Research shows what happens in the sensory cortex when learning and recognising patterns

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A study by scientists at the University of Sussex is challenging the common understanding of how mammalian brains work.

The research, published in *Current Biology*, suggests that neurons in the sensory cortex don't just detect sensory information, but could actually decipher meaning and regulate bodily responses too.

The findings could have significant implications for understanding how perceptual learning works, or for how we interpret brain activity in the context of brain-machine interfaces, such as prostheses.

Professor of Neuroscience Miguel Maravall and his team were investigating the idea of 'sequence learning', using mice to understand what might happen in our brains when we learn a new song or a passage of speech.

Dr. Maravall explained: "In those conditions, what allows us to learn and recognise the song isn't just the single notes—it's their order, rhythm or pattern."

The researchers trained mice to recognise a sequence delivered as a sensation to the animal's whiskers which, to us, would feel like a pattern of vibrations through our fingertips. Mice would then report when they felt the learned sequence by licking for a reward.

Dr. Maravall said: "The cerebral cortex is the part of the mammalian brain where we make sense of new objects and relate them to actions and memories.

"We reasoned that, somewhere in the sensory part of the mouse's cerebral cortex, there would be a group of neurons that processed these sequences of vibrations. There would perhaps then be another group of neurons elsewhere that prompted the animal to respond whenever the target sequence was presented. This would be the basis for the animal reporting the sequence.

"However, we found something far more intriguing. Even in the most sensory parts of the cortex, we observed neurons that directly linked the learnt sequence to the animals' motor response. Some neurons even responded to whether the animal was getting the expected reward or not."

The findings suggest that the sensory cortex is not just sensory, as previously thought. Instead of responding only to stimuli around us, Dr. Maravall's study suggests that the sensory neurons are also involved in processing the meaning of the stimuli, and planning the subsequent behavioural responses.

This means that learning to recognise a specific pattern or sequence and process the ensuing actions and outcomes, whether that be a new song or a speech, involves neurons across the whole cortex. This fundamentally challenges basic ideas about how our brains work.

He explained: "We can compare this research with situations where we hear a song on the radio that we've heard many times before. Within just a few notes, we might decide to turn up the volume or switch the radio off.

"The textbooks would say that the first thing to happen in the brain is that the neurons in the sensory parts process the song and recognise it. Then this information gets passed on to higher decision-making centres. They then make a decision to choose either the action of turning the volume knob or hitting the power button. This then gets sent to the motor command centres, and so on.

"Our findings challenge that process. Instead, we've seen that all kinds of information makes its way to the sensory cortex and that neurons there are even able to predict the animal's response, and report its consequences—almost as if the normal decision making process I've just

explained is bypassed.

"What's exciting is that we're seeing similar results coming out of multiple labs. Neurons in the sensory cortex are doing so much more than we first thought. An animal does not, it seems, sense the world separately from what it needs to feel in order to guide behaviour.

"If sensations are tied into the task itself, this has implications for how we think about how the cortex is organised and how this might be affected by disease."

Similar results have also been reported in the same brain region within humans, although not published in a formal peer-reviewed journal yet. Such research is rare due to the invasive recording techniques but the similarities in the results are promising for the Sussex team, showing that mice are a valid model for investigating this particular property of the brain.

Moving forward, Dr. Maravall and his team will now be looking at how these non-sensory neurons are wired and connected to the rest of the brain—and if they're the ones which are key to driving a bodily response.

More information: Sequence learning induces selectivity to multiple task parameters in mouse somatosensory cortex, *Current Biology* (2020). DOI: 10.1016/j.cub.2020.10.059

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