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PRESS RELEASE

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RANDOM BUT CRUCIAL: HOW RANDOM BRAIN WIRING WORKS

Some brain areas operate using a specifically structured network of connections between neurons, which support particular functions. Yet in other areas, connections and activities between brain cells seem to be random.

In the quest to uncover how brain networks communicate, research by **Professor Larry Abbott** at Columbia University in New York has revealed that these random connections can work in surprisingly effective and sophisticated ways, and that they are essential parts of brain function.

"If you look at different brain regions, there are two ways things may work," Professor Abbott told delegates at the FENS Forum of Neuroscience in Copenhagen. Some regions, for example, the cerebral cortex, feature a high number of connections between neurons communicating back and forth, forming a 'recurrent network'. Yet others, including areas of the cerebellum, may have many neurons, yet fewer connections. "We're studying that 'other way' which many brain regions use."

Speaking today (3 July), Professor Abbott, whose specialty is computational modelling and mathematical analysis of neural networks, described his collaborative partnership with colleagues doing experimental work. His colleagues conduct research studies on similar but simpler brain structures in flies and electric fish, recording and collecting neuronal activity, measurements, data, and observations. He then translates the data into equations which help better reveal how these unstructured brain circuits work.

When conducting research, "we only observe a piece of a system," he explained. Developing analytic techniques and computer simulation modelling "allows us to build a model of a whole system and put all the pieces together, to see how it all might work," he added. "We ask whether these facts all hang together into an understanding of what may actually be going on in the structure. Once we have a model, we can manipulate it in ways that might otherwise be difficult." This method helps determine which aspects of a brain circuit might be more crucial, and enables feedback to research colleagues to hone research and extract new data.

Testing, interpreting, and analysing in this collaborative research loop, Professor Abbott and colleagues found that randomness is crucial for healthy brain function. Some brain areas have a part that is wired in a completely unstructured way. It may be just one piece in the middle of a brain region, or more. "It's a challenge - how can you have a randomly wired system, and yet still use it for constructive purposes? It's a surprise when you think of nervous systems being highly evolved and connected in very specific ways," he reflected. But in these randomly wired areas, "one still gets reliable behaviours, consistent across individual animals."

How do we make sense of the world and produce appropriate responses on the basis of random circuitry? "You have to interpret what look like random events in your brain, and associate them with things in the outside world," Professor Abbott explained. "These circuits have mechanisms for doing that. Part of the model is revealing the mechanisms that make sense of these random neural activity patterns."

How does this occur? Random circuits are not useful until one's brain learns to interpret and associate them with stimuli in the outside world to make sense. In a learning system, one doesn't want to have bias for a particular way of learning or behaving. One doesn't want all similar animals to learn the same way. Randomly wired circuits provide flexibility, so different animals (or humans) can come up with different, often flexible solutions. Nevertheless, different animals that have these random connections can end up being consistent with each other, in that and other behaviours.

Professor Abbott believes that continuing research in this area is uncovering how the brain uses both random and highly-structured circuits. He noted that these findings, in a human context, show that having unique and highly flexible representations of the world is not only healthy, but crucial for one's state of mind. "Reality inside our heads is just a bunch of neurons firing. We constantly interpret these patterns of neural activity and can endow them with deep personal meaning. This process is mysterious. Studying simpler circuits that similarly allow random patterns of neural activity to gain meaning and acquire complex associations with behaviour gives us an opportunity to study this remarkable transformation in depth."

This research area "gives us a chance to see how that transformation may take place," he said. "As we continue to gather more data, computer modelling is a tool allowing us to ask how these systems work and gain further insights."

END

Abstract Reference: Making sense of randomness
Plenary lecture: PL03

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NOTES TO EDITORS

The 10th FENS Forum of Neuroscience, the largest basic neuroscience meeting in Europe, organised by FENS and hosted by the Danish Society for Neuroscience will attract an estimated 6000 international delegates. FENS mission is to advance research and education in neuroscience within and outside Europe, to facilitate interaction and coordination between its members. FENS represents 43 national and single discipline neuroscience societies with about 24,000 member scientists from 33 European countries. http://www.fens.org/

Further Reading

The Neuronal Architecture of the Mushroom Body Provides a Logic for Associative Learning. Aso Y, Hattori D, Yu Y, Johnston RM, Iyer N, Ngo TB, Dionne H, Abbott LF, Axel R, Tanimoto H and Rubin G, *eLife* (2014) 3:e04577.

A Temporal Basis for Predicting the Sensory Consequences of Motor Commands in an Electric Fish. Kennedy A, Wayne G, Kaifosh P, Alvina K, Abbott LF and Sawtell LB *Nature Neuroscience (*2014) 17:416-424.