A Primer on Consciousness and the Brain[1]

By Ezequiel Morsella

> *Energy had been building within the millions of neurons since they'd first formed six months previously. The nerve cells were sizzling with electrical energy steadily galvanizing toward a voltaic threshold. The arborization of the nerve cells' dendrites and the supporting microglia cells had been increasing at an exponential rate, with hundreds of thousands of new synaptic connections arising every hour. It was like a nuclear reactor on the brink of hypercriticality.*
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> *At last it happened! The threshold was reached and surpassed. Microbolts of electric charges spread like wildfire through the complicated plexus of synaptic connections, energizing the whole mass. Intracellular vesicles poured forth their neurotransmitters and neuromodulators, increasing the level of excitation to another critical point. Out of this complex microscopic cellular activity emerged one of the mysteries of the universe: consciousness!*
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> —Robin Cook, *Mutation*, 1989.

How consciousness emerges from the brain is one of the greatest mysteries in science. The depth of this puzzle has been noted by several Nobel Laureates, including Leon Cooper, Francis Crick, Gerald Edelman, Eric Kandel, and Charles Sherrington. I am speaking about the most basic form of consciousness, such as a yellow afterimage, the sound of a bell, or

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[1] A more accurate, but much longer, title for this piece would be "A Primer on Consciousness and the Brain from the Standpoint of One, Action-Based Theory," as the primer presents the topic of consciousness-and-the-brain from only one perspective. To increase the readability of the piece, I omitted scholarly citations. All the citations can be found in the three works on which this primer is based: (1) Morsella, E., Godwin, C. A., Jantz, T. K., Krieger, S. C., & Gazzaley, A. (2016). Homing in on consciousness in the nervous system: An action-based synthesis. *Behavioral and Brain Sciences* [Target Article], *39,* 1-17; (2) Morsella, E., Godwin, C. A., Jantz, T. K., Krieger, S. C., & Gazzaley, A. (2016). Passive frame theory: A new synthesis. *Behavioral and Brain Sciences, 39,* 44-70; (3) Dou, W., Walker, E. B., & Morsella, E. (in press). "The prospective nature of involuntary entry into consciousness." In Z. Radman (Ed.), *Acting ahead of Actuality.*

nausea. (A "conscious content" is anything that one is aware of; the conscious field contains everything [all the conscious contents] that one is aware of at one moment in time.)

Consciousness seems to be associated with only a subset of brain function. Consciousness of some kind persists with the nonparticipation (e.g., because of lesions) of several brain regions, including the cerebellum, amygdala, basal ganglia, mammillary bodies, insula, and hippocampus. In addition, investigations of 'split-brain' patients reveal that consciousness survives following the nonparticipation of the non-dominant (usually right) cerebral cortex or of the commissures linking the two cortices. Recently, it has been proposed that, to isolate the critical subset of brain regions that is essential for consciousness, it is best to focus on the olfactory system.[2]

Thus, in the brain, there are both conscious and unconscious processes, which are the majority of processes. This contrast is encountered in all subfields of inquiry in psychology and neuroscience. For example, in memory research, there is the contrast between "implicit" (unconscious) and "explicit" (conscious) processes, in perception there is "subliminal" (unconscious) versus supraliminal (conscious), and in action research there is the contrast between controlled (conscious) and automatic (unconscious) processes.

As is obvious in inter-sensory illusions such as the ventriloquism effect and McGurk effect, consciousness is unnecessary for the integration of diverse information across different sensory modalities. This can be done unconsciously, as can syntactical processing and motor programming (e.g., which neural impulses are sent to which muscles to utter one word versus another word). Sophisticated forms of unconscious motor programming are

