

Half a World

Victims of a disorder called neglect just don't get the whole picture

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

A PATIENT NAMED SALLY recently suffered a stroke that damaged her right parietal lobe without affecting other parts of the brain. The left side of her body—controlled by the right hemisphere—was paralyzed. But she was mentally normal and continued to remain the talkative, intelligent woman that she was before the stroke.

Yet Sally's father observed other disturbing symptoms to which—oddly enough—Sally herself seemed oblivious. When she attempted to move around the room in her wheelchair, she would sometimes bump into objects on her left.

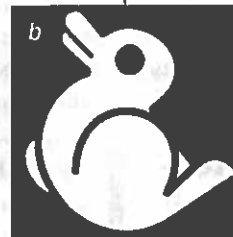
Further testing confirmed that Sally was largely indifferent to objects and events on her left, even though she was not blind to them; once her attention was drawn to them, she could see them. Her eyesight was normal; her problem was in *attending* to the left. For example, when she ate, she would consume only the food on the right (a), ignoring the left side of the plate. But if her attention was drawn to the food on the left, Sally could see it perfectly, recognize it and reach for it. Sally's deficits indicate that she suffers from hemineglect (or simply neglect), which can also occur in isolated form, unaccompanied by major paralysis.

Seeds of Neglect

How do such perturbations of perception arise? Neglect is, fundamentally, a disorder of attention. Although the hu-



man brain has 100 billion neurons, only a small subset of them can be active at any time creating meaningful patterns, and this limit results in an attentional bottleneck. That is why you can see either a duck or a rabbit in *b* but never both simultaneously. It also explains why when you are driving, you are not consciously aware of most things going on around you while you focus on the pedestrian in front of you. Seen in this light, the neurological syndrome of neglect is really a floridly exaggerated version of the kind of



neglect we all engage in to avoid sensory overload.

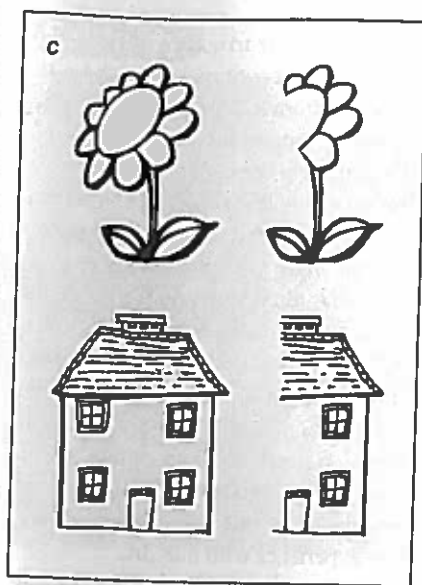
To understand neglect, we need to consider some anatomy. Visual input from the retina is sent along the optic nerve and diverges into two parallel pathways called the “old” and the “new,” reflecting when each evolved. The former, sometimes called the “where” pathway, projects into the parietal lobes and is involved in locating and orienting to things around you. The latter projects to the visual cortex, and from there two other pathways emerge called “what” and “how,” which project into the temporal and parietal lobes, respectively. The what pathway is involved in object recognition and identification, whereas the how pathway directs how to attend to and interact with objects. The how and where pathways converge

on the parietal cortex and are functionally linked—you must process both where a chair is and how to move to avoid bumping into it. Sally had damage to the how pathway in her right hemisphere, so she was ignoring everything on her left side.

Curiously, neglect is seen only with damage to the right brain. Why doesn't left damage result in neglect of the right half of the world? Marsel Mesulam of Harvard University proposed an ingenious explanation. The right hemisphere, which

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has more attentional resources and a preeminent role in spatial vision, can survey the entire visual scene, both right and left hemifields, simultaneously. The left parietal, in contrast, can attend to only the right side of the world. So when the left hemisphere is damaged, the right can compensate. If the right parietal is damaged, however, the left visual field is unattended; in other words, unilateral neglect occurs.

It is fairly easy to diagnose neglect. The patient will tend to look rightward constantly and will not spontaneously look left even if a person approaches from that direction. When tracking an object moving from right to left, she will “lose” the object halfway through its excursion—not following it leftward past her nose. She applies makeup only on the right side of her face. A male patient will shave only his right chin. Or brush only the teeth on the right.

