Subconscious Sight

People with "blindsight" can correctly deduce the visual features of objects **they cannot see.** Such visual intuition can even exceed what is possible with normal vision

By Susana Martinez-Conde

DB is a 67-year-old man whose view of the world is dark from the center of his gaze leftward. He has been blind to this left part of his visual scene since age 33, when he had surgery to remove an abnormal tangle of blood vessels at the back of his brain. Unfortunately, while taking out the tangle, surgeons destroyed an important center of visual processing called the primary visual cortex, or area V1, which relays information from the eyes to higher-level brain areas dedicated to sight.

DB lost just the right half of V1. Because the right part of the brain processes visual information from the left visual field (and vice versa), his doctors were not surprised that DB became blind to the left portion of his view. But they were astounded that although DB

CHRISTINA PEDRAZZINI SPL/*Photo Researchers, Inc.* (*blindfolded man*); GETTY IMAGES (*meadow*)

denied seeing anything to the left of center, he was nonetheless able to accurately "guess" many properties of targets, such as shape and specific location, presented in this perceptually dark field.

DB's ability to somehow intuit features of unseen objects and patterns is called blindsight. Researchers believe this strange phenomenon stems from the flow of information through neural pathways that bypass V1 but still convey a small amount of visual information to higher brain regions involved in sight. For unknown reasons, these secondary routes do not convey the feeling of sight.

Recent data suggest that the accuracy of a blindsight patient's guess about what something looks like, or where it is, can improve markedly with practice, hinting that such practice might improve blindsight patients' ability to detect objects in their everyday surroundings. And although an individual with blindsight cannot see in his or her blind field, a new study shows that DB, at least, has some object-detection abilities that surpass those of ordinary sighted people. This research also reveals that some awareness of unseen visual stimuli can accompany blindsight. DB's and others' cases of blindsight indicate that consciousness and visual perception can be separated in our brains.

Blind Beginnings

Neurological oddities typically emerge from studies of brain-damaged people, but experiments in animals offered the earliest hints of blindsight. Beginning in the 1930s and 1940s, neurobiologists who had surgically removed V1 in monkeys noticed that the animals appeared to retain some visual skills, such as the ability to detect contrast and to tell one object from another by the objects' shapes.

But few scientists believed that people could see without V1: the known human patients whose primary visual cortex had been destroyed were totally blind. Some exceptions to this rule included soldiers who had sustained injuries during World Wars I and II that abolished the function of V1. A few neurologists who treated these men claimed that some of them retained residual visual function. But at the time the scientific community did not take such observations seriously. Instead researchers concluded that humans and monkeys were different in this respect, despite the striking anatomical similarities in their visual pathways.

In 1973 neuroscientist Ernst Pöppel, then at the Massachusetts Institute of Technology, and his colleagues reported measuring eye movements in patients who had lost area V1. The patients said that they could not see visual targets, but their eye movements were biased toward them nonetheless, hinting that their visual system was obliquely informed of the targets.

But it was the work of University of Oxford psychologist Larry Weiskrantz and his colleagues, who first examined DB in the early 1970s, that shattered the skepticism about blindsight in people. Like Pöppel's patients, DB showed eye movements biased toward visual targets. In addition, however, Weiskrantz and his co-workers unmasked other visual skills with a technique borrowed from animal experiments: they forced

When the primary visual cortex, or area V1 (*light- and dark-green patches*), at the back of the brain is destroyed, so, too, is the conscious sensation of sight.

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FAST FACTS

Sensing the Unseen

1» The ability to subconsciously intuit the features of unseen objects and patterns in patients with injuries to the visual brain area known as V1 is called blindsight.

2» Researchers believe that the blindsight phenomenon stems from the flow of information through neural pathways that bypass the damaged visual region. For unknown reasons, these secondary conduits for visual information do not convey the feeling of sight.

3» Recent data suggest that blindsight patients' visual intuition can improve with practice and that the detection abilities of such patients can surpass those of ordinary sighted people.

Patients with "blindsight" can correctly guess the color or shape of an unseen object but cannot detect **complex trajectories**.

BETSIE VAN DER MEER *Getty Images*

DB to choose between defined options instead of just asking him what he saw. That is, Weiskrantz's team presented DB with a choice of, say, two possible colors or locations and asked him to guess which one applied to a visual target he claimed he could not see. DB's "guesswork" was correct much more often than would have been expected by chance—matching the findings in primates.

