-dead." Somatic educator and philosopher Thomas Hanna replaced Descartes' outmoded phrase "I think, therefore I am" with "I think, therefore I *move*."[14] As adaptive, self-regulating organisms, our behavior (perceptions, attitudes, drives) is expressed through movement. Scientists agree that "…all mental activity is emergent, situated, historical, and embodied; there is in principle no difference between the process engendering walking, reaching, looking for hidden objects, and those resulting in mathematics and poetry."[15]

To act (move) requires the whole self. Imaging technology has helped neuroscientists understand that the structures involved in motor planning actually facilitate self-recognition.[3] Movement requires a complex interplay of signals in the development of a body schema that can provide the foundation for motor planning and initiation of action. While perception of self (the sum of the somatosensory information) helps us orient to the world (a *feedforward* control system), movement itself is a stimulant, perturbing the body through complex *feedback* control for error detection and correction.[16]

To act (move) requires a number of steps, including sensing/perceiving, forming a body schema, setting a goal, predicting consequences, generating the intention to move, become aware of this intention to move, generating a "readiness potential,"[17] initiating the movement, knowing that the movement has occurred, and receiving ongoing feedback regarding whether the action matched the intended plan.

Certain parts of the brain are essential for distinguishing the moving self from other moving objects in the environment. Distributed networks co-activate throughout the entire nervous system, with certain regions playing specific roles in maintaining a unified sense of "self" in movement initiation and control. These include the prefrontal area (initiation and temporal organization of action), the supplementary motor area (organizing motor sequences based on internal programs), the premotor area (preparation of action), the sensorimotor cortex (coding of movement details and conscious awareness of the sensations of movement), the inferior parietal lobe (generation of an integrated body image for actual- or imagined movement), the cerebellum (temporal control of action sequences), basal ganglia (subcortical regulation of force, sequencing, and direction), the limbic system (for judging the safety of an action), and the spinal cord (massive inhibition of reflexes to protect motor neurons from premature firing).[18]

Of all the areas involved in motor planning and execution, the parietal cortex appears to be crucial in the ability in forming a body schema that is uniquely you and yours. Studies on persons with schizophrenia who have control delusions have shown that they are aware of all aspects of motor planning *except* the fact that they have initiated a movement themselves. This essential piece of agency appears remarkably absent.[19] Jean Decety's observations, both clinically and through neuroimaging, show over-activity in the right inferior parietal cortex, implying that this portion of the parietal cortex, at least, helps match the body schema of agency with the intended motor plan.[19]

Persons suffering stroke in the parietal cortex often demonstrate loss of recognition of their body parts (agnosia).[20] Many different kinds of agnosia exist (finger, face, whole arm, or entire half of the body and its hemi-space (hemi-neglect).[21] Afflicted persons will deny ownership of a body part even though they can see, feel, and name it. They will also deny that they have any impairment, leaving them without a locus from which to act.

Persons with parietal lesions following stroke can also demonstrate "apraxia," the inability to perform common actions (e.g., they might recognize a toothbrush but cannot demonstrate how to use it.) In a compelling study, neuroscientists tested the recognition of hand gestures (self- vs. other) in persons with apraxia post-parietal stroke. They found the subjects were unable to correctly distinguish their own hand from the examiner's hand while viewing a computerized sequence of hand gestures.[22] Similarly, subjects with parietal lesions could not distinguish their own hand positions from that of the examiner's through imagining either their own hand or the examiner's hand in various postures and positions. As task complexity increased ("imagine your/my hand behind your/my back with the fingers pointing downwards"), correct responses decreased. The researchers concluded that the parietal cortex plays a vital role in generating and maintaining a kinaesthetic model of ongoing movements.[23]

The Self is "Use-Dependent"

F.M. Alexander allegedly was the first somatic educator to advocate the indivisibility of posture and action.[24] Neither "good" nor "bad," posture varied flexibly with "use." No "self" existed in isolation, but rather surfaced in activity, functional or expressive. In the *Use of the Self*, Alexander describes how merely thinking of speaking a sentence was associated with a total body response.[25]

Brain mapping studies (using imaging technology to interpret the relationship between brain structure and function) have led to the theory of a "use-dependent"[26] map of the human cortex. Each area of the human body is "somatotopically" mapped (neurally organized) within all regions of the nervous system. The cortical region representing the hand has been studied the most, probably because it is the easiest to study movements of the hand during imaging (fMRI and PET scans), because a wide variety of movements can be performed with minimal distortion to the image.

The brain tissue immediately adjacent to the central sulcus (see Figure 2, page 4) forms the sensorimotor cortex, the anterior portion traditionally being the "motor" area, and the posterior portion being the "sensory" area. The concept of the strictly mapped homunculus of Penfield from the 1930s is outdated, however. Strict division between these areas does not exist; rather, the map is similar to a three-dimensional mosaic[27] that represents both body (structure) and abstract coding for action (function). Vast numbers of neurons form networks that help define the body regions anatomically and functionally.

