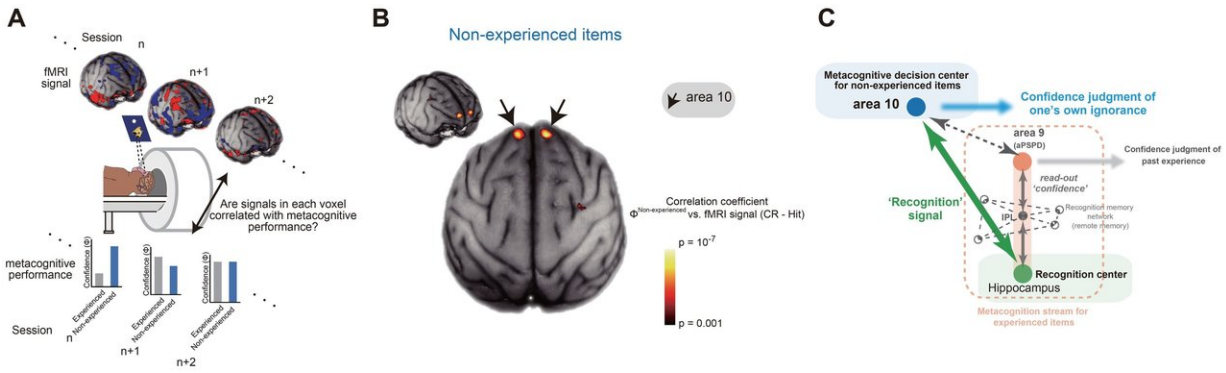
Cognitive neuroscience—the awareness of ignorance

January 26 2018



Metacognitive judgments of non-experienced events are processed in the frontopolar cortex of the brain, whereas metacognition of experienced events is associated with the dorsal prefrontal cortex, as reported in a study on non-human primates just published in *Neuron*.

To establish that a non-experienced event was, indeed, not previously experienced requires a more comprehensive and introspective memory search. Thus, involvement of highly intellectual cognitive processes is expected, of which neuronal substrate should be different from that of being confident about experienced events.

To shed light on the area of the brain involved in the evaluation of

experienced and non-experienced events, Yasushi Miyashita and colleagues at Juntendo University Graduate School of Medicine and the University of Tokyo School of Medicine combined a whole-brain neuronal substrate search via functional magnetic resonance imaging (fMRI) with causal behavioral tests by reversible silencing of the localized brain areas.

Monkeys were presented with a metacognition task composed of a memory and a bet stage. After exposure to a set of images, the monkeys had to indicate whether or not an image was part of the set, and successively make a confidence judgment about their decision by wagering. The researchers then calculated a correlation coefficient between the metacognitive performance and the fMRI activity recorded in each voxel, finding that only the fMRI activity in the bilateral frontopolar cortex (dorsal area 10) predicts metacognitive performance for non-experienced events, whereas the activity in the dorsal prefrontal cortex (area 9) is predictive of metacognitive performance for experienced events. Area 10 and area 9 show a strong intrinsic functional connectivity, thus seeming to work cooperatively to enable metacognitive judgments.

In order to establish a direct causal link between the neuronal activity in area 10 and metacognitive performance, Miyashita and colleagues injected the area with muscimol that suppresses neuronal activities specifically within a few millimeter from the injected point. As a control, a saline solution was also injected. The result of the muscimol injection was an impairment in confidence judgment for non-experienced events, but not for experienced events. Notably, the ability to identify novel events by distinguishing from experienced events was not affected by inactivation of area 10.

The authors believe that the observations provide a general framework to explain the function of the frontopolar cortex, an evolutionary novel

brain area developed only in humans and monkeys. "Area 10 possibly contributes to abstraction of novel concepts with respect to one's own goal, or metacognitive reasoning to deal with unfamiliar situations. Our findings demonstrating the causal impairment of metacognition for non-experienced items by inactivation of area 10 provide direct evidence with this idea" comment Miyashita and colleagues.

Functional magnetic resonance imaging (fMRI) measures brain activity by detecting changes associated with blood flow and metabolization.

fMRI extends MRI for visualization of body tissues with magnetization by monitoring neuronal activity harnessing the differences between the magnetic properties of arterial (oxygen-rich) and venous (oxygen-poor) blood, as when neurons are activated the blood flow in the region increases, with oxygen-rich blood replacing oxygen-poor blood.

Metacognition is the ability to think about thinking. With metacognition, people can evaluate their own cognitive processes introspectively and feel confident about their decisions. The monkeys performed a metacognition task that included a memory stage and a bet stage. The animals were presented with a series of images and then performed a recognition test in which they had to decide whether a certain image had been previously seen or not. Afterward, the monkeys made a self-confidence judgment regarding their previous decision, assessing through a wager how likely their decision was to be right. A correct answer in the memory stage combined with a high bet resulted in a high reward, whereas a wrong decision and a high bet led to no reward. Low bet was always associated with a low but sure reward.

The present study causally reveals that the frontopolar cortex (dorsal area 10) serves as the neural substrate of metacognition of non-experienced events. By contrast, the dorsal prefrontal cortex (area 9) contributes to metacognition of experienced events.

More information: Reversible silencing of the frontopolar cortex selectively impairs metacognitive judgment on non-experience in primates. *Neuron* DOI: doi.org/10.1016/j.neuron.2017.12.040

Provided by Juntendo University