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It Binds, Therefore I Am!

*Review of Rodolfo Llinás' 'I of the Vortex'*¹

What do tunicates and professors have in common? The larval forms of tunicates or 'sea squirts' (*Ascidacea*), equipped with a ganglion containing approximately 300 cells, go through a brief phase of free swimming. Upon finding a suitable substrate, the larva buries its head into the selected location and becomes sessile. Then it absorbs most of its small brain and nervous system and returns to a rather primitive condition — 'a process paralleled by some human academics upon obtaining university tenure', Rodolfo Llinás joked several years ago (1987, p. 341). An academic himself, namely professor of neuroscience at the New York University School of Medicine, he tells the tunicate story again in his latest book, but leaves out the academic point. However, this does mean in no way that he has become a sessile tunicate himself. He is still equipped with an excellent brain creating bold, inspiring and far-reaching thoughts. Thus, *I of the Vortex* is a pleasure to read: mostly concise and quite easy to follow, concentrated and learned but often entertaining nevertheless, sometimes surprising and frequently first-hand because it is also a synopsis of Llinás' own three decades of brain research and neurophilosophical thinking. And it contains some quite astonishing pictures. It informs about the evolution of eyes, neuronal coding, control of movement, communication, learning and memory. But mainly — and for *JCS* readers most interesting — it is arguably one of this year's most important books about action, consciousness, and self. Unfortunately, some parts are a bit lengthy, with their subjects well covered elsewhere, while the most important and original sections could have used much more detail.

For Llinás, mind, or 'mindness state' as he prefers to call it, 'is that class of all functional brain states in which sensorimotor images, including self-awareness, are generated' (p. 1). Mind coincides with functional brain states and has evolved as a goal-oriented device that implements predictive interactions between the

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organism and its environment. Multicellular creatures, which move actively, need this to orchestrate and express their movements. The ‘capacity to predict the outcome of future events — critical to successful movement — is, most likely, the ultimate and most common of all global brain functions’ (p. 21). Thus, having a nervous system — and here the tunicates enter again — is an exclusive property of motricity which is at the centre of the evolution of neuronal activities. Mindness and thinking are the evolutionary internalization of movement (pp. 5, 34), and any internal image can only be externalized through movements; ‘the brain’s control of organized movements gave birth to the generation and nature of the mind’ (p. 50). And the self is the centralization of prediction (p. 23).

Till now Llinás’ story is straightforward and reasonable (and predominantly outlined already in his 1987 paper). It stresses the motor function and embodiment of mind, which is still often neglected (but cf. *JCS*, November/December 1999). Next, Llinás discusses some of the neuronal constraints. For him, cognition is an intrinsic property of the brain which is not learned but ‘neurological a priori’ (p. 58). Consciousness is based on simultaneity of activities in the thalamocortical system, i.e. a superposition of spatial and temporal mapping via thalamocortical resonant interactions. Intrinsic oscillatory electrical activities, resonance and coherence are at the root of cognition and self-awareness. In important studies with magnetoencephalography, Llinás *et al.* discovered that both wakefulness and dreaming (REM sleep) — unlike dreamless deep sleep — are characterized by coherent thalamocortical oscillations at 40 Hertz. The difference is that the 40 Hertz oscillations are reset by sensory input during wakefulness but not REM sleep. Thus, we do not perceive the external world while dreaming because the intrinsic activity of the nervous system does not place sensory input within the context of the functional state being generated by the brain (p. 130). Unfortunately, Llinás discusses these important results and their implications only very briefly — although he has done it more extensively elsewhere in a not too technical manner (Llinás & Paré, 1996; Llinás *et al.*, 1998). Worse, he does not discuss them in comparison with other approaches and findings about coherent neuronal activities and neural correlates of consciousness, especially the work of Wolf Singer *et al.*, Francis Crick and Christof Koch, Ernst Pöppel *et al.*, and Gerald Edelman — mostly he does not even cite their papers. To learn more about Llinás’ opinions regarding these issues and how the above authors differ from his on views would not only be of great interest for many readers but would also have sharpened and clarified his own approach.

Another central theme of the book is what Llinás calls FAPs (fixed action patterns). They are sets of ready-made motor patterns which produce well-defined and coordinated movements, e.g. walking, swallowing, speaking; some can be learned (e.g. playing guitar), most can be modified by experience; they are not reflexes, although some are highly automatized, others are activated by volition. FAPs reduces the immense degrees of freedom of the motor system in movements. They are based on the basal ganglia which are connected extensively to the thalamus and the cortex. FAPs liberate the self to spend time and attention on other things. Llinás interprets emotions as another kind of FAPs with premotor

(not motor) actions, providing the trigger and internal context for action, then to be shown via other FAPs, e.g. as facial expressions. In another chapter — unfortunately, a much too short and eclectic one for the enormous topic — Llinás also interprets language as a premotor FAP. He then mentions the strange case of a patient who has been in coma for the last twenty years owing to a stroke, which destroyed most of his cortex; but part of Broca's area, the thalamus and the basal ganglia are intact, and occasionally the patient, although in a vegetative state, still generates words.