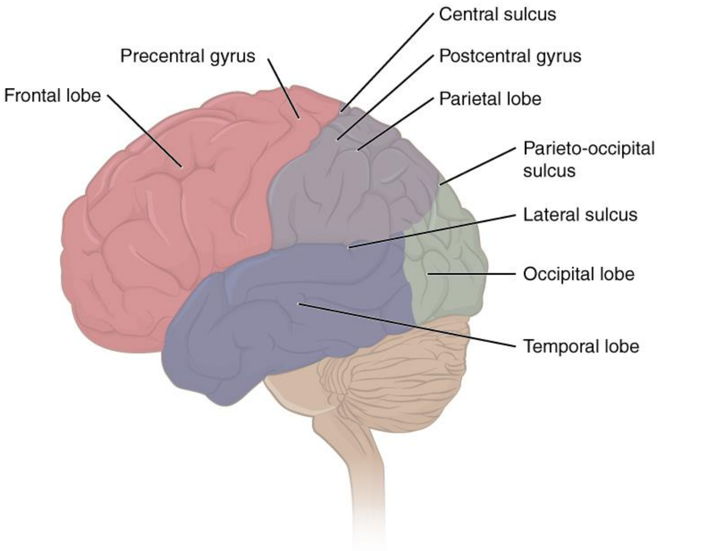

Figure 2: Lobes of cerebral cortex showing central sulcus

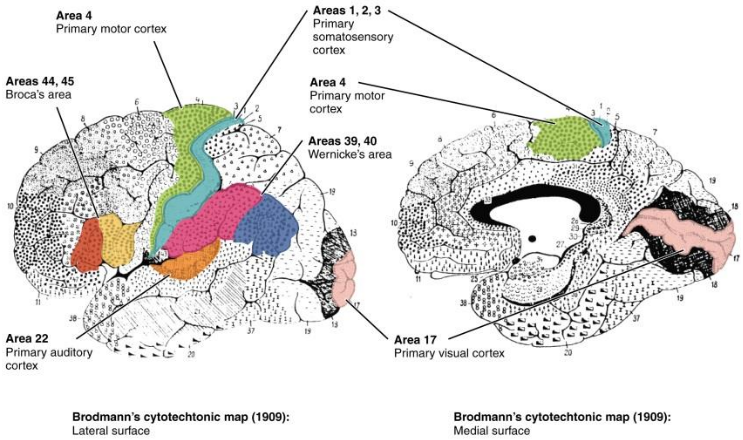

Figure 3: Brodmann's cytotechtonic map

This map affords you a great degree of functional flexibility. You can sign your name, for example, using virtually any instrument (pen, stick, crayon, wire) in a variety of contexts (on paper, sand, in the air) using either your hand, your toe, (or – however crudely – even by holding a pen between your buttocks if you had to!) The hand region of the sensorimotor homunculus lights up regardless of whether the finger or toe "writes," as if the brain is more readily coded for function than it is for structure.[28]

Neuroscientist Antonio Damasio states: "There is no one 'place' where the body or body part is mapped. The 'proto-self' does not occur in one place only in the rigid homunculus, but emerges dynamically and continuously out of multifarious interacting signals that span varied orders of the nervous system…The proto-self is a coherent collection of neural patterns which map, moment by moment, the state of the physical structure of the organism in its many dimensions."[29]

The sensorimotor map is extremely flexible, or "plastic." Neuronal networks within the cortex dynamically reconfigure themselves rapidly in response to trauma (stroke, for example, or amputation), and in response to experience and learning (that is, in response to use.) Use can often make the difference between functional recovery (appropriate reorganization of the maps) or persistent dysfunction after injury.[26]

Remarkable plasticity has been demonstrated in the motor cortex of musicians (string players) and Braille readers in which greatly enlarged representations of the hand in the somatosensory cortex resulted from intensive practice and diminished greatly with layoffs from practice.[30,31]

Theoretical mechanisms for plasticity include changes in synaptic strength, the unmasking of existing, silent synaptic connections, or the sprouting of neurons to form new connections. The behavioral component of use is key, however, in whether the changes are functional and adaptive or degraded/dysfunctional.[3]

Poor use (misuse) can degrade the discretely mapped sensorimotor cortex. The somatotopic area of the hand, for example, is finely "mapped" so that each portion of the finger is represented in a discrete portion of the sensorimotor cortex. Extensive research involving animals and humans has led to a "neural hypothesis" for the cause of repetitive strain injury and focal dystonia (seen in computer operators and pianists). Not just any kind of poor use but, rather, a specific kind of movement quality apparently drives these changes in the sensorimotor map that result in dysfunction: intensive, goal-directed, repetitive practice of rapid, impulsive, alternating movements (those related to keyboard use) results in abnormal shifts in the spatial cell assemblies so that their sharply differentiated and segregated locations "smear," causing the map to become degraded.[32] The brain can no longer distinguish between timely and appropriate flexion and extension of the fingers. With highly attended, rapidly alternating and repetitive flexion and extension of the fingers, the sensory input is interpreted as simultaneous rather than sequential and the somatotopic representation of the adjacent digits become fused, causing obligatory hand cramping and dyscoordination.[32]