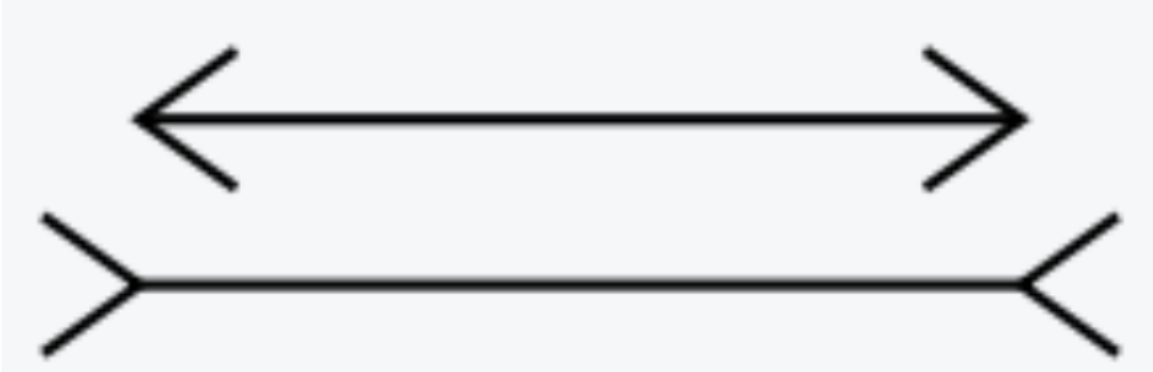
[2] Morsella, E., Godwin, C. A., Jantz, T. K., Krieger, S. C., & Gazzaley, A. (2016). Homing in on consciousness in the nervous system: An action-based synthesis. *Behavioral and Brain Sciences* [Target Article], *39,* 1-17

evident in automatisms (e.g., during seizures).

If so much can be achieved unconsciously, then what does consciousness contribute to brain function? It has been proposed that, in order to understand the role of consciousness in the brain, one must first understand the notion of "encapsulation," which I will now discuss.

Take a look below at the famous Müller-Lyer illusion. Every student of psychology knows that the two horizontal lines are actually the same length, even though the lines certainly do not appear that way. Knowledge of the true length of the lines cannot turn off or change the nature of the illusion. Hence, the illusion is said to be "encapsulated," insulated from the influence of higher-order knowledge (that the two lines are actually of the same length). In short, because of encapsulation, the Müller-Lyer illusion cannot be modified or turned off as a result of one's beliefs, desires, or knowledge. The same could be said for the McGurk illusion (and intersensory effect) mentioned above. Knowledge of what one is actually hearing in the McGurk effect does not turn off or diminish the effect in many ways, no matter how many times one experiences the illusion. Many perceptual processes are encapsulated in this way.

Conscious states such as pain, nausea, and guilt, too, can be encapsulated. When one receives an injection from the doctor, for example, the pain associated with the injection cannot be turned off by the knowledge that the injection will benefit one's health. Similarly, while holding one's breath while underwater, one cannot turn off the desire to inhale, nor the negative feelings associated holding one's breath (which is the adaptive thing to do in that context).



In cases such as these, encapsulation seems disadvantageous. However, over the course of development, encapsulation is adaptive: It would not be adaptive to turn off states such as pain, guilt, or nausea at will, for the role that these states play in guiding behavior would be gone. Just imagine the negative consequences that would arise if a young child could turn off pain signals at will. It is likely that the behavior of such a child would become riskier. In summary, many percepts, urges, and bodily feelings are encapsulated, and they should be. Regarding urges and the behavioral inclinations associated with them, one can suppress overt behavior (e.g., to grab a cupcake that belongs to someone else), but not the urges associated with those behaviors (e.g., the desire to eat the cupcake). One can suppress the action, but not the urge.

Because of encapsulation, each "conscious content" in the conscious field does not in a sense "know" of the nature of the other conscious contents composing the field. Because of encapsulation, each content in the conscious field also does not know whether it is relevant to current goals and actions.

This leads to a question: How come behavior does not always reflect encapsulation, and how can one, say, hold one's breath while underwater, not grab someone else's cupcake, or report that the two lines in the Müller-Lyer illusion are actually of the same length? This is because normal behavior is not dictated by any single conscious content, but rather by the

whole conscious field. The conscious field thus permits the "collective influence" of all conscious contents activated at a given time. When consciousness fails, behavior is not "integrated" in this way. For example, in anarchic hand syndrome, the hand might grab a cupcake that belongs to someone else or might out of the blue unbutton a button in the sleeve. These actions are not unsophisticated behaviors (neither a robot nor a 3-year-old can unbutton clothing). Rather, these actions are "unintegrated" actions that reflect encapsulation and not a fully operational conscious field.

