

SCIENTIFIC AMERICAN™ **The Mind-Body Problem**

What does it feel like to have too many arms?

By [Moheb Costandi](#) | Tuesday, April 14, 2009 | 3

If people told you that they wanted to have a perfectly good leg amputated, or that they have three arms, when they clearly do not, you would probably think that they are mentally disturbed. Psychiatrists, too, long considered such conditions to be psychological in origin. Voluntary amputation, for example, was regarded as a fetish, perhaps arising because an amputee's stump resembles a phallus, whereas imaginary extra limbs were likely to be dismissed as the products of delusions or hallucinations.

These bizarre conditions—named [body integrity and identity disorder](#) (BIID) and supernumerary phantom limb, respectively—are now believed to have a neurological basis, and a growing body of literature suggests that such body awareness disorders occur as a result of abnormal activity in the right superior parietal lobule (SPL). This brain region integrates different types of sensory information and processes it further to generate an internal model of the body. Two forthcoming studies provide strong evidence that the gross distortions of body image experienced in both conditions do indeed occur as a result of SPL dysfunction.

A Useless Limb

In BIID, or apotemnophilia, individuals say that a limb, or part of it, feels "intrusive" or "over-present." They usually report that they have had the desire to remove the limb since early childhood, but do not understand why. This desire can be so strong that they sometimes resort to damaging the limb irreparably, thus forcing doctors to amputate it.

Almost all BIID sufferers have no other psychological

disturbances, and almost always say that they feel much happier when the limb is eventually amputated.

Paul McGeoch of [The Brain and Perceptual Process Laboratory](#) at the University of California, San Diego, and his colleagues tested the hypothesis that BIID occurs as a result of abnormal activity in the right SPL. They recruited three male BIID sufferers (apotemnophiles) who expressed a desire to have their left leg amputated, and a fourth who wanted both legs removed. The researchers tapped the participants' feet with a bundle of fiberoptic filaments, while recording the electrical activity of their brains using magnetoencephalography (MEG). Their responses were compared with those of four controls.

In the controls, tapping either foot caused activation of the right SPL. In the three apotemnophiles who wanted one leg amputated, tapping the unaffected foot evoked a response in the right SPL, but tapping the affected one did not. In the fourth apotemnophile, neither foot evoked a response. These preliminary findings confirm the researchers' hypothesis, and have been posted on the pre-print server [Nature Precedings](#). They suggest that the brain does not register the limb as a part of the body, and contains no representation of it. As a result, the limb is not incorporated into the body image, so the apotemnophile has no sense of ownership over the limb—he feels that it does not "belong" to him, and so wishes to have it removed.

The Third Arm

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Supernumerary phantom limb is a much rarer condition that usually occurs following a stroke. Mostly this feels much the same as the phantom limbs of amputees—an illusion, from which sensations sometimes emanate. In a small number of cases patients report that they can also see, feel and use the limb. This phenomenon has not been investigated thoroughly, because there are so few reported cases. But now clinical neuropsychologists from the Geneva University Hospitals describe what they believe to be the second documented case.

In [*Annals of Neurology*](#), the researchers, led by Asaid Khateb, report the case a 64 year-old librarian who began to experience a supernumerary phantom limb four days after being hospitalized with a stroke. The phantom, she said, started from the elbow of her left arm (which had been paralyzed by the stroke) and felt "just like a real hand," but was "weightless." "transparent" and "thinner" than her actual arms. The patient also told the doctors that the phantom was not experienced permanently, but only when she intentionally "triggered" it. Furthermore, it was anatomically correct and functional—she said that it had flexible, independently moveable joints at the elbow, wrist and fingers, and claimed that she could not only see it, but also feel it and purposefully move it.

The doctors placed her into a brain scanner, and asked her to scratch her cheek with her phantom limb. Remarkably, the scan confirmed the patient's subjective reports. When she willed the phantom limb into action, the doctors observed an increase in the activity of the right motor cortex. When she said that the phantom was approaching her face, they observed an increase in visual cortical activity. And

when she told them that the limb had made contact, they observed increased activity in the region of somatosensory cortex corresponding to the cheek. The patient's brain had generated a virtual simulation of a fully functional arm, which had been incorporated into the body image and which ran alongside the neural representations of her real arms. In her mind, this virtual arm was just as real as her actual arms.

Disturbing the Body Image

These findings fit perfectly with the current view of how the brain constructs a mental representation of the body. In the case of supernumerary phantom limb, the parts of the brain that relay body image-related sensory information to the SPL have been starved of oxygen. Cell death occurs, so the SPL is deprived of some the information it normally processes. This perturbs SPL function, and so distorts the body image. In this particular case, the brain's representation of the left arm has been duplicated, and incorporated into the mental scheme of the body.

In BIID, the situation is apparently reversed: the body image is [missing a representation](#) of the affected limb. This body image distortion is almost certainly congenital—the body image is probably “hard-wired” in the brain during development, because children born with missing limbs sometimes experience phantom limb syndrome. Thus, the brains of apotemnophiles apparently fail to generate a representation of the affected limb, because of some aberrant developmental mechanism. The limb has never been a component of the [body image](#), so the afflicted person grows up thinking that it feels "wrong."

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