Vol. XX / No. X

Kevin Ing / Vedang Uttarwar / Yama Akbari / Theo G.M. van Erp / Mark Fisher

Consciousness, Cortex, and Neuropsychoanalysis

THE HIDDEN SPRING: A JOURNEY TO THE SOURCE OF CONSCIOUSNESS. By *Mark Solms*. New York: W. W. Norton, 2021, 432 pp., $18.95 paperback.

FEELING & KNOWING: MAKING MINDS CONSCIOUS. By *Antonio Damasio*. New York: Pantheon, 2021, 256 pp., $17.00 paperback.

Two recently published books provide intriguing and sometimes contradictory insights into the nature of consciousness. Mark Solms, neuropsychologist and leader of the neuropsychoanalysis movement, provides his view in *The Hidden Spring: A Journey to the Source of Consciousness,* while neurologist and neuroscientist Antonio Damasio continues his contributions in *Feeling & Knowing: Making Minds Conscious*. The two books make for fascinating reading, and one can't help but feel enlightened and provoked by the obvious brilliance of both authors.

THE VIEW OF SOLMS

Solms takes up the ambitious task of attempting to solve what has been called the hard problem of consciousness. Simply stated, why and how is it that physical processes in the brain give rise to the phenomena of

Kevin Ing, Yale School of Medicine, New Haven, Connecticut. Vedang Uttarwar, University of California, Irvine, Irvine, California. Yama Akbari, University of California, Irvine, Irvine, California. Theo G. M. van Erp, University of California, Irvine, Irvine, California. Mark Fisher, School of Medicine, University of California, Irvine, Irvine, California.

DOI: 10.1177/00030651241268091

conscious experience? In other words: what is consciousness and why and how does it arise?

Solms begins by critiquing the cortical theory of consciousness. According to this view, the cerebral cortex is an essential component of consciousness, which incorporates the concepts of arousal and awareness; while the brainstem regulates arousal, awareness is thought to be primarily a cortical domain. In simple terms, normal waking life is characterized by both arousal (wakefulness) and awareness, coma has neither wakefulness nor awareness, the vegetative state exhibits wakefulness but not awareness, and the dreaming state is characterized by awareness without wakefulness. Solms argues that feeling is the primordial source of subjective, conscious experience, and that any origin story for consciousness must account for the centrality of affect. Unlike cortical cognitive functions (e.g., visual perception) which can operate unconsciously, feelings are necessarily conscious. This is because feelings must be *felt*—they *must* be subjectively experienced. This necessitates a focus not on the cortex, but on subcortical affective systems, most significantly the reticular activating system and the affective/sensory/motor interface between the periaqueductal gray, the superior colliculi, and the midbrain locomotor region (Solms 2021a, p. 129). In support of Solms is considerable evidence indicating the critical role of these subcortical affective systems in emotion, behavior, and consciousness (Damasio and Carvalho 2013; Edlow et al. 2012; Venkatraman, Edlow, and Immordino-Yang 2017).

Solms relies heavily on the information theory of computational neuroscientist Karl Friston (Solms and Friston 2018). Friston's statistical-mechanical approach views conscious living systems as unique self-organizing systems, which have the characteristic of resisting entropy. This capacity relies upon a formation of a boundary between the system and the not-system (the "Markov blanket") by which information about the *not*-system/environment is communicated *to* the system. The system thus has a *point of view*—the environment is presented *to* the system, mediated by the Markov blanket, in such a way as to detect and resist entropic threats of the existence of the system. The system can then act on its environment, based upon its "predictions" or models of the state of the not-system. "Prediction errors" are discrepancies between predicted and actual sensory states and are utilized to update and maintain accurate models of the environment, thus minimizing future prediction errors

("free energy"). Consciousness, both with respect to levels of arousal and distinct qualia of different types of feeling, is explained by the need to maximize *precise* predictive models and minimize variance (Solms 2021a, p. 198).