Unreliable sensory appreciation

Senses are embodied "modes" of intelligence – evaluating, judging, responsive, reflexive, organizing, redirecting.[7] Bodily sensations and feelings, particularly, play a key role in the (re)organization of the moving self.[23] Alexander recognized that relying on kinaesthetic sensations to guide action was "unreliable." The non-conscious familiarity of habit brought about a feeling of "rightness in action" that was untrustworthy." He could never be sure that he was doing precisely what he intended.[33]

The unreliability of sensory perception is vividly demonstrated in the sensory cortex of persons recovering from amputations. The stability of the cortical (sensory) map is extremely labile after amputation, even within hours of the insult. Spontaneous sensations and even visual impressions of emerge from the missing limb (the "phantom limb" phenomenon resulting from traumatic disuse). While activation of sensory nerves in the amputation scar can contribute to this experience, it is now clear that phantom phenomena have a central origin. Melzack has shown that the body schema is subserved by a distributed neural network including the somatosensory cortex and the limbic system, largely prewired by genetics, but continuously shaped by experience (use).[13] Phantom phenomena would be caused primarily by the persisting activity of those parts of the brain now deprived of their normal inputs because of the loss of a body part, and by the brain's interpretation of this activity as originating from the lost part.[3]

When the brain is deprived of natural sensory inputs from amputation, it becomes reactive to input from neighboring body parts. After loss of an arm, for example, the "arm" region of the somatosensory cortex becomes "invaded" by neighboring regions, as neurons seek synaptic connections as they recover from the insult. One remarkable result is that mechanical stimulation to the face or chest (lightly brushing the skin, e.g.) causes phantom sensation in the arm. The facial region of the sensory cortex spreads to occupy the arm region of the somatotopic cortex. Following hand or arm amputation, the hand cortical territory becomes responsive to facial cutaneous stimulation. This amputation-induced remapping of the cortex can reverse itself after transplantation of a grafted hand, or with the use of a prosthesis.[34,35]

Thinking in Activity – The Emergent Self

The self "emerges" from the interplay of person, use, and context, inseparable from the task and the environment.[36] We are situated, embedded in experience. As Damasio states:

> …consciousness consists of constructing knowledge about two facts: that the organism is involved in relating to some objects, and that the object in the relation is causing a change in the organism…elucidating the biology of consciousness (is) a matter of discovering how the brain can construct neural patterns that map each of the two players and the relationships they hold. Consciousness depends on the internal construction and exhibition of new knowledge concerning an interaction between organism and object/environment. Instead, it comes into relationship with the environment and context, out of which meaning grows.[29,p.133]

The body, the intended action, and the environment together offer an infinite potential for movement. Bones, joints, and muscle configurations combine in ways that are "softly assembled"[36] in response to the demands of the situation or task. Movement repetition is not robotic; rather, the brain solves the "motor problem" time and time again with each strike of the hammer on the nail.[37] This is "poise," a kind of "balanced concentration immediately prior to action…ever fresh in its ability to answer to the forms addressing it."[38] F. M. Alexander realized that poise is much more than softly assembled mechanical constraints, however. His contribution of the primary control has yet to be elaborated in contemporary neuroscience. We have to look to the philosophers to find support for Alexander's concept of poise: "Before poise can reveal itself, a tension that is the psychophysical milieu of accomplishment must ease….All evidence suggests that poise is not a natural outgrowth of a process that begins in distraction, preoccupation, and insensitivity.[38]

Neuroscience equates poise with "skilled" movement (as opposed to automatic, habitual movement). Researchers suggest that repetition renders the brain more static. Sensorimotor maps change more rapidly in response to learning new motor skills rather than in response to habitual, previously learned patterns. In an elegant experiment in which monkeys learned to reach for pellets of food with increasing speed and efficiency, neuroscientist Randolph Nudo showed that it is the acquisition of new motor skills, rather than the repetition of previously learned movements, that drove neuroplastic changes in the brain. The emergent properties of cortical maps are dynamically maintained, based on temporal correlation of sensory and motor events.[27]

"Habit, indeed, may be defined as the manifestation of a constant," wrote F.M. Alexander in the *Universal Constant in Living*.[9,p.107] Alexander drew the attention of many scientists years ago, perhaps because, with his astute mastery of behavioral observation, he was himself a scientist. From the shift away from mind-body dualism to an understanding of the emergence of self through poised living,[39] F.M. Alexander was way ahead of his time. Discoveries in neuroscience continue to bear this out.

Figures

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Figure 1: "1421 Sensory Homunculus" downloaded from http://cnx.org/contents/29cade27-ba23-4f4a-8cbd-128e72420f31@5/Central_Processing ,

Figure 2: “1306 Lobes of cerebral cortex” and Figure 3: “1307 Brodmann Areas” downloaded from http://cnx.org/contents/f7896ff3-01c7-48a4-b085-61928696b2db@4/The_Central_Nervous_System

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