You can also diagnose neglect with some simple tests. Have the subject copy or draw from memory a flower or other object, and she will draw only half of it (c). Strangely, this half-drawing effect is true even if she works with her eyes closed, implying that she is even neglecting the left half of the object that she

conjured in her head. (Our colleague Stuart Anstis has requested that if he ever develops neglect from stroke, we ensure his Botox series continues on both sides of his face!)

When asked to draw a clock, the patient draws only half of it. The entire circle is drawn—partly because this is an overlearned “ballistic” response that does not require focused attention. But she packs the 1 to 12 on the right half of the clock (d) or inserts only 1 to 6.

Ask her to bisect a horizontal line; her bisector is way off to the right because she is bisecting the right half of the line. Now you might think that if the horizontal line is moved entirely into her right (nonneglected) side, she would bisect it accurately. But she does not. Even if her plate of food is moved entirely into her nonneglected right visual field, she continues to eat the food only on the right side of the plate. In addition to neglecting the left side of her visual world, she neglects the left sides of objects even if they are entirely on her right.

There is no sharp line going down the center of the visual field separating the neglected left and the nonneglected right. We should think, instead, in terms of a gradient of neglect. This effect is different from what one sees when the right visual cortex—rather than right parietal lobe—is damaged. In this case, the result is a sharp boundary between the blind region on the left and the intact right region of the visual field. And of course, the subject cannot see objects on her left even if she is forced to “attend” to the blind region. She can no more see these items than she can see behind her head.

Annihilation of the Left

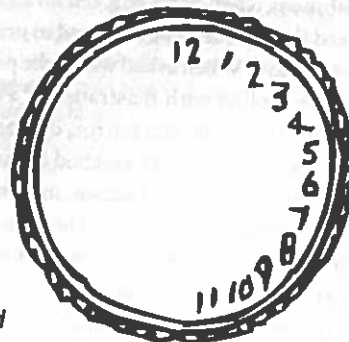
A curious aspect of neglect is that the patient is largely unaware of it. He neglects the neglect! At some level, he may be dimly aware that something is wrong, telling us he “needs glasses.”

Sally’s obliviousness to her neglect

suggests yet again that what she has is not merely a sensory deficit or blindness to visual input coming from her left nor even just a failure to attend to the left. We should think of it instead as an existential annihilation of the left side of the universe. For her, “left” has simply ceased to exist. Maybe she even has problems with abstract ideas or words that require the use of the word “left,” but we have not tested this idea.

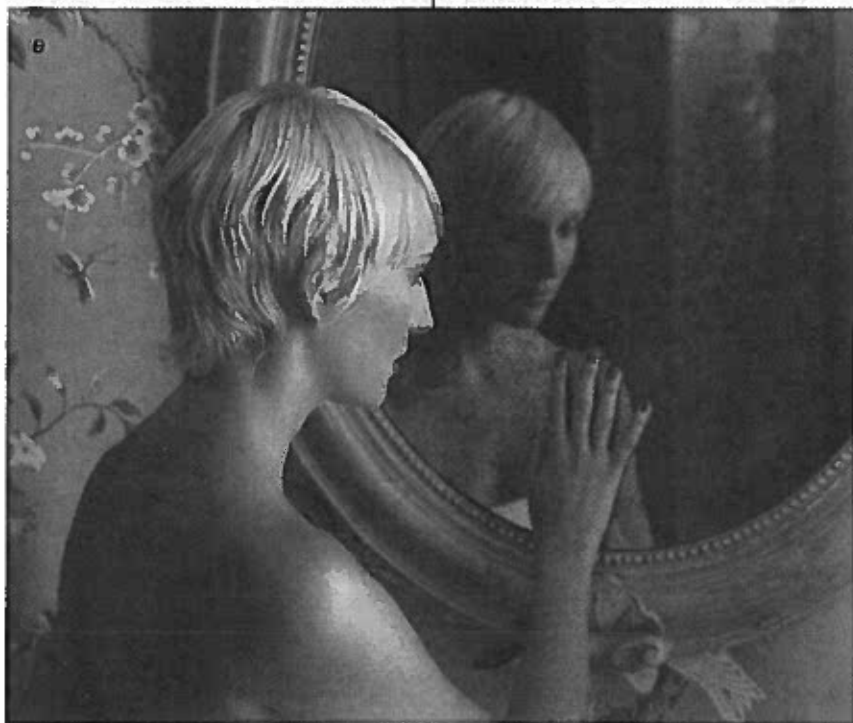
Extraordinarily, neglect patients may be even unaware of the paralysis of their left arm, a condition called anosognosia. When we asked Sally to touch her nose with the nonparalyzed right hand, she did so. When asked if she could move her left hand, she said, “Yes, I can move it fine.” But when we then asked her to touch her nose with her left hand, she promptly grabbed the lifeless left hand with her right and raised it toward her face using it as a “tool” to touch her nose! Clearly, even though “she” (the conscious person) was unaware of the paralysis, some part of the brain “knew” the left arm was paralyzed. Why else would she unhesitatingly grab it and raise it toward her nose?