But why is it that the statistical necessity for precision optimization in self-organizing systems would give rise to *conscious* experience? Solms here incorporates the work of Jaak Panksepp (1998), arguing that complex self-organizing systems such as living creatures must monitor and reduce free energy across distinct affect systems. Each affect system is activated via need detectors that measure deviation from homeostatic set points, and this deviation is manifest to the organism as *feeling*. These feelings, in turn, activate a set of instinctual behavioral responses. These are basic emotions, capitalized to distinguish them from their more common usage: "SEEKING," "LUST," "FEAR," "RAGE," "PANIC - GRIEF," "CARE/ATTACHMENT," and "PLAY." Each of these affects reflects qualitatively distinct organismic needs and has its own distinctive subjective quality. Because such needs cannot be quantitatively summed up, there is a requirement for complex self-organizing systems to register these subjective needs via feelings.

Solms concludes his work by framing his argument in a return to a discussion of the hard problem of consciousness. He writes: "Objectivity and subjectivity are observational perspectives, not causes and effects. Neurophysiological events can no more produce psychological events than lightning can produce thunder. They are parallel manifestations of a single underlying process" (Solms 2021a, p. 301). Just as an atmospheric electrical process produces the auditory and visual phenomena of thunder and lightning, Friston's statistical-mechanical computation theory is the single underlying process that explains both the thunder of consciousness and the lightning of neurophysiological mechanisms. The constraint of minimizing entropy with a system that acts as a Markov blanket, and the priority of affect as the optimal solution for most efficiently minimizing that entropy, is his answer for why consciousness arises.

These are fascinating observations, and it is sometimes difficult to reconcile the persuasiveness of the notion of free energy as an operating principle of the central nervous system with the disregard of the cortex as an essential element of consciousness. It is therefore useful to examine the primary evidentiary basis of the contra-cortical viewpoint: the case of

hydranencephaly. Solms provides heartwarming accounts of apparently conscious behavior by children afflicted with the neurodevelopmental disorder of hydranencephaly which, as Solms indicates, means that they are "born without a cortex" (p. 53). If subjects without cortex can exhibit conscious behavior, then cortex is not essential for consciousness. Simple as that.

Well, perhaps not so simple. Hydranencephaly is a rare disorder with extensive brain injury thought due to occlusion of both carotid arteries, probably late within the first trimester. During this period, the blood supply to the back of the brain (primarily the occipital lobes) begins to be supplied by the posterior cerebral arteries, meaning that there is relative preservation of blood supply to the cortex of the back of the brain even in the face of carotid occlusions. This explains why most case reports of hydranencephaly describe at least some occipital cortex present (often with other lobar remnants) (Cecchetto et al. 2013). As the primary brain injury is ischemic, and this region of the hemispheres is spared ischemia, there is no good reason why this residual cortex should not be functional. This functionality has been difficult to prove using standard electrophysiological techniques, as absence of visual evoked responses is typically encountered in hydranencephalic children (Lott, McPherson, and Starr 1986). Nevertheless, this absence of evoked responses is explainable by injury to optic pathways in parietal and temporal lobes by carotid occlusion, rather than necessarily indicating direct injury to occipital lobes. Electroencephalograms will not be particularly helpful, without the exquisitely sensitive "brain death" recordings not typically performed in these subjects.

Perhaps a better way to demonstrate cortical functionality in hydranencephaly is by positron emission tomography, for which there is a single case report that interestingly demonstrated glucose uptake in occipital (and frontal) lobes, suggesting functioning cortex (Short and Kardan 2014). Then there is the impact of neuroplasticity of the prenatal brain, which refers to the biological capacity of the brain to change and adapt structurally and functionally in response to injury with a repertoire not available to the adult brain (Ismail, Fatemi, and Johnston 2016). In other words, the reparative responses to severe cortical injury in an adult will be quite different (and limited) compared to that of a neonate. Thus, residual functioning cortex in hydranencephalic children, combined with the remarkable capacity for neuroplasticity in the young, may well be sufficient to support consciousness in these children.