DB himself was astonished. Because he could not see the objects, he had thought that his guesses were completely random. In the wake of these experiments, Weiskrantz coined the term "blindsight," which appeared in a 1974 article in the journal *Lancet*.

Scientists then identified and examined other patients who displayed this curious ability. Although none of them so far has demonstrated detection skills as acute as those of DB, many of these patients can deduce the color or shape of an object in their blind field and predict whether it is moving or still; they can also guess the orientation of unseen lines or gratings, the timing of an object's appearance, and the expressions on unperceived faces at better-than-chance levels. On the other hand, these patients cannot intuit fine details in their blind fields. Nor can they detect complex movements.

Extraordinary Vision

Whatever a patient's ability to detect the unseen, practice can enhance it. In a 2006 study Weiskrantz, along with neuroscientists Ceri T. Trevethan and Arash Sahraie of the University of Aberdeen in Scotland and their colleagues, asked 12 patients with blindsight to repeatedly guess which of two stimuli—a flickering grating or a gray dot—had appeared in the middle of their blind field. After three months of daily practice, the patients increased the number of correct responses by up to 25 percent and could detect gratings of lower contrast than those they could detect before. They also generally reported being more consciously aware of the correct answer.

(The Author)

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The results suggest that these patients can learn to "see" in ways that could enhance their quality of life.

DB might not need much more practice, however, after having participated in numerous vision experiments over four decades. Indeed, in 2007, Weiskrantz, Trevethan and Sahraie showed that DB's blind-field sensitivity is actually better than what normal vision can achieve. The researchers showed DB a two-second-long stimulus called a Gabor patch [*see illustration below*] on a gray screen in one of two time spans. Because the patch was small and had very low contrast, even a person with normal vision would find it hard to perceive. Weiskrantz's team asked DB to indicate, with a button press, in which time interval he thought the pattern had appeared.

In two different experiments involving more than 150 distinct presentations of the stimulus, DB performed significantly better in his blind field than in his sighted field. He consistently identified the time span containing the stimulus 87 percent of the time in his blind field as opposed to only half of the time—a rate no better than chance—in his sighted field. By varying the stimulus contrast, the researchers also learned that DB could detect stimuli of significantly lower contrast in his blind field as compared with his sighted field. Ironically, DB found the tests on the sighted field hard work, whereas the blind-field tests seemed effortless: "No problem, I'm just guessing," he remarked.

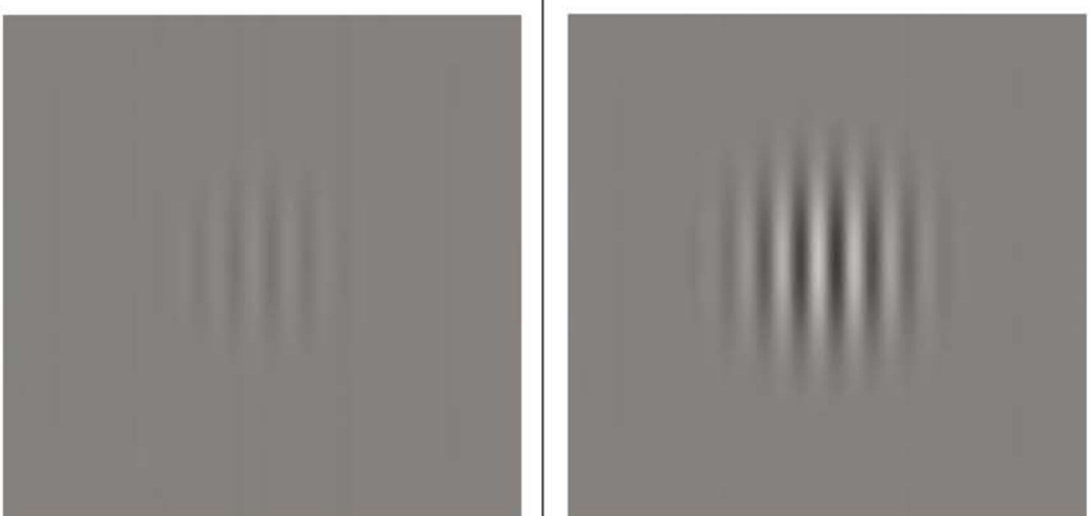
The researchers ruled out the possibility that DB might simply have abnormally poor vision in his sighted field. When they compared DB's performance in his sighted field with that of six age-matched participants who had normal vision, they found DB's sighted-field vision to be equal to that of the unimpaired subjects. Thus, DB's blind-field sensitivity is not superior merely to that of his own sighted field but also to that of normal vision.

