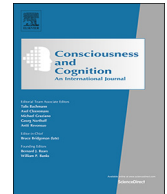




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Review article

What phantom limbs are

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ABSTRACT

Nearly everyone who undergoes the sudden loss of a limb will continue to feel the presence of and experience sensations in the missing limb for at least some time after the loss. This “phantom limb” phenomenon has been known for centuries, but remains poorly understood. Most work on phantom limb phenomena focuses on the phantom sensations, especially pain, that seem to emanate from the missing limb. This work tends to focus on the role of the body image in maintaining the sense of the phantom. A minority of work in the field distinguishes the body image from body schema, and offers an important corrective to the literature by outlining the unique contribution of the latter to generating and maintaining phantom limb phenomena. Here I review this literature, and motivate a further distinction between a motor body schema and a somatosensory body schema, which allows me to develop a novel hypothesis about the specific contributions of each to the experience of a phantom limb.

1. Introduction

In 1866 Civil War era physician Silas Weir Mitchell published “The case of George Dedlow”, a short story about a wounded Union officer who required the amputation of his legs, an event he describes as follows:

[A] steward put a towel over my mouth, and I smelt the familiar odor of chloroform, which I was glad enough to breathe. In a moment the trees began to move around from left to right, then faster and faster; then a universal grayness came before me, and I recall nothing further until I awoke to consciousness in a hospital-tent. I got hold of my own identity in a moment or two, and was suddenly aware of a sharp cramp in my left leg. I tried to get at it to rub it with my single arm, but, finding myself too weak, hailed an attendant. “Just rub my left calf,” said I, “if you please.”

“Calf?” said he, “you ain’t none, pardner. It’s took off.”

“I know better,” said I. “I have pain in both legs.”

“Wall, I never!” said he. “You ain’t got nary leg.”

As I did not believe him, he threw off the covers, and, to my horror, showed me that I had suffered amputation of both thighs, very high up.

“That will do,” said I, faintly.

This phenomenon of pain in, and the continued feeling of the presence of an absent limb—dubbed a “phantom limb” by Mitchell (1871)—has been known for hundreds of years, but remains poorly understood. In this paper I describe the phenomenon in more detail, offer a novel hypothesis about its roots, and briefly consider some implications of the hypothesis.

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2. The varieties of phantom limb experience

Ramachandran and Hirstein (1998) report that as many as 90–98% of people who undergo the sudden loss of a limb will experience its continued presence for at least some time, an estimate generally supported by other attempts to quantify prevalence (e.g. Pirowska et al., 2014; Jerath, Crawford, & Jensen, 2015). The precise symptoms and duration, however, vary widely across patients. Some patients experience the missing limb for only a few days or weeks, while others, an estimated 30%, continue to experience the limb for decades. Some patients report phantom pain, including shooting pains and cramping, or pain associated with uncomfortable postures, such as the nails of the phantom hand digging into the palm (Ramachandran & Hirstein, 1998; Ramachandran, 1998). Other patients report that the phantom is generally pain free, but they nevertheless experience sensations of temperature, or itching. Many patients also report sensations of movement, from both voluntary and involuntary, spontaneous and automatic actions (Pirowska et al., 2014).

Ramachandran and Blakeslee (1998) report the case of Tom Sorensen,¹ who lost his left arm just above the elbow in a car accident.

In the weeks afterward, even though he knew that his arm was gone, Tom could still feel its ghostly presence below the elbow. He could wiggle each ‘finger’, ‘reach out’, and ‘grab’ objects that were within arm’s reach. Indeed, his phantom arm seemed to be able to do anything that the real arm would have done automatically, such as warding off blows, breaking falls or patting his little brother on the back. Since Tom had been left-handed, his phantom would reach for the receiver whenever the telephone rang. (p. 21–2)

As Tom’s case illustrates, patients can often engage the phantom in fully voluntary actions: wiggling phantom fingers and reaching for objects. But the phantom can also be active in *quasi-voluntary* (habitual) actions, such as reaching for the phone, and *involuntary*, *reflexive* actions like warding off a blow and breaking a fall. Such persistent dispositions can be problematic for some patients. As patient JM reports:

I got out of bed and fell one time. Even when I had the leg on before and would take it off, I still couldn’t remember the amputation for two weeks after I was out of the hospital. And, I would try to walk and couldn’t. I would just fall. I couldn’t fathom I didn’t have a leg there. (Crawford, 2015: 236)

Similarly, John McGrath, an avid tennis player, reports that his missing arm still participates when he plays, as if it were still there: “It’ll want to throw the ball up when I serve or it will try to give me balance for a hard shot. It’s always trying to grab the phone. It even waves for the check in restaurants.” (Ramachandran & Blakeslee, 1998: 42)

The importance of habitual experience shows up not just in phantom limb movements but also in the more general experience of the limb. For instance, Giummarra et al. (2010) report that nearly 80% of the 283 participants they studied experienced their phantom limb to be occupying a “normal or habitual position.” (p.799) Moreover, Giummarra et al. (2010) found that those who reported their phantoms to be in an unusual or even anatomically impossible posture were more likely to be traumatic amputees, a finding echoed by Pirowska et al. (2014). This raises the possibility that the amputated limb *occupied* the unnatural position as the result of the trauma and just prior to amputation; if so, this would mean both varieties of experience are equally instances of “remembered” posture. This applies as well to patients who do not experience movement in their phantom limb. Such paralyzed phantoms occur most often in patients whose limb was paralyzed before the amputation (Carruthers, 2008). Such findings underscore the importance of various forms of bodily memory to phantom limb experience.

In general, the movement of the phantom limb, and the experience of sensations from the limb, are mutually reinforcing. Giummarra et al. (2010) report that perceptual awareness of the phantom is strengthened during both non-conscious and intentional action execution (and is generally more vivid in those who retain voluntary phantom limb control), and fades when patients are engaged in tasks that would not normally include use of the missing limb. Moreover, this reinforcement can be caused not just by one’s own movements, but by observing the actions of others. Giummarra, Gibson, Georgiou-Karistianis, and Bradshaw (2007) report that “[a]mputees may experience ‘somatic’ or ‘postural’ empathy during mirror neuron activity when observing others use their limbs” (p. 225) and they hypothesize that the mirror neuron activity serves to reinforce the experience of the phantom. Nevertheless, this association can come apart in various ways, as illustrated by cases of *increased* pain due to phantom paralysis, and by patients who “describe the embodiment and awareness of the phantom without having *any* sensations from the lost part of the body.” (Pirowska et al., 2014: 55, emphasis added). We will return to the question of how best to understand what might be called “asensory awareness” of a limb later in the paper.

One of the most striking things about phantom limb phenomena is the sheer number of dissociations it appears to implicate. I have emphasized above the importance of bodily memory to the phenomenon, and in particular the *stability* of the memory over time, but plasticity is equally important. Consider, for instance, the phenomenon of “telescoping”. Brugger et al. (2000) report one striking case as follows:

While manipulating objects with the arm stump, the subject usually feels the phantom fingers attached to the stump, and she is no longer aware of a forearm. As soon as contact with the object is lost the fingers immediately switch back to their regular distal position. (p. 6168)

¹ A pseudonym, as with all the patient names reported here.

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