

Juntendo University research: Cognitive neuroscience: the awareness of ignorance

(Tokyo, 26 January 2018) **Metacognitive judgments on non-experienced events are processed in the frontopolar cortex of the brain, whereas metacognition on 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 experienced before 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 whole-brain search of the neuronal substrate by 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 being exposed 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 they seem 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.

Background

fMRI

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.

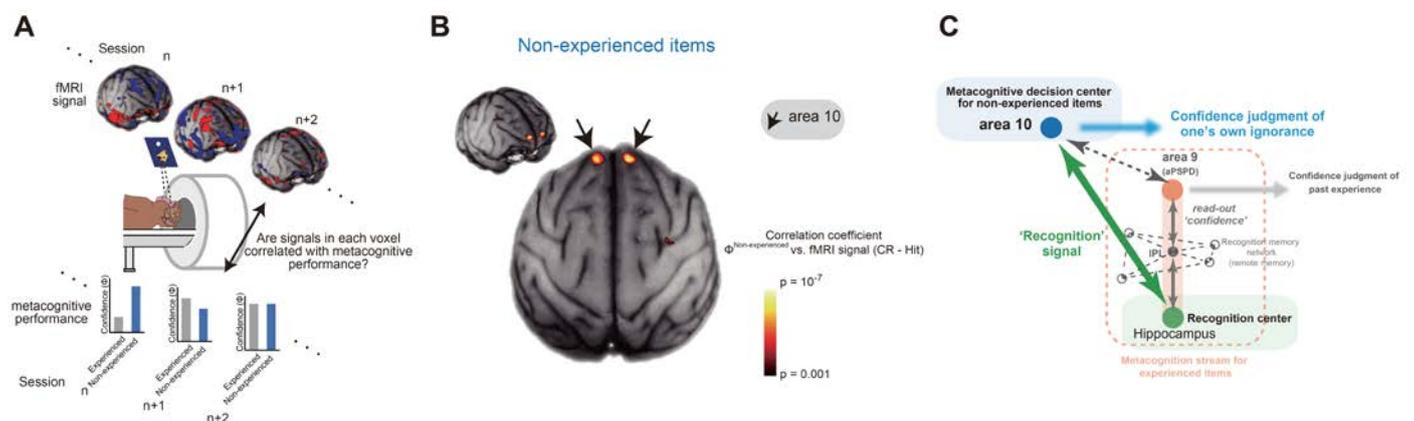
Details of the behavioral test

Metacognition is the ability on “cognition about cognition.” Owing to metacognition, we can evaluate our own cognitive process introspectively and feel confident about our own decision. 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. Afterwards, 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.

Implications of the current study

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.

Suggested image:



Reference:

Kentaro Miyamoto,^{1,2} Rieko Setsue,^{1,2} Takahiro Osada,^{1,2} Yasushi Miyashita^{1,2,3,*}. Reversible silencing of the frontopolar cortex selectively impairs metacognitive judgment on non-experience in primates. *Neuron*

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About Juntendo University

Mission Statement

The mission of Juntendo University is to strive for advances in society through education, research, and healthcare, guided by the motto “Jin – I exist as you exist” and the principle of “Fudan Zenshin - Continuously Moving Forward”. The spirit of “Jin”, which is the ideal of all those who gather at Juntendo University, entails being kind and considerate of others. The principle of “Fudan Zenshin” conveys the belief of the founders that education and research activities will only flourish in an environment of free competition. Our academic environment enables us to educate outstanding students to become healthcare professionals patients can believe in, scientists capable of innovative discoveries and inventions, and global citizens ready to serve society.

About Juntendo

Juntendo was originally founded in 1838 as a Dutch School of Medicine at a time when Western medical education was not yet embedded as a normal part of Japanese society. With the creation of Juntendo, the founders hoped to create a place where people could come together with the shared goal of helping society through the powers of medical education and practices. Their aspirations led to the establishment of Juntendo Hospital, the first private hospital in Japan. Through the years the institution’s experience and perspective as an institution of higher education and a place of clinical practice has enabled Juntendo University to play an integral role in the shaping of Japanese medical education and practices. Along the way the focus of the institution has also expanded, now consisting of four undergraduate programs and three graduate programs, the university specializes in the fields of health and sports science and nursing health care and sciences, as well as medicine. Today, Juntendo University continues to pursue innovative approaches to international level education and research with the goal of applying the results to society.