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# Attention and awareness uncoupled in brain imaging experiments

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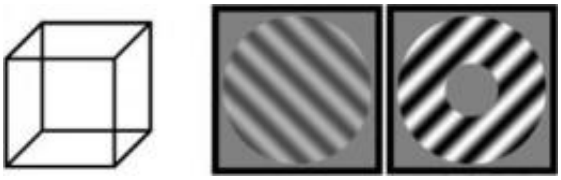


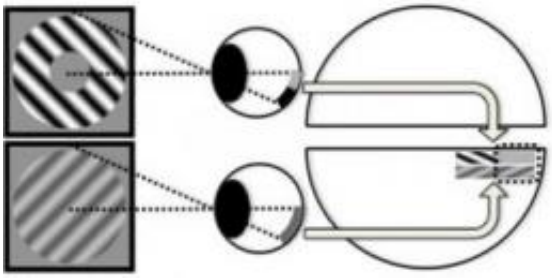
This is bi-stable visual stimuli used for awareness studies. Left diagram shows a classical example, the Necker cube, where the surface depth perception switches over time. On the right, a binocular rivalry stimulus is shown. By putting one grating in one eye and the other grating in the other eye, our percept starts to switch between the two gratings. Interestingly, as in our main stimuli, the unpatterned donut region also takes over the left grating when the right stimulus is perceived. They are ideal and widely used tools to investigate the neural correlate of visual awareness because our percept switches while the physical stimulus remains constant. Credit: MPI for Biological Cybernetics

In everyday life, attention and awareness appear tightly interwoven. Attending to the scissors on the right side of your desk, you become aware of their attributes, for example the red handles. Vice versa, the red handles could attract your attention to the scissors. However, a number of behavioural observations have recently led scientists to postulate that attention and awareness are fundamentally different processes and not necessarily connected.

In the study now published in the journal *Science*, scientists of the Max

Planck Institute for Biological Cybernetics in cooperation with Japanese colleagues provide the first experimental evidence that the primary visual cortex, the entrance stage to cortical visual processing, is modulated only by attention and not by awareness. This finding supports the hypothesis that attention and awareness differentially affect nerve cells.

Functional magnetic resonance imaging measures the neural activity of the brain based on the blood oxygen level dependent (BOLD) signal. Masataka Watanabe, a visiting scholar from University of Tokyo, and Yusuke Murayama in the department of Nikos Logothetis at the Max Planck Institute for Biological Cybernetics in Tübingen, Germany in cooperation with Kang Cheng, Keiji Tanaka and others of RIKEN Brain Science Institute had a closer look at the BOLD signal from the primary visual cortex. "We knew from previous experiments that visual awareness can occur without attention, and attention without awareness," says Masataka Watanabe. "But it was a real challenge to design experiments that can reliably record BOLD activity while reproducing the rather unnatural two laboratory conditions."



Measuring BOLD activity exclusively from the target region. Low-level visual areas such as the primary visual cortex shows retinotopy, where adjacent points in the visual field correspond to adjacent points in the brain. Functional magnetic resonance imaging has high enough spatial resolution to take advantage of this property and measure BOLD signal from regions of the primary visual cortex which corresponds to the “unpatterned inner whole of the donut” in the right-eye

stimulus. This made it possible for us to extract BOLD signal arising exclusively from the physically constant target visual stimulus (a part of the left grating which matches the “inner whole of the donut”), while the target became perceptually visible or invisible depending on the contextual configuration. Credit: MPI for Biological Cybernetics

The scientists managed this by experiments with participants in a two-by-two factorial design: The visual target "visible" versus "invisible" and attention "to" versus "away" from the target. Cleverly designed composite images shown at high frequency intervals to one eye allowed a target presented in the same or the other eye to be either visible or invisible, respectively, whether or not the subject directed their attention to it. "It was important not to depend on the participant to report the visibility of the target," explains Masataka Watanabe, since the task of reporting would itself direct attention towards the target.

"The results of the experiments astonished even the scientists. "I, myself, was surprised by the finding, it shifted my mind a little," says Masataka Watanabe. Paying attention to the target almost doubled the BOLD activity in the visual cortex, while sheer visibility of the target had almost no effect. "Here the BOLD signal is not modulated by awareness," the scientist summarizes the results.

The outcome of these experiments may even hold implications for philosophy and psychology: So far, many scientists hold a holistic view about awareness being part of all other areas of the brain and being inseparably interwoven with other mental processes. That is because previous studies without independently controlling attention have shown robust awareness modulation in the BOLD signal of the primary visual cortex. According to the new results, these findings have to be put into question. But Masataka Watanabe cautions: "The experiment is one of a

kind, showing differences in modulation between awareness and attention in the primary visual cortex, hence supporting the idea that neural activity corresponding to attention and awareness are, if not more, partially dissociated. The results need to be followed up by other types of stimuli, measurement methods, species, etc., with independent manipulation of attention and awareness." In further experiments he wants to explore at exactly which level the hierarchical visual system starts to be modulated by awareness.

**More information:** Masataka Watanabe; Kang Cheng, Yusuke Murayama, Kenichi Ueno, Takeshi Asamizuya, Keiji Tanaka, Nikos Logothetis, Attention but not Awareness Modulates the BOLD Signal in Human V1 During Binocular Suppression, *Science*, Nov. 11 2011.

Provided by Max-Planck-Gesellschaft