

Stuart Hameroff

## *The Good, the Bad and the Octopus*

*Conference Report on ASSC 11, Las Vegas 2007*

The Association for the Scientific Study of Consciousness ('ASSC') held its 11th annual meeting June 22–25 at The Imperial Palace Hotel on 'The Strip' in Las Vegas, Nevada. It was a landmark event for ASSC which bid goodbye to Patrick Wilken, its workaholic major domo (now at Elsevier Publishing), and seemed to cement relations with The Mind Science Foundation, a Texas-based philanthropic group.

The meeting highlight was 'The Magic of Consciousness Symposium', brainchild of conference co-organizers (and visual illusion scientists) Susana Martinez-Conde and Steve Macknik. Symposium speakers were five professional magicians including Teller (of 'Penn and Teller' — yes, he actually speaks), The Amazing Randi (well-known debunker and skeptic), Apollo Robbins (who once pick-pocketed an on-duty Secret Service agent), Mac King ('Never do the same trick twice for the same audience') and Johnny Thompson (a.k.a. The Great Tomsoni). The prestidigitators seemed to genuinely relish explaining how to distract attention and manipulate expectations. This followed scientific talks on unconscious perceptions, attention and change blindness (e.g. Marvin Chun who showed Dan Simons' famous gorilla-in-their-midst video before realizing Simons himself sat live in the first row). Most impressive was a video in which UK researcher Richard Wiseman performed a card trick. The trick was *not* that he identified a supposedly random unknown card, but

Correspondence:

Stuart Hameroff, Anesthesiology, Psychology, and Center for Consciousness Studies, The University of Arizona, Tucson, Arizona, USA.

[hameroff@u.arizona.edu](mailto:hameroff@u.arizona.edu)

that the colour of the entire 52 card deck changed from blue to red. Actually, that wasn't the trick either. Upon reviewing the unedited video, what really surprised the audience was that, not only did the deck's colour change, but also did the colours of the tabletop, back curtain, Wiseman's shirt and that of his lovely assistant!

There were other highlights, and some disappointments. Incoming ASSC President Michael Gazzaniga (suffering from an injured knee) spoke about split-brain patients, extrapolating to a call for 'local' rather than global connection models of consciousness. (A video of one hand fighting with its opposite, Doctor Strangelove-like, delighted the crowd.)

Gazzaniga was scheduled to debate Dan Dennett the following morning, but bowed out due to his knee problem (I, for one, have a hard time imagining what these two could have possibly disagreed about). Hail and hearty after his life-threatening surgery, we were happy to see, Dennett soldiered on solo, shadow-boxing in broad strokes. He reiterated one key feature of his multiple drafts model, that activity *anywhere* in the brain could elicit consciousness, as long as that particular activity was *more* than activity in any other brain area at that moment. When asked precisely what *type* of neural activity did the trick, Dennett passed. Put both Gazzaniga and Dennett in the 'local' camp (apparently with Christof Koch, who took that position in last year's ASSC debate). The globalists came later.

The opening reception and gala banquet at the opulent Venetian Hotel were splendid. The Imperial Palace itself is rather old, noisy and slightly seedy, but perfectly located and inexpensive. We were able to take in 'Spam-a-lot' at the new Wynn's, Cirque de Soleil's 'Love' (about the Beatles) at the Mirage, plus a few hundred dollars from the craps tables.

The Mind Science Foundation-sponsored Tom Slick award program included two high tech presentations (fMRI biofeedback, anyone?) by young scientists. New labs and faces in the field are truly good to see.

Most of the science sessions dealt with fMRI and electrophysiological studies of conscious and unconscious perceptions, attention, cues, forward and backward masking, lesions and some other methods. Philosophers (usually in a separate room) talked a lot about variations of Higher Order Thought ('HOT') theory, some introspection and Ned Block's access/phenomenal consciousness. The next ASSC President, HOT guru David Rosenthal, gave the closing plenary talk.

As Patrick Wilken said at the conference opening, ASSC has always had a narrow focus, e.g. cognitive neuroscience and attendant

philosophy. Controversial topics like altered states, quantum mechanics and parapsychology have always been off-limits. But also missing at ASSC 11 were any talks on gamma synchrony, the best candidate for the neural correlate of consciousness ('NCC'). Not discussed, for example, was a recent study by Wolf Singer and colleagues which showed conscious word perception (and not unconscious word perception) is preceded by early gamma synchrony across cortical regions and hemispheres.

Koch (ASSC's scientific compass) and most neuroscientists assume axonal firings, or spikes are the bit-like currency underlying the NCC. Gamma synchrony (coherent 30 to 90 Hz EEG, a.k.a. 'coherent 40 Hz') and other EEG are generated not by spikes, but by dendritic local field potentials (LFPs), a distinction addressed in two excellent posters from David Leopold's NIMH group. Recording both spikes and LFPs in monkey cortex and thalamus, they found that subjective awareness correlates with dendritic LFPs rather than axonal spikes.

