Recent Developments in Science and Medicine - 2008

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This is the first of a new series of brief reports which will update members on recent items of interest.

Consciousness and free will

In May 2008, John-Dylan Haynes (neuroscientist, Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany) reported that your brain makes decisions before you even know it – 10 seconds before you realise. Researchers could predict what choice people would make before they themselves were even aware of having made a decision. This challenges the 'consciousness' of our decisions and even how 'free' we are to make a choice at a particular point in time. Volunteers were asked to press one of two buttons when they felt the urge to perform a decision-making task. At the same time, a stream of letters were presented on a screen at half-second intervals, and the volunteers had to remember which letter was showing when they decided to press their button. When the researchers analysed the data, the earliest brain activity signal the team could pick up started seven seconds before the volunteers reported having made their decision. Because there is a delay of a few seconds in the imaging, this means that the brain activity could have begun as much as ten seconds before the conscious decision. The signal came from a region called the frontopolar cortex, at the front of the brain, immediately behind the forehead. What does this say about free will?

References

Soon, CS, Brass M, Heinze H-J & Haynes JD.
***Nature Neurosci 11**: 543-5 (2008)*

Conservation

In July 2008, Galapagos scientists became extremely excited with the possibility that Lonesome George, the sole surviving giant tortoise of the northerly Galapagos island of Pinta, was at last to become a father. Lonesome George, aged somewhere between 60 and 90 years, has been resident at the Charles Darwin Research Station, Santa Cruz, since 1972. George has been supplied with females of a closely related species for the past 18 years now and conservationists hoped that some hybrid offspring might result. Finally, one of the females produced significant numbers of eggs. If the eggs do turn out to be fertile, scientists will begin entertaining the possibility of captive breeding the Pinta tortoise back from the brink of extinction. However, hope is running out and in November it was thought that the few remaining eggs in the incubator are sterile.

Brain and belief

In September 2008, research from neuroscientists at Cold Spring Harbour Laboratory suggests that the estimation of confidence that underlies decisions may be the product of a very basic kind of information processing in the brain, shared widely across species and not strictly confined to those, like us, that are self-aware.

This remarkable prospect arises from experiments performed on laboratory rats and reported this week in *Nature* by CSHL scientist Professor Adam Kepecs in collaboration with Professor Zachary F. Mainen (Associate Professor at CSHL and Group Leader in the Champalimaud Neuroscience Programme at the Instituto Gulbenkian de Ciência near Lisbon, Portugal). 'We all possess some intuitive sense; we know our convictions from our mere hunches,' said Kepecs, who heads a lab at CSHL devoted to uncovering neural circuitry underlying decision-making. 'This sense of confidence, or lack thereof, is critical to our success, but how it arises in the brain has long been a mystery.'

To solve this mystery, Kepecs, Mainen and colleagues trained rats to make decisions of different difficulty. Because rats excel at olfaction, this was achieved by repeatedly presenting them with odours composed of mixtures of two chemicals and asking them to determine which component was stronger in order to receive a small reward. By precisely varying the exact mixture of components, it was possible to manipulate the difficulty of the decision and therefore the animals' predicted level of uncertainty. The team recorded signals from individual neurons in the rodents' brains while they were put to the test of distinguishing smells. They found that neurons in a part of the brain known as the orbitofrontal cortex (an area of the brain found in both rats and humans) signal the uncertainty of the decisions, 'firing' much more vigorously in difficult tests compared with easier tests.

Having demonstrated that rat brains make confidence calculations, the researchers sought a way to demonstrate whether such calculations informed the rats' behavior. As in the first set of trials, rats made decisions involving the discrimination of two smells; they were rewarded, after a defined period of delay, if they decided correctly, and received nothing if their decision was incorrect. In a modified task, the reward delay was increased substantially. However, while waiting for the reward, the rats were given the option to abort the trial – short of learning whether their decision was right or wrong – and return to the beginning to start a new trial.

'This new option to abort and restart constitutes a decision that should be made based on the level of confidence about getting a reward,' Kepecs said.

The researchers did indeed find that rats preferentially aborted uncertain trials. This showed that they could not only calculate their level of confidence in a given decision, but also use that calculation in subsequent decisions to guide behavior.

Taken together, these experiments reveal 'that confidence estimation is not a complex function specific to humans but a core component of the process of decision-making probably found throughout the animal kingdom,' said Kepecs. According to Mainen, 'future studies of this kind may illuminate the question of how we form an intuitive sense of the solidity of a belief, how we distinguish fact from fiction itself.'