The inadvertent humor of her response was lost on her. Bear in mind that in every other respect she was completely lucid, intelligent and articulate. The full implications of neglect were brought home to us even more vividly when we hung a two-foot-by-two-foot mirror on the wall to her right. When she turned her head to the right to look in the mir-



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(Recognizing a mirror image as a mirror image requires a peculiar **dual representation** in the brain.)



ror, she saw her face and, of course, reflections of objects on her left that she had been neglecting. She “knew” she was looking at her face in the mirror. But our question was, Would the mirror “correct” her neglect by making it obvious to her that there was a whole world on the left that she had been ignoring?

We asked a student to stand on her left holding a pen so Sally could see the reflection of the pen in the mirror on her right (and she said she could). We then asked Sally to take the pen with her (non-paralyzed) right hand and write her name on a notepad on her lap. Imagine our astonishment when Sally reached straight toward the mirror and attempted to grab the reflection! When asked where the pen was, she replied with frustration: “The pen is inside the darned mirror, doctor.” On other occasions, she reached behind the mirror, groping for the pen, insisting that “the pen is behind the mirror.” It was as though her brain were saying, “This is a mirror reflection, so the pen is on my left. But left doesn’t exist in my universe,

so the pen must be *in* the mirror. That is the only ‘solution’ to the problem.”

What is surprising is the illusion’s resistance to intellectual correction. Her high-level knowledge about mirrors and what they do cannot correct her behavior even after repeated failed attempts to grab the pen. Indeed, it is the other way around: her knowledge of mirror optics has been warped to accommodate the strange sensory world she is now trapped in (to the extent of rationalizing her action by saying things such as “The pen is inside the darned mirror, doctor”). We have dubbed this new neurological disorder (or “sign”) mirror agnosia.

Hope for Recovery?

Mirror agnosia is unlikely to be a deficit that is restricted to mirrors. In fact, we have seen patients recover temporarily

from neglect (by irrigating the ear with cold water) but continue to reach for the pen in the mirror. We should regard it as a specific—if dramatic—manifestation of a more general disorder: an inability to deal with complex spatial relations caused by the right parietal damage. Recognizing a mirror image as a mirror image requires a peculiar dual representation in the brain: a mirage superimposed on reality (e). With a damaged right parietal lobe, Sally’s brain cannot handle this peculiar juxtaposition. Even a four-year-old child or an orangutan rarely confuses a mirror image of a banana for the real thing, but the older, wiser Sally does, despite her lifetime experience with mirrors.

Neglect is a common clinical problem. It is frustrating to therapists who try to educate the use of the left arm during the critical window of the first few weeks after a stroke; the patient’s indifference to her left side becomes an impediment to therapy. We found that with repeated coaxing, Sally would start reaching for the pen on the left, but when we came back after a few hours the mirror agnosia returned. Would repeated training sessions, spread over several days, finally correct her mirror agnosia? Would it get rid of the neglect entirely? This cure remains to be seen.

What is clear for now, though, is that studying patients with Sally’s deficits can give us valuable insight into how the brain constructs reality. **M**

VILAYANUR S. RAMACHANDRAN and DIANE ROGERS-RAMACHANDRAN collaborate on studies of visual perception at the Center for Brain and Cognition at the University of California, San Diego. They serve as members of the board of advisers for *Scientific American Mind*.

(Further Reading)

- ◆ Can Mirrors Alleviate Visual Hemi-neglect? Vilayanur S. Ramachandran et al. In *Medical Hypotheses*, Vol. 52, No. 4, pages 303–305; April 1999.