THE VIEW OF DAMASIO

Antonio Damasio continues his long-standing quest to understand and explain the human psyche. This began with his now classic *Descartes' Error: Emotion, Reason and the Human Brain* (Damasio 1994), in which he convincingly demonstrated the importance of the emotional basis of rational behavior. In *Feeling & Knowing: Making Minds Conscious* (Damasio 2021), Damasio's fifth book following *Descartes' Error,* he expands his ideas to the nature and evolution of consciousness itself. This is a slim and elegant work in which readers quickly realize they are in the hands of a master.

The key to this book is in the subtitle: *Making Minds Conscious*. In other words, there is an important distinction between minds and conscious minds; the latter is a feeling-enriched state of mind. Other key distinctions and definitions are clearly drawn throughout the work: *intelligence* can be explicit (as in human reasoning and creativity) or nonexplicit (as in bacterial behavior regulated by molecular processes); nonexplicit intelligence is regulated by *homeostasis,* the how-to rules for staying within physiological boundaries required for the survival of living creatures; homeostasis is governed by *sensing* (or detecting) in primitive creatures but over time has come to be regulated by *minds* (requiring a nervous system) and ultimately by *consciousness* (requiring a nervous system with feelings); *feelings* are a conscious hybrid phenomenon consisting of interactions between, and presence in, both body and brain which inform the mind of the state of the organism in which the mind exists; *feeling* and *reason* are distinct but do not oppose each other; *emotions* are internal events triggered involuntarily by perception; *consciousness* requires interactions between brain and nonneural parts of the body; and *images* are explicit knowledge arising from consciousness by construction of spatial patterns. The evolutionary transition is from *being* to *feeling* and ultimately to *knowing*.

For Damasio, consciousness is a mental experience that has the characteristic of perspective ("point of view") of a mind linked by feelings to a body. Perspective cannot exist without feeling. This perspective ("self-reference") is a defining feature of consciousness. And so, feeling is essential for consciousness. In Damasio's view, the hard problem of Chalmers ("Why and how do physical processes *in the brain* [italics added] give rise to conscious experience?") is actually the wrong

question. And it is the wrong question because the non–nervous system provides essential contributions to consciousness via feelings.

Damasio's feelings allow consciousness to adhere to the homeostatic requirements of survival. This is entirely consistent with Solms's view of the organism's necessity for limiting free energy. But for Damasio, the fundamental neuroanatomic substrate of consciousness is entirely different. In his view, consciousness requires both imagery and the ownership of that imagery as provided by feelings. The imagery is based in cortex, specifically cortex of the sides ("lateral") and back ("posterior") of the brain. But the posterior-lateral cortex-derived imagery is insufficient for consciousness without the sense of ownership of that imagery as provided by feelings. And feelings are thought to derive from the "affect complex," a combination of what is termed the "peripheral interoceptive system" (presumably in part nonneural), nuclei of the brainstem, and insular and anterior cingulate cortices. For Damasio, consciousness ultimately requires both imagery and affect components, with contributions from cortex, brainstem, and the periphery. As we shall see, this neuroanatomic substrate is a more mainstream view than that of Solms.

CONTEMPORARY CORTICAL THEORIES AND CLINICAL NEUROLOGY

An accurate neuroscience theory of consciousness is critical to medical decision making and must account for not only psychoanalytic phenomena, but also medical disorders of consciousness (coma, vegetative state, and minimally conscious state). From a neurocritical care perspective, the field of neurology assesses consciousness along two major axes: motor and cognitive function (Kozlov 2023). And cognitive function has levels, of arousal and awareness. Arousal/wakefulness is thought to involve the ascending reticular activating system and thalamic nuclei, while awareness is generally thought to involve cortical-thalamic circuitry (Gammel et al. 2023).

For those interested in engagement with contemporary cortical theories of consciousness, some discussion of global neuronal workspace (GNW; Baars 1993, cited in Gammel et al. 2023) and integrated information theory (IIT; Tononi 2004 and Dehaene and Changeux 2005, 2011, cited in Gammel et al. 2023) is warranted (but see Seth and Bayne 2022 for a more comprehensive list of consciousness theories). GNW postulates that conscious experience is facilitated by a *global workspace*

generated in the frontal cortex via connections with the thalamus (Gammel et al. 2023). Alternatively, IIT proposes that consciousness is produced by "massively integrated" information processing and emphasizes the centrality of parietal and sensory cortices (Gammel et al. 2023).