Are dendrites and gamma synchrony outside ASSC's narrow focus? After Singer discovered gamma correlations with consciousness in the 1980s, Francis Crick and Christof Koch helped launch the gamma synchrony NCC bandwagon. But they later jumped ship, along with many others, related to an influential analysis by Shadlen and Movshon which rejected gamma synchrony. Gamma synchrony was rejected *not* because it doesn't correlate with consciousness — it clearly does — but because it doesn't jive with axonal spikes, the anointed currency of the NCC. Gamma synchrony EEG derives from LFPs, in turn derived from post-synaptic dendritic potentials. Forced to choose between dendritic synchrony and axonal spikes as the NCC, Shadlen and Movshon, Crick and Koch and many others chose spikes, and ASSC followed. Too bad.

LFPs and gamma synchrony occur both locally and globally, compatible with both local origin theories, and global/hierarchical views like Global Workspace (GW) and HOT. With GW guru Bernie Baars in the house, global hierarchies surfaced in the superb session 'Cortical Networks and Conscious Awareness' with Alumit Ishai (Zurich), Rafael Malach (Israel) and Giulio Tononi (Wisconsin).

Tononi, more suave than even Koch, claimed that effective connectivity (measurable through EEG/LFPs) in thalamocortical circuits correlates with consciousness. Tononi used transcranial magnetic stimulation on himself, among others, to see how it disrupted normal sleep. (What an interesting college roommate he could have been!) Put Tononi in the globalist camp.

Alumit Ishai used fMRI to study face recognition. She found activity in a feed-forward (posterior to frontal) hierarchical network, including posterior visual, limbic/emotional and frontal cortex. Put Ishai in the globalist camp (along with Koch — now in both camps — whose tutorial covered ‘top-down’, frontal to posterior, attention mechanisms).

So ... does consciousness require hierarchical organization as the globalists and HOT proponents advocate? Or are the localists correct in that consciousness can erupt in any sufficiently active brain region? Rafael Malach from the Weizman Institute in Israel addressed this issue. He studied continuous fMRI in subjects watching Sergio Leone’s epic spaghetti Western *The Good, the Bad and the Ugly*, correlating specific fMRI activity with precise movie scenes and frames. While viewing the film, all above-baseline fMRI activity remained posterior in the subjects’ visual cortical areas, with occasional snippets of activity in sensory cortex. Malach showed that the appearance of faces in the film (Clint Eastwood, Lee van Cleef, Eli Wallach) corresponded with activity in viewers’ posterior visual cortex face regions. Activity in the ‘hand’ area of sensory homunculi occurred precisely during scenes/frames showing characters’ hands gripping a gun, cigar or dealing cards.

Without posterior-frontal connections, Malach suggested lateral links among basal dendrites of layer 5 pyramidal cells and cortical interneurons worked in a distributed, rather than hierarchical, LFP-friendly architecture to produce conscious experience. Put Malach in his own camp — not local but not necessarily global. Call it lateral/distributed.

Sid Kouider from CNRS in Paris received ASSC’s William James Prize for young researchers. He showed fMRI of unconscious processes in posterior cortical regions, arguing for an intermediate level of pre-conscious activity supportive of Ned Block’s access consciousness concept. Kouider implied that top-down, frontal to posterior actions spotlighted access/pre-conscious activity into phenomenal experience, deftly linking Block’s access view with HOT and GW hierarchical approaches. Put Kouider in the globalist camp.

But Malach had shown all-posterior cortical activation patterns nearly identical to Kouider’s pre-conscious access, but clearly correlated with conscious experience. Do we really need top-down, front-to-back GW/HOT-type organization to be conscious?

Some light on this question came in the Animal Consciousness session. Although we cannot directly measure or determine consciousness in animals (we can’t do it for humans, either), complex

behaviour, apparent emotions and functional analogies in hierarchical brain/nervous system organization suggest that animals may be conscious. In the session, Irene Pepperberg talked about Alex, the famous grey parrot, and Bjorn Merker discussed behaviour and hierarchical neuronal organization in lower vertebrates and invertebrates. The third talk was to be about octopus, whose nervous system is *not* hierarchical, but lateral/distributed. When the speaker didn't show up, session chair David Edelman filled in admirably. He showed video of an octopus roused from restful camouflage, his huge startled eye suddenly bulging straight toward the camera, and then whirling away like a fleshy propeller out of hell. Maybe Malach is correct, and lateral, distributed neuronal organization *can* provide conscious experience. It can certainly accommodate complex adaptive behaviour.

Could local, global and/or lateral/distributed neuronal organizations each support different modes of consciousness in different circumstances? When we are passively engrossed in a film, brain activity remains posterior, e.g. in Malach's lateral/distributed scheme. When we become introspective or engage in command-and-control modes, frontal cortex kicks in and more global GW/HOT networks take over. Very localized activity could also result in consciousness (e.g. Zeki's famous colour consciousness in isolated V4 activity, or Damasio's or Panksepp's emotional core suggestions).

So the question becomes not so much *where*, but precisely *what type* of neural activity distinguishes consciousness from unconscious processes. The evidence points to synchronized dendritic LFPs rather than axonal spikes. And if Block and Kouider are correct, neural activities supporting *unconscious* processes must be further divided into (at least) two sub-types: non-conscious and pre-conscious/access. There's plenty of need for lower level subtlety.

Ringo Starr's 'Octopus's garden' was never one of my favourite Beatles songs, but was a definite highlight of the Cirque de Soleil show at the Mirage. I may never forget the high-flying gossamer cephalopod, rocking out to the best sound system ever made — and doing so without a hierarchical nervous system.

It was a great conference.