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Background on the award of the 2013 Paul Ehrlich and Ludwig Darmstaedter Prize for Young Researchers to Dr. James F.A. Poulet

Brain research
From sensory perception to behavior

Sight, hearing, touch, smell and taste: these five senses allow us to perceive the world around us so that we can respond. We reach for something we see. We follow an intriguing sound, flee from acrid smoke, spit out something inedible, and feel our way along in the dark. In each case, the way the brain processes sensory information leads to a precise motor response.

This activity is managed at the level of the nerve cells, synapses and neuronal networks in the cortex of the brain, and it leads to some interesting questions that are almost philosophical. How does the brain distinguish between external sensory perceptions and stimulations that arise internally? Did I just call out or did someone else?

These are the questions that Dr. James Poulet from the Max Delbrück Center for Molecular Medicine Berlin-Buch and the cluster of excellence NeuroCure have been studying for more than ten years. Poulet is the winner of this year's Paul Ehrlich and Ludwig Darmstaedter Prize for Young Researchers. The young British scientist has received the award because, as stated by the Scientific Council of the Paul Ehrlich Foundation, "His research furthers our understanding of the neuronal basis of behavior."

The young neurobiologist focuses on voluntary behavior that requires some sort of decision-making process rather than stereotypical reflexes. Taking your hand off a hot surface is a reflex, while responding to a touch is a voluntary reaction. "We want to know how neuronal activities alter behavior," Poulet explains. "We are interested in the causal connection

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between sensory perception, the activity of neurons and the motor response that results from them." After starting with crickets, Poulet has now turned to mice. He is primarily interested in brain regions called the primary somatosensory and motor cortex. Here sensory perceptions are translated into behavioral responses.

Poulet has now trained the mice to stretch out a forepaw to probe the nearby environment. New optical and electrophysiological techniques are giving Dr. Poulet a look directly into the brains of alert, active mice, allowing him to record and manipulate the activity of specific neurons. "These processes underlie healthy behavior and are disrupted during certain diseases," Poulet says. "If we can determine which neuronal signals underlie sensory perception and how these signals are linked to an appropriate behavioral response, it may give us a key to understanding both healthy and defective activity. Before we can know what is pathological, we should know what is normal."

Why can't we tickle ourselves?

One of James Poulet's early interests was to study how the brain discriminates between self-generated and external sensory perceptions. Am I touching my own hand or am I being touched? If the distance increases between me and another person, is it because I am moving away or because the other person is? The brain has to discriminate between these situations because they evoke different behaviors. It manages this task using an internal feedback mechanism that has additional effects: it ensures that we don't damage our ears when we shout and makes us unable to tickle ourselves. Rather than causing us to laugh ourselves nearly to death, self-tickling barely evokes a weak smile. This intelligent feedback process is known as "corollary discharge," and Poulet's investigations of it began in the singing cricket.
On warm summer nights, male crickets attract females by rhythmically rubbing its forewings together at a level that exceeds 100 decibels. That level of noise can be compared to the sound of a chainsaw, the thundering of disco music or the din of a pneumatic drill. "We wondered why male crickets don't go deaf from the noise," explains Poulet. "How do they shut it out?" The young prizewinner demonstrated that as male crickets begin to chirp, they "turn down" or inhibit very specific neurons responsible for hearing; when they stop they remove the inhibition. This "on" and "off" switch protects crickets against deafness – but they can still hear the approach of an enemy. That's crucial because their loud mating call not only attracts interested females but broadcasts a cricket's location to predators and rivals. Poulet and his co-workers identified a precise neuron that tunes down the hearing system – the so-called "corollary discharge neuron." Other organisms have these neurons as well, but virtually nothing is known about them.

Poulet and his co-workers also investigated how females react to the chirping. Here the question was whether they approach males as a reflex or whether it is a reaction to complex acoustic recognition in the females' brain? Poulet showed that the females display an

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approach movement in response to individual sounds that resembles a reflex rather than a complex behavioral response. More support for this comes from the fact that once the approach process has been triggered by the right song, females react to any acoustic stimulus. At that point only the sound is important; it doesn't even have to be the right one.

What's the difference between dozing and being wide awake?

James Poulet is also interested in what is generally known as brain states. The concept can easily be illustrated by an example. Someone is sitting dozing in the sun with his eyes closed, thinking of nothing in particular. Suddenly, he is startled awake by some internal or external signal. It may be an unusual sound, an unexpected breeze, or the recollection of a missed appointment. From one second to the next, the person who was dozing is wide awake. "We were wondering what happens in the brain in such a situation," Poulet says. "How does one brain state differ from the other?" In 1929 Hans Berger, the inventor of the EEG, first showed that different brain states exist in the awake human brain. EEG measures brainwaves, and when you are sitting still with your eyes closed, they are different than when your eyes are open and you are looking around. Poulet found something similar in mice in a state of quiet wakefulness, compared to mice that are moving their whiskers. In the quiet mice, neurons are excited in a rhythmic and orderly pattern, whereas their excitation is much more desynchronized in actively moving, "whisking" mice. This apparently gives them greater flexibility to react to the tasks at hand. "We know that brain states are part of the brain's normal functions," says Poulet. "Our aim is to discover how they come about and the role they play in regulating sensory perception and motor behaviour."

Further information

You can obtain the full resume, selected publications, the list of publications, and a photograph of the prizewinner from the Press Office of the Paul Ehrlich Foundation (c/o Dr. Hildegard Kaulen, phone: +49 06122/52718, email: Paul-Ehrlich-Stiftung@pvw.uni-frankfurt.de) and at www.paul-ehrlich-stiftung.de.