Solms (2021a, p. 81) comments that nothing in these theories would explain why or how the unification or integration of information should *necessarily* give rise to experience. Why should such information processing, either via "global workspace" or massively integrated information processing, be experienced *consciously?* If computers generate global workspaces and massively "integrate information" all the time—then why is the internet not conscious?

Clinical neurologists and neuroscientists who favor cortical theories may articulate that GNW and IIT are proposed against a background that still presumes functional brainstem arousal structures as necessary prerequisites for consciousness. Thus, there is no disagreement regarding the necessity of the brainstem for consciousness. What is in dispute is whether these brainstem structures are also sufficient in themselves, or is the cortex also required: Solms argues the former, while cortical theorists assert the latter.

Dehaene et al. (2006) elaborate on GNW by differentiating subliminal, preconscious, and conscious processing. They argue that cortical and thalamic structures select and attend to all internal and external information that will rise to the level of conscious processing, as distinct from unconscious processing. Only stimuli that implicate the top-down goals of GNW neurons will rise to a threshold of attention that reaches conscious awareness (Dehaene and Changeux 2011). Thus, while brainstem and diencephalic structures vertically control levels of consciousness and corticothalamic relationships mediate them, the content and flow of conscious experience is processed through horizontal networks of pyramidal neurons in thalamocortical regions, cingulate, parietotemporal, and other association areas (Lagercrantz and Changeux 2009). Solms (2021a, pp. 207–210) acknowledges global workspace as a description of optimizing precision and reducing prediction error, but maintains that the cortex is not strictly necessary for fundamental conscious experience, as "consciousness generated by the upper brainstem has qualitative content of its own. This is affect. Since cortical consciousness is contingent upon brainstem consciousness, affect is revealed to be the foundational form of consciousness" (p. 302).

Is affect then the foundational form of consciousness? When considering the various ingredients of a conscious experience, psychoanalysts may easily accept that a conscious not-feeling experience is due to psychological obstacles to feelings. Those emphasizing the primacy of cortex in consciousness will accept that feeling is *necessarily* conscious and that consciousness requires brainstem structures responsible for affect, but will dispute the notion that full conscious experience can be produced via these structures alone in absence of cortex.

BUILDING A MIND: NEUROPSYCHOANALYSIS-INFORMED CONSCIOUSNESS RESEARCH

The task of validating a theory of consciousness remains profoundly difficult. An intriguing proposal suggests that *building* a mind may be a way to validate a model of consciousness. The project of creating conscious, artificially intelligent machines is the subject of both Solms's and Damasio's concluding chapters. Solms is optimistic that consciousness can be artificially created, while Damasio remains skeptical.

Damasio refers to the world of soft robotics and artificial general intelligence (Man and Damasio 2019). Robotics composed of soft electronics embedded in soft and malleable materials (e.g., an electronic gel skin) may be a prerequisite for an approximation of organic conscious experience. If feeling states require a level of material self-concern nested within higher levels of interoceptive integration, then Damasio's attention to the sensory and structural properties of a system is well taken. It remains to be seen whether silicon and/or other base materials have the necessary characteristics that would allow for the subjective experience ubiquitous in hydrocarbon-based animal life. Perhaps only "wet" biological tissues, and not alternative artificial materials, have the physicochemical properties that can produce the causal events that give rise to genuine feeling and consciousness.

Psychoanalysis, with its unique approach to exploring the subjective interiority of feeling states, will be singularly equipped to contribute to the emerging attempts to build a conscious mind. No other field inquires so deeply into the hidden levels of image, affect, motivation, and fantasy beneath verbal articulation of thought. The possibility of psychoanalytic inquiry into artificially intelligent minds could provide novel directions in the development of models of consciousness.

ORCID iD

Kevin Ing https://orcid.org/0000-0002-2428-7793

REFERENCES

Baars, B.J. (1993). *A Cognitive Theory of Consciousness*. Cambridge, UK: Cambridge University Press.