References

Nature 455: 227-31 (2008)

Evolution

September 2008. Professor Michael Reiss was forced to retire from his position as director of education at Britain's Royal Society in a row over approaches to creationism in the classroom. Michael Reiss is also a professor at London's Institute of Education and an ordained minister in the Church of England. His retirement follows complaints from three Nobel-prize winning fellows of the Royal Society following Reiss's remarks on the need to engage in dialogue with the creationist views some children express in science classes. Others had the view that Reiss, as a priest, should never have been appointed to the Royal Society post in the first place.

However, Reiss has been staunchly defended by many professional colleagues who argue that his rare blend of transdisciplinary credentials give him critical insight into the social controversy surrounding the teaching of evolution. After all, he was not advocating the teaching of creationism in the classroom.

The Royal Society itself initially insisted that Reiss had been misrepresented and that his views did not differ from the society's position that 'creationism has no scientific basis and should not be part of the science curriculum'. On this basis, if a child raises the topic teachers should explain why evolution is a scientific theory and creationism is not.

This supportive stance then changed. After the letter of complaint and with the reported statements continuing to receive press coverage, including hostile opinion pieces, the society announced Reiss's departure on 16 September. In a statement it said that 'some of Professor Michael Reiss's recent comments ... were open to misinterpretation. While it was not his intention, this has led to damage to the society's reputation.'

But scientists and science teachers must also grapple with the central challenge that Reiss was addressing: how to respond to students who have been steeped in, or confused by, scientifically nonsensical creationist beliefs when they ask about those beliefs in science classes? Responding to student's questions provides one opportunity that a school has to engage resistant students and introduce them to what science has to say. An effective approach is for the teacher to follow the route Reiss advocated: deal with the question without ridicule, but make it clear that in science, theories must be testable to be valid. 'You ask if Earth is 6,000 years old, and why the descendents of Adam and Eve have no relation to the lower animals? So how can we test those hypotheses, and what does the evidence say?'

GM crops

In November 2008 there was report by Rex Dalton in the journal *Nature* on the work of Elena Álvarez-Buylla et al on the spread of modified genes from genetically modified maize into traditional crops in Mexico. The work confirms a similar result published in Nature in 2001 (Quist, D. & Chapela, I. Nature 414: 541-3, 2001). The spread appears to have occurred despite the Mexican Government ban on planting GM maize. The importance of the study is not the impact of the transgenes themselves, but the fact that their spread has occurred so easily. The findings have refuelled the controversy surrounding these tests and their validity.

References

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Mol Ecol 18: 750-61 (2009)

Cosmology

November 2008. Planets beyond the solar system? Ashley Yeager reports in the journal *Nature* that two teams of astronomers are independently claiming to have the first ever images of planets in orbit around a star other than the Sun - one team took infrared images of three objects, each 5-13 times the mass of Jupiter, in orbit around HR 8799, a star 130 light years from Earth in the constellation Pegasus. The three objects are all orbiting in the same direction indicating they are formed from a single rotating disk of dust.

The other team used the Hubble Space Telescope to take photographs of a potential planet that's no bigger than three Jupiters. It circles Fomalhaut, a star 25 light years away from Earth in the constellation of Piscis Austrinus, completing one orbit every 872 years. The object is roughly 119 times further away from its star than Earth is from the Sun, and is located at the inner edge of a debris disk that it appears to have sculpted into a sharp smooth ring by pulling in stray dust as it orbits.

Both teams make excellent cases for their discoveries but agree it's too early to declare these images the first, historic images of worlds beyond our Solar System.

References

Krist J. *Science* 322:1345-8 (2008)

Science and God

And finally, of interest to many SMN members is the question, 'Does science make belief in God obsolete?' The John Templeton Foundation put this question to 13 distinguished scholars - Steven Pinker (Yes, if by...), Christoph Cardinal Schönborn (No, and yes.), William D. Phillips (Absolutely not!), Pervez Amirali Hoodbhoy (Not necessarily.), Mary Midgley (Of course not.), Robert Sapolsky (No.), Christopher Hitchens (No, but it should.), Keith Ward (No.), Victor J. Stenger (Yes.), Jerome Groopman (No, not at all.), Michael Shermer (It depends.), Kenneth Miller (Of course not.) and Stuart Kauffman (No, but only if...). The full versions of these responses may be accessed Online at www.templeton.org/belief.

Answers to another big question 'Does the universe have a purpose?' may be found at the same site.