

**Confirmation Bias, Power Politics and Innovation in Science**

Free thinkers and research innovators must believe in their vision to push forward new ideas in science that buck mainstream ideas. However, a strong belief in your theories may create a natural vulnerability to confirmation bias that affects how experiments are designed and how experimental results are interpreted. On the other hand, mainstream science is also subject to confirmation bias and has the institutional advantage of peer acceptance and availability of grant funding often judged by mainstream advocates. Sometimes mainstream institutions can actually suppress innovative thinking that doesn't support accepted trends or dogma. A healthy scientific community requires a balance between these 2 forces. Where do we draw the line?

At today's Chaos and Complex Systems session, I'll lay out a specific example in neuroscience of where productive scientific thinking may have limited critical progress in related areas. I will ask participants in the session for other examples of this dichotomy for good or bad in the recent history of science.

In the 1950's, a landmark neurological case of global amnesia (memory loss) was critical to our current understanding of multiple neural systems underlying human memory. The neurological patient, H.M. (now known post-mortem by his real name, Henry Molaison), suffered terribly from multiple daily grand mal seizures (status epilepticus) before the advent of anti-epileptic drug treatments. The effective and established procedure at the time was to identify the damaged part of the brain that was initiating the seizures and to remove this so-called "focus" surgically.

In the case of H.M., the treatment was bilateral removal of the hippocampus and other limbic system structures deep in the temporal lobes that were causing the grand mal seizures. The treatment worked immediately. However, H.M. was left with a profound amnesia where he was unable to recall any memories from the time of his surgery onward (anterograde amnesia). His recall of his life before surgery was relatively normal but he couldn't recall what he ate for breakfast that morning or if he even had breakfast at all. Sadly, Henry's condition persisted throughout the rest of his long life.

The paradoxical outcome of Henry's profound memory loss is that investigators soon learned that he was in fact able to acquire and retain new information at normal rates but was unable to recall any specific learning experiences per se. He was able to learn complex sensorimotor tasks such as tracing a star in a mirror image (and other motor tasks like riding a bike more generally) but was surprised when performance on this task became easier and easier since he didn't recall ever doing the test before. These observations stimulated a revolution in the way researchers thought about human memory, not as a single unitary system, but as a system of systems with multiple levels of behavior that included explicit conscious recall of events and implicit unconscious learning and habit formation.

Advances in neurophysiological techniques during the 1970's allowed researchers to pinpoint neurobiological changes in brain regions like the hippocampus that were associated with learning in a variety of non-human animals, from mice and monkeys to the simple nervous system of the lowly sea slug, *Aplysia*. Eric Kandel won a Nobel prize for Physiology or Medicine in 2000 for his critical and groundbreaking work detailing the molecular changes underlying learning in *Aplysia* at the level of the single synapse (aka neural plasticity).

Kandel, a psychiatrist interested in fundamental mechanisms of human learning and memory, took a reductionist approach to the problem and spawned a huge body of extremely productive work looking at the molecular basis of synaptic plasticity associated with learning. The issue remains unresolved whether understanding the molecular basis of synaptic plasticity really provides insight into the question that piqued Kandel's original interest: human learning and memory.

In the 1970's and 1980's, proponents of synaptic plasticity as the underlying mechanism of learning and memory were on the ascendance in numbers of new investigators, published papers and grant funding. Reductionist molecular biology approaches began to dominate scientific approaches to the problem of human memory. The practical impact of this growth was that it was more proportionally difficult to get grant funding for systems level research at higher levels of behavioral analysis. While well-intentioned, this bias probably restricted progress in other levels of analysis that provide critical insight into the nature of human memory.

Similarly, other advances in experimental technologies drove the direction and funding of neuroscience, often triggering horse races to publish with a new technique before others would do the same work. For example, the advent and widespread deployment of functional Magnetic Resonance Imaging (fMRI) brain scanning in the 1990's flooded the literature with descriptive but atheoretical studies of the brain substrates of human behavior. In a zero-sum funding environment, funding of technology-based research crowded out more innovative studies.

### **Some Discussion Points**

- 1) Does belief in a scientific vision undermine the scientific method?
- 2) How does confirmation bias affect innovators and mainstream researchers?
- 3) How can we guard against the suppression of new ideas by mainstream institutions?
- 4) What are other examples of mainstream suppression of new ideas across the sciences?