'Cognition and consciousness probably evolved from the emotional states that trigger FAPs', Llinás speculates (p. 168). So what about qualia? Llinás is well aware of what is known as the hard problem (cf. Shear, 1998), and his line of reasoning is straightforward: He takes qualia to denote not primarily the feeling character of sensations but 'the ability of the nervous system to generate a sensory experience of any type' (p. 201). Qualia are not an epiphenomenon but 'a very important and influential drive throughout evolution' (p. 203), especially in the organization of behaviour. Consciousness is necessary because of its ability to focus and choose, thus for action. Roughly speaking, sensations are 'FAPs turned inside out' (p. 209), i.e. internal expressions activated by stimuli from the external world (or experimental electrical brain stimulation) or through internally derived activation as in dreams. 'Qualia are that part of self that relates (back) to us! . . . Qualia facilitate the operation of the nervous system by providing well-defined frameworks, the simplifying patterns that implement and increase the speed of decision and allow such decisions to re-enter (the system) and become part of the landscape of perception' (p. 221). This is not as intelligible as one might wish, and a functional explanation of qualia is of course not sufficient to deal with the phenomenal aspects. However, it is clear that Llinás favours a naturalistic account of consciousness: Qualia are based (at least in biological organisms on Earth) on electrical activity and location or are even, as Llinás postulates, identical with them (p. 218) or 'simplified constructs' of neuronal circuits (p. 222). He also summarizes some astonishing parallels or analogies between qualia and single-cell properties, which lead him to conclude that they 'must be, fundamentally, a property of single cells, amplified by the organization of circuits specialized in sensory functions' (p. 212). Here we are on shaky grounds. He even gives a cryptic hint about 'proto-qualia' (p. 219), and he doubts that quantum mechanical approaches are promising at any serious level.

Interpreting the coherent neuronal activities in the 40 Hertz range as a binding mechanism, Llinás updates René Descartes: 'It binds, therefore I am!' (p. 126). However, the self is not a substance or stable irreducible entity, but for philosophical and evolutionary reasons some sort of a fiction or illusion (Vaas, 2000). Llinás' neurophilosophical reasoning points in the same direction. For him, the self is a 'convenient invention on the part of the brain to corral its predictive properties for better efficiency of movement' (p. 109), a 'very important and useful construct. . . . It exists only as a calculated entity. . . . The "I" of the vortex, that which we work for and suffer for, is just a convenient word that stands for as global an event as does the concept of Uncle Sam vis à vis the reality of a

complex, heterogeneous United States' (pp. 127–8). And Llinás goes even further. He views the brain as a self-referential, closed system, a functional reality emulator that constructs the world, rather than reconstruct it. Sensory input modulates rather than informs the operations of the nervous system: 'we are basically dreaming machines that construct virtual models of the real world' (p. 94). However, at the end of the book, discussing the future of human beings and digital virtual reality, Llinás insists: 'Life is not a dream; it is about physical survival and continuation. Virtual reality will not fill the need' (p. 261). Thus, there is a tension between realism and constructivism in Llinás' epistemology and ontology: He is convinced that our brain 'is making a simplification of the external world, but a very useful one' (p. 108) — and he takes science not as a special kind of dreaming but as a powerful means to unveil what is really going on. It is difficult to see, though, how our fictional self is able to leave the prison of its closed system. Energetically, the brain is of course an open system, and views about informational and semantic aspects depend, implicitly at least, on a theory of information and semantics, which Llinás does not explicate. Furthermore, he does not discuss the problems of constructivism and the challenge of direct realism, externalism etc. He only rejects solipsism. 'I say that I am a closed system but not a solipsist. . . . I am a closed system for I have a point of view; if I were not closed, I would not be distinguishable from the outside world, but rather in some way continuous with it' (p. 109).

For Llinás, 'cognition is first and foremost an empirical problem, not a philosophical one' (p. 113). His book gives some impressive data and examples of how scientific research can approach and illuminate cognition, consciousness and self-awareness. Philosophy however is not superfluous: First, for many different reasons neural correlates of consciousness are not enough (Vaas, 1999); secondly, Llinás himself turns more than once to philosophical claims and reasoning; and thirdly, if we do not get the terminology, consistency and empirical implications of our hypotheses straight (e.g. regarding identity claims, qualia, self, constructivism, realism, etc.), the investigation of cognition and consciousness balances on one leg only. Thus, both the strengths and the weaknesses of Llinás' book also provide evidence that philosophy is still needed; and especially given the success of neuroscience, neurophilosophy remains here to stay.

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