Cecchetto, G., Milanese, L., Giordano, R., Viero, A., Suma, V., & Manara, R. (2013). Looking at the missing brain: Hydranencephaly case series and literature review. *Pediatric Neurology* 48:152–158.

Damasio, A.R. (1994). *Descartes' Error: Emotion, Reason and the Human Brain*. New York: Penguin.

Damasio, A. (2021). *Feeling & Knowing: Making Minds Conscious*. London: Hachette UK.

Damasio, A.R., & Carvalho, G.B. (2013). The nature of feelings: Evolutionary and neurobiological origins. *Nature Reviews Neuroscience* 14:143–152.

Dehaene, S., & Changeux, J.-P. (2005). Ongoing spontaneous activity controls access to consciousness: A neuronal model for inattentional blindness. *PLoS Biology* 3:e141.

Dehaene, S., & Changeux, J.-P. (2011). Experimental and theoretical approaches to conscious processing. *Neuron* 70:200–227.

Dehaene, S., Changeux, J.-P., Naccache, L., Sackur, J., & Sergent, C. (2006). Conscious, preconscious, and subliminal processing: A testable taxonomy. *Trends in Cognitive Sciences,* 10:204–211.

Edlow, B.L., Takahashi, E., Wu, O., Benner, T., Dai, G., Bu, L., Grant, P.E., Greer, D.M., Greenberg, S.M., Kinney, H.C., & Folkerth, R.D. (2012). Neuroanatomic connectivity of the human ascending arousal system critical to consciousness and its disorders. *Journal of Neuropathology & Experimental Neurology* 71:531–546.

Gammel, T.C., Alkadaa, L.N., Saadon, J.R., Saluja, S., Servider, J., Cleri, N.A., Egnor, M., Davis, R.P., Huang, C., Saalmann, Y.B., Mofakham, S., & Mikell, C.B. (2023). Brain circuitry of consciousness: A review of current models and a novel synergistic model with clinical application. *Neurosurgery Practice* 4:e00031.

Ismail, F.Y., Fatemi, A., & Johnston, M.V. (2016). Cerebral plasticity: Windows of opportunity in the developing brain. *European Journal of Paediatric Neurology* 21:23–48.

Kozlov, M. (2023). What does "brain dead" really mean? The battle over how science defines the end of life. *Nature* 619:240–242.

Lagercrantz, H., & Changeux, J.-P. (2009). The emergence of human consciousness: From fetal to neonatal life. *Pediatric Research* 65:255–260.

Lott, I.T., McPherson, D.L., & Starr, A. (1986). Cerebral cortical contributions to sensory evoked potentials: Hydranencephaly. *Electroencephalography and Clinical Neurophysiology* 64:218–223.

Man, K., & Damasio, A. (2019). Homeostasis and soft robotics in the design of feeling machines. *Nature Machine Intelligence* 1:446–452.

Panksepp, J. (1998). *Affective Neuroscience: The Foundations of Human and Animal Emotions*. New York: Oxford University Press.

Seth, A.K., & Bayne, T. (2022). Theories of consciousness. *Nature Reviews Neuroscience* 23:439–452.

Short, R.G., & Kardan, A. (2014). ^{18}F-FDG PET/CT in a 16-year-old patient with hydranencephaly. *Clinical Nuclear Medicine* 39:e445–e447.

Solms, M. (2021a). *The Hidden Spring: A Journey to the Source of Consciousness*. New York: W. W. Norton.

Solms, M., & Friston, K. (2018). How and why consciousness arises: Some considerations from physics and physiology. *Journal of Consciousness Studies* 25:202–238.

Tononi, G. (2004). An information integration theory of consciousness. *BMC Neuroscience* 5:1–22.

Venkatraman, A., Edlow, B.L., & Immordino-Yang, M.H. (2017). The brainstem in emotion: A review. *Frontiers in Neuroanatomy* 11:15.

Mark Fisher
UC Irvine Medical Center
101 The City Drive South
Building 55, Room 121
Orange, CA 92868
Email: mfisher@hs.uci.edu