Hence, from one theoretical standpoint, the conscious field could be construed as a "frame" that affords adaptive *action selection*[3], specifically for the *skeletal muscle output system*, which is the effector system for what in everyday life is called "voluntary behavior." (The everyday term "voluntary" is usually not used in science because, in some contexts, it implies the existence of a homunculus.) In other words, the conscious field is necessary to integrate what appear to be multiple inclinations toward the skeletal muscle output system, as captured by the principle of *Parallel Responses into Skeletal Muscle* (PRISM): Just as a prism can combine colors of the rainbow to yield one color (white), the conscious field permits for multiple inclinations to influence ongoing behavior and yield one "integrated" behavior, such as carrying a very hot dish of food or holding one's breath while underwater. These are different from the unintegrated actions in anarchic hand syndrome.

The skeletal muscle output system is a subset of the somatic nervous system. The conscious field itself is passive, like a car window, but essential for encapsulated conscious contents to influence action selection collectively. Unlike in "workspace" models of consciousness, the field itself has no memory, does not resolve conflicts, and performs no judgments. The

[3] "Action selection," as when one presses one button versus another button or moves leftward versus rightward, is distinct from motor control/motor programming, processes which are largely unconscious.

conscious field is like the Wifi system that permits two people to debate over the internet. As in the case of the Wifi system, the field itself resolves no conflicts, has no memory, and performs no transformations on the contents being presented within it. In other words, the field itself has no moving parts and does not resolve conflicts. In short, the conscious field is passive, but essential. In addition, there is no single homunculus involved in skeletomotor action selection, but only collective influence over the skeletal muscle output system. The function of consciousness is for adaptive action selection in a system that features encapsulation.

In the *conscious-unconscious cycle*, the active processes are unconscious and the conscious processes are passive. That is, the processes that generate the contents of consciousness, though sophisticated and very busy at all times, are unconscious. This is why the great psychologists George Miller and Karl Lashley concluded that one is unconscious of thinking but is conscious only of the products of thinking. It is important to note that these processes that generate conscious contents are unconscious and are different from the processes in the skeletal muscle output system that, in a sense, apprehend and respond to the contents. These response systems in the skeletal muscle output system, too, are unconscious. Consciousness is a passive but essential stage of processing between those of the active content generators and response systems.[4]

[4] Unlike in the popular "workspace" approaches to consciousness, which propose that conscious contents are broadcast to modules engaged in both stimulus interpretation and content generation, in the present approach, conscious contents are directed only at the unconscious processes of the skeletomotor output system. Second, unlike in workspace approaches, in which consciousness serves more than a handful of functions, here the conscious field serves only one basic, passive role. It performs this same basic function for several kinds of processes, including some high level functions. Figuratively speaking, the real work is not done in the conscious field: The conscious field is, in sense, a workspace without the work. In contrast, in workspace approaches, consciousness serves many functions, including adaptation and learning, decision-making, analogy forming, editing and debugging, metacognitive self-monitoring, and autoprogramming.

The Five Burdens of Encapsulation

In order for encapsulation to yield adaptive behavior, several conditions must be met. These conditions could be construed as the five burdens of encapsulation, which are delineated below.

As explained below, in order for adaptive action to result from a system that has encapsulation, then something resembling the conscious field seems to be required. Most properties of the conscious field can be explained by the challenges imposed by encapsulation. In other words, if there is encapsulation, then the solution to the problems posed by it are the properties of the conscious field.

Why is the Conscious Field So Capacious?

The first burden is that, because no content knows whether it is action-relevant or not, and also does not know of the nature of the other contents composing the conscious field, the conscious field must be very thorough and represent as many (potentially actionable) contents as possible, just in case. This explains why, even though the conscious field is for adaptive behavior, one is often aware of things to which one does not need to respond. Thus, encapsulation explains why the field is always so capacious and inclusive.