Blindly Aware

Meanwhile DB reported no awareness of the Gabor patch when it was presented to his sighted field (confirming that he was essentially guessing about when it showed up). Nevertheless, DB had some subjective awareness of 80 percent of stimuli presented to the blind field. This awareness was nothing like vision, DB explained; he described it instead as "feeling as if a finger is pointing through the screen."

Interestingly, DB's awareness of the unseen pattern vanished during trials in which researchers randomly alternated its presentation to the blind or sighted field. DB reported being aware of the presence of the Gabor patch only during the trials in which the researchers first showed it repeatedly to the blind field and then switched to the sighted field for a second block of 30 trials. That is, DB's awareness of a stimulus seems to

The patient DB was often oddly aware of the unseen patterns placed in his blind field.



Gabor patches of two different contrast levels are shown at the right. Such patches are commonly used in tests of visual perception.

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Parsing the Unseen

People with blindsight cannot see anything in their blind field, and yet they may be vaguely aware of objects there and even proffer correct guesses about the objects' visual features. Such a peculiar skill is exclusive to patients with bona fide brain damage. The phenomenon shares similarities with common experiences such as navigating in dim light and gut feelings of danger, but these subconscious capacities differ from blindsight in important ways.

A soldier may display a type of "sixth sense" that warns him or her of danger; that skill is not the same thing as blindsight, however.

The ability to navigate in the dark—say, through the woods on a moonless night—without being able to see exactly what is underfoot also relies on an awareness of objects in a blind spot. But contrary to the situation in blindsight, researchers can account for the dim-light phenomenon with known properties of visual neurons. In the eye, a type of light-detecting neuron, or photoreceptor, called a rod can respond to very little light. There are no rods in the center of your vision, where you have the best perception of detail in daylight, so in darkness you are literally blind to the portion of your field of view on which you focus most during the day. People are not aware of this central blind spot when they are in the dark, because the brain fills it in with information from the surroundings. The use of peripheral vision (rather than central vision) to navigate in the darkness may partly explain why people think they are using their hunches to prevent themselves from bumping into branches.

The ability of some people to sense approaching danger probably involves yet another type of subconscious process. Although this skill might result from a dim awareness of unseen objects akin to blindsight, it more likely stems from expertise. Experts can use so-called implicit knowledge to make automatic analyses and, in such cases, are often unaware of how they came to their decision. For instance, an infantry soldier in a war zone may have a gut feeling that something is amiss. He might not be able to pinpoint the problem, however, because the thought process that led to the decision *"we must leave immediately"* was subconscious. Although it may seem as if that soldier has a "sixth sense," his skill is not related to blindsight but to his expert ability to automatically analyze complex information. For further reading on this topic, I recommend the book *Blink,* by Malcolm Gladwell. *—S.M.-C.*

depend on his ability to predict its appearance in the blind field—and thus on the expectation that he will *not* be able to actually see it.

The feeling of being aware of something is, of course, different from actually seeing it. Because DB was aware but unseeing, his damaged brain area, V1, may be essential only to the sensation of visual perception and not to subjective awareness. Thus, if you sustain damage to V1, you may be aware of much that you cannot see.

Still, not all studies of blindsight indicate that patients are aware of unseen visual stimuli. Tests of a blindsight patient known as GY showed that his talent for detecting a symbol was not accompanied by the ability to consciously predict (and bet on) his performance [see "Put Your Money Where Your Mind Is," by Kaspar Mossman; Scientific American Mind, April/May 2007].

DB is probably a particularly gifted patient. From all his experience, he may have developed an intuitive sense for when something is going to appear—and may have learned to trust his intuition. Thus, DB may represent the pinnacle of a phenomenon in which brain damage or inborn defects that lead to amnesia, dyslexia, blindness or myriad other difficulties can nonetheless leave behind surprising residual powers. Such revelations give new meaning to the legendary rejoinder of the blind comic-book superhero Daredevil: "Yeah, tell them you got beat by a blind man, too." M

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(Further Reading)

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- **Can Blindsight Be Superior to "Sighted-Sight"?** C. T. Trevethan, A. Sahraie and L. Weiskrantz in *Cognition,* Vol. 103, No. 3, pages 491–501; June 2007.
- Blindsight. Larry Weiskrantz: **www.scholarpedia.org/article/Blindsight**