

# Consciousness Does Not Reside Here

Psychology and functional brain imaging disentangle two closely related processes, attention and consciousness

BY CHRISTOF KOCH



**WHAT IS THE RELATION** between selective attention and consciousness? When you strain to listen to the distant baying of coyotes over the sound of a campsite conversation, you do so by attending to the sound and becoming conscious of their howls. When you attend to your sparring opponent out of the corner of your eye, you become hyperaware of his smallest gestures. Because of the seemingly intimate relation between attention and consciousness, most scholars conflate the two processes.

Indeed, when I came out of the closet to give public talks on the mind-body problem in the early 1990s (at that time, it wouldn't do for a young professor in biology or engineering who had not even yet attained the holy state of tenure to talk about consciousness: it was considered too fringy), some of my colleagues insisted that I replace the incendiary "consciousness" with the more neutral "attention" because the two concepts could not be distinguished and were probably the same thing anyway. Two decades later a number of experiments prove that the two are not the same.

Stage magicians are superb at manipulating the audience's attention. By misdirecting your gaze using their hands or a beautiful, bikini-clad assistant, you look but don't see, inverting Yogi Berra's famous witticism, "You can observe a lot just by watching." Scientists can do the same, sans the sexy woman. I described a psychophysical technique called continuous flash suppression in an earlier column [see "Rendering the Visible Invisible," October/November 2008], in which a faint image in one eye—say, an angry face in the left eye—becomes invisible by flashing a series of colorful overlaid rectangles into the other eye. As long as you



keep both eyes open, you see only the flashed pictures. Attention is drawn to the rapidly changing images, effectively camouflaging the angry face. As soon as you wink with the right eye, however, you see the face. This technique has been used to great effect both to hide things from consciousness—such as a naked man or woman—and to demonstrate that the brain will still attend to them.

A Japanese-German collaboration has moved such an experiment into the confines of a magnetic scanner to record the brain's response to unseen stimuli. Rather than using erotic pictures, they projected a low-contrast grating that was drifting horizontally into one eye [see *box on opposite page*]. It was surrounded by a scintillating ring in the same or in the opposite eye. In the latter case, the central

stimulus became perceptually invisible. It disappeared. This experiment used what is known in the lingo as a  $2 \times 2$  design. The scientists manipulated the visibility of the moving grating (two conditions); they also manipulated whether or not subjects attended to the grating (two conditions). They achieved the second condition by asking them to monitor a series of single letters that appeared on the ring and to report the presence of a particular letter. On the other half of the trials, subjects were told to ignore these letters. In total, four conditions were tested.

Note that the layout on the monitor always contains the same elements with the ring being projected into the same eye as the moving grating or the opposite eye, et cetera. The key difference was in the minds of the volunteers whose brains

CHRISTOF KOCH (Koch): JOHN RENSTEN/Getty Images (this page); FROM "ATTENTION BUT NOT AWARENESS MODULATES THE BOLD SIGNAL IN THE HUMAN V1 DURING BINOCULAR SUPPRESSION," BY MASATAKA WATANABE ET AL., IN SCIENCE, VOL. 334; NOVEMBER 11, 2011. REPRINTED WITH PERMISSION FROM AAAS (opposite page)

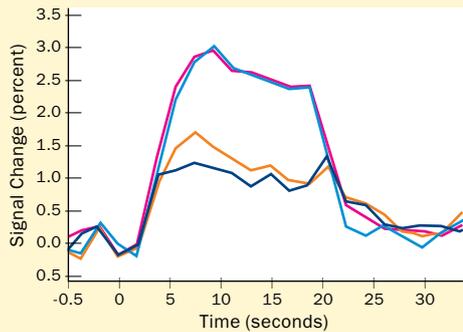
( Consciousness and attention are not the same,  
and the **brain responds differently** to them. )

## Separating Attention from Consciousness

In an experiment (*below*), a low-contrast grating that was drifting horizontally was projected into one eye; it was surrounded by a scintillating ring in the same or opposite eye. In the latter case, the central stimulus—the grating—became invisible to the subject’s conscious awareness. Subjects were asked to attend to either the grating or a letter superimposed on the ring. By testing four different conditions, scientists could manipulate whether the volunteer consciously saw the grating.

Whether or not the volunteer was consciously aware of the grating (*below*), the brain responded to it, as activity in the primary visual cortex revealed by functional MRI shows. But if the subject attended to letters rather than grating, the response was much reduced. The plots indicate the time course of the signal for the four different perceptual conditions: grating visible (*magenta*) or invisible (*cyan*) and attended (*upper two curves*) or grating visible (*orange*) or invisible (*dark blue*) and not attended (*lower two curves*). —C.K.

		Manipulating consciousness	
		Visible grating	Invisible grating
Manipulating attention	Attend to grating		
	Attend to letters		



were scanned—whether or not they consciously saw the grating (which they had to report) and whether or not they attended to it.

The cognitive neuroscientists measured the brain’s functional MRI response in the primary visual cortex (or V1) in the brain’s posterior. Roughly the area of a credit card, this part of the brain receives visual input from the eye. It is the first of 30 or more regions in the cortex that deal with visuomotor behaviors and visual perception.

The data from the seven participants were unambiguous. Paying attention to the target consistently and strongly increased the fMRI activity, regardless of whether the subject saw the target or not. This result was expected because many previous studies had shown that attend-

ing to a signal reinforces its representation in the cortex. Much more intriguing, though, was that whether or not the stimulus was consciously perceived made no difference to signal strength [see *box above*]. Visibility didn’t matter to V1; what did was whether or not selective visual attention focused on the grating. Indeed, the experimentalists could not decode from the signal whether or not the subject saw the stimulus.

I am very pleased by their finding be-

cause it is fully in line with the hypothesis that Nobel laureate Francis Crick and I advanced in 1995. Writing in *Nature*, we had argued that neurons in V1 do not directly contribute to visual consciousness. Our speculation was based on the absence of a direct connection between cells in V1 and their partners in the frontal lobe in macaques. The fMRI experiment described here provided evidence for our conjecture. Whether or not our connectational argument is valid remains open, of course.

It appears that the habitat of consciousness is not the cortical region at the bottom of the extended hierarchy of cortical areas dedicated to vision. Consciousness is restricted to higher regions, possibly those that are engaged in a reciprocal, two-way communication with the prefrontal cortex, the seat of planning.

The history of any scientific concept—energy, atom, gene, cancer, memory—is one of increased differentiation and sophistication until it can be explained in a quantitative and mechanistic manner at a lower, more elemental level. These and related experiments put paid to the notion that consciousness and attention are the same. They are not, and the brain responds differently to them. This distinction clears the decks for a concerted, neurobiological attack on the core problem of identifying the necessary causes of consciousness in the brain. **M**

CHRISTOF KOCH is Lois and Victor Troendle Professor of Cognitive and Behavioral Biology at the California Institute of Technology and chief scientific officer at the Allen Institute for Brain Science in Seattle. He serves on *Scientific American Mind*’s board of advisers.

### (Further Reading)

- ◆ **Are We Aware of Neural Activity in Primary Visual Cortex?** Francis Crick and Christof Koch in *Nature*, Vol. 375, pages 121–123; May 11, 1995.
- ◆ **Attention but Not Awareness Modulates the BOLD Signal in the Human V1 during Binocular Suppression.** Masataka Watanabe, Kang Cheng, Yusuke Murayama, Kenichi Ueno, Takeshi Asamizuya, Keiji Tanaka and Nikos Logothetis in *Science*, Vol. 334, pages 829–831; November 11, 2011.