The second burden is that, in order to benefit action selection, each content (e.g., the color blue versus the smell of lavender) must differentiate itself from all the other contents in the field, for a contrast not apparent in the field cannot be reflected in voluntary action. Each content must differentiate itself not only from contents within the same modality (vision), but also from contents from other modalities (smell). These contrasts must arise even though all content must somehow exist in the same decision space,

and therefore share the same underlying format.

As noted by several theorists, basic conscious contents (e.g., the color blue, urges, or the smell of lavender) are "unanalyzable," with their qualities being irreducible.

> *Quality is something unique, indescribable, except in terms of itself. Red is red, green is green. Neither is, by any stretch of the imagination, a form of ether vibration or chemical change in the brain… when by analysis the simplest qualities are reached, nothing more can be said of them save that they are in different, undefinable degrees diverse. They have no describable characters inherent in themselves; they are not analyzable into anything else. They exist by virtue of their indescribable differences and by virtue of nothing else discoverable by introspection.*
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> —Lashley (pp. 252 - 253)[5]

Thus, the conscious contents of blue, red, a smell, or the urge to blink are the tokens of a mysterious language understood, not by consciousness itself (nor by the physical world), but by the unconscious action mechanisms of the skeletomotor output system. Why do things appear the way they do in the field? Because, in order to benefit action selection, they must differentiate themselves from all other tokens in the field – across various modalities/ systems but within the same decision space.

Why Is the Conscious Field So Thorough Regarding the Current Spatial Layout?

The third burden is that, because of encapsulation, the spatial layout of the stimulus scene must represent spatial coordinates as thoroughly as possible. This occurs for many sensory modalities (but not olfaction). This is

[5] Lashley, K. S. (1923). The behavioristic interpretation of consciousness. *Psychological Bulletin, 30,* 237-272 (Part 1), 329-353 (Part 2).

because it is often the case that the "discriminative stimulus" that determines which action should be performed is not a single stimulus, but rather the spatial distance between two stimuli, as in the case of driving. Such a scenario also arises in athletic competitions. For example, in soccer, whether or not a midfielder passes the ball back to the goalie could depend on the distance between another midfielder and the opposing player who is covering that midfielder. Hence, our conscious field must have a rich and thorough representation of the spatial dimensions of the external world. The field does not know which such spatial relation might be essential for adaptive action selection.

Why Is the Conscious Field Always Apprehended from the First-Person Perspective, both in Dreams and while One Is Awake?

The fourth burden is that, for action to be adaptive, such a spatial model of the world must include the emergence of first-person perspective, due to the demands of action selection, for example, when deciding between reaching for a large (but faraway) banana on one's right or a smaller (but nearby) banana on one's left. The first-person perspective, which also emerges in the dream world, is essential for this kind of action selection. The adaptive nature of the first-person perspective has been discussed at length by the theorist Björn Merker.

The fifth burden is that, because of encapsulation, and in order for action to be adaptive, the contents that compose the conscious field must all be comparable at some level, for they must exist as comparable tokens in a common decision space. These contents include information about the immediate environment, the representations of anticipated actions (e.g., mental imagery of to-be-produced actions), the effects of actual action (e.g., proprioceptive feedback), and even high-level cognitions. All of these contents, which tend to have a perceptual-like format, are sampled not by

other conscious contents (which would violate encapsulation), but rather by the action systems in the Skeletal Muscle Output System. These systems are unconscious.

In short, encapsulation explains why the conscious field, though in the service of adaptive action, contains contents that are not action-relevant, and why it has a first-person perspective and is so thorough (both in terms of its contents and the representation of spatial coordinates). To reiterate, in order for adaptive action to result from a system that has encapsulation, then something resembling the conscious field seems to be required. Most properties of the conscious field can be explained by the challenges imposed by encapsulation. In other words, if there is encapsulation, then the solution to the problems posed by it are the properties of the conscious field.

In conclusion, the conscious field is what allows for encapsulated conscious contents to influence action collectively, thereby yielding what in everyday life is called voluntary behavior.

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