Probing the Unconscious Mind

Cognitive psychology is mapping the capabilities we are unaware we possess

BY CHRISTOF KOCH

SIGMUND FREUD popularized the idea of the unconscious, a sector of the mind that harbors thoughts and memories actively removed from conscious deliberation. Because this aspect of mind is, by definition, not accessible to introspection, it has proved difficult to investigate. Today the domain of the unconscious—described more generally in the realm of cognitive neuroscience as any processing that does not give rise to conscious awareness—is routinely studied in hundreds of laboratories using objective psychophysical techniques amenable to statistical analysis. Let me tell you about two experiments that reveal some of the capabilities of the unconscious mind. Both depend on "masking," as it is called in the jargon, or hiding things from view. Subjects look but don't see.

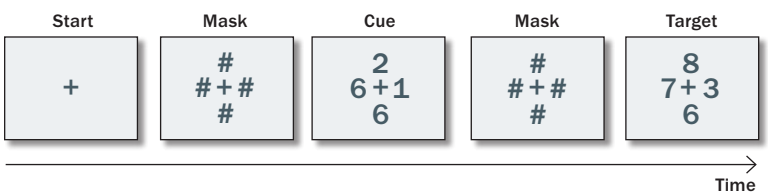
Unconscious Arithmetic

The first experiment is a collaboration among Filip Van Opstal of Ghent University in Belgium, Floris P. de Lange of Radboud University Nijmegen in the Netherlands and Stanislas Dehaene of the Collège de France in Paris. Dehaene, director of the INSERM-CEA Cognitive Neuroimaging Unit, is best known for his investigations of the brain mechanisms underlying counting and numbers. Here he explored the extent to which a simple sum or an average can be computed outside the pale of consciousness. Adding 7, 3, 5 and 8 is widely assumed to be a quintessential serial process that requires consciousness. Van Opstal and his colleagues proved the opposite in an indirect but clever and powerful way.

A quartet of single-digit Arabic numbers (1 through 9, excluding the numeral 5) are projected onto a screen. Volunteers had to indicate as quickly as possible whether or not the average of the four projected numbers exceeded 5. Every trial was preceded by a hidden cue that could be valid or invalid. The cue consisted of a very brief flash of another set of four numbers whose average was either smaller or larger than 5 [*see illustration below*]. These were preceded and followed by hash marks at the location of the flashed numbers. The marks effectively masked the cue so that no subject ever consciously saw this quartet. Forcing them to guess whether the average of the four hidden numbers was less than or greater than 5 did not work either: they were at chance.

Yet the cue still influenced the subject's reaction to the main response. If the implicit cue was valid, the response to the target was consistently faster than if the cue was invalid. In the illustration, the mean of the four invisible cues (3.75) is less than 5, whereas the average of the visible target numbers is greater than 5. Resolving this conflict demands additional processing time (about 1/40 of a second). That is, the cue triggers neural activity representing the assertion "less than 5," which interferes with the rapid establishment of a coalition of neurons represent-

In the experiment, subjects saw four numbers for 600 milliseconds and had to judge quickly whether their average exceeded 5. Masks with hash marks ensured that the four cued numbers were not consciously seen. The unconscious was nonetheless able to estimate the average.



CHRISTOF KOCH (*Koch*); YULIA_M Getty Images (*woman in clothes hanger*)

The ability to rapidly integrate **disparate elements** in a scene and place them in context is a hallmark of consciousness.

ing "greater than 5." That invisible and undetectable cues influence behavior implies that the unconscious can somehow estimate the average of four single digits. It is unlikely that it does so following the precise, algebraic rules children learn in grade school. Instead it may rely on heuristics: for example, for each number larger than 5, increase the probability of pushing the greater than 5 button.

This is just the latest in a flurry of experiments demonstrating so-called ensemble coding, the ability of the mind to guesstimate the dominant emotional expression of a crowd of faces or the approximate size of a bunch of dots even though the individual faces or dots are not consciously perceived.

What's Wrong with this Picture?

Liad Mudrik and Dominique Lamy of Tel Aviv University and Assaf Breska and Leon Y. Deouell of the Hebrew University in Jerusalem set out to test the extent to which the unconscious can integrate all the information in any one picture into a unified and coherent visual experience. Giulio Tononi and I had proposed in the last Consciousness Redux column [September/October 2011] that the ability to rapidly integrate all the disparate elements within a scene and place them into context is one of the hallmarks of consciousness.

The Israeli researchers used "continuous flash suppression," a powerful masking technique, to render images invisible. A series of rapidly changing, randomly colored patterns was flashed into one eye while a photograph of a person carrying out some task was slowly faded into the other eye. For a few seconds, the picture is completely invisible, and the subject can see only the colored shapes. Because the images become progressively stronger, eventually they will break through, and the subject will see them. It is like Harry Potter's cloak of invisibility fading with time and revealing what is underneath.

The unconscious mind can tell if there is something amiss in these doctored images.

The fascinating aspect of the Mudrik study is that the time to become visible depends on the content of the image. Realistic scenes that depict a woman placing a pizza into an oven, a boy taking aim with a bow and arrow, or a basketball player dunking a ball into a hoop took 2.64 seconds to become visible, whereas unnatural scenes were masked for only 2.50 seconds, a small but significant difference. That is, the unconscious mind detected something incongruent about these pictures: a woman puts a chessboard into the oven, the cocked arrow is replaced by a tennis racket, and the basketball becomes a watermelon. The psychologists made sure that both congruent and incongruent images were truly invisible and could not be distinguished from one another when masked in this way. This discovery implies that the unconscious can recognize something is amiss in these images, that the object handled by the person in the image is not appropriate to the context.

How the mind recognizes that something is wrong is puzzling. Maybe because the vast and tangled neural networks of the cerebral cortex that encode images have learned that certain objects go together but others do not (akin to the software programs—bots—that Google and other search engines employ to trawl the Internet to list all images, sentences and Web pages so when you search for them they are readily accessible). Given the sheer infinite number of possible pairings of objects and context, is this solution likely to be done by the brain? Or maybe the masking techniques suppress visibility of the image but do not fully eliminate conscious access to them? Only more research will tell. In this way, we shall ultimately know the capabilities of the cognitive unconscious and the truly essential function that consciousness plays in our life. M

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(Further Reading)

- **Integration without Awareness: Expanding the Limits of Unconscious Processing.** Liad Mudrik, Assaf Breska, Dominique Lamy and Leon Y. Deouell in *Psychological Science,* Vol. 22, No. 6, pages 764–770; June 2011.
- **Rapid Parallel Semantic Processing of Numbers without Awareness.** Filip Van Opstal, Floris P. de Lange and Stanislas Dehaene in *Cognition,* Vol. 120, No. 1, pages 136–147; July 2011.

COURTESY OF LIAD MUDRIK *Tel Aviv University*