From Phantom Limb to Phantom Body
Varieties of Extracorporeal Awareness

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Corporal awareness refers to the experience of having a body. While this may appear self-evident given our constant daily experience of embodiment, the neuronal processes mediating this experience are nonetheless highly manifold and complex. Corporal awareness relies on perceptual functions (e.g., tactile, proprioceptive, gravitational, visual) and on motor programs for bodily action. Yet, it also comprises a sense of the self as the object of sensory stimulation and as the agent of motor intentions and executions. Moreover, identifying with a body implies knowledge of its borders. Thus, the study of corporal awareness includes investigations of the many functionally organized spaces for each distinct sensory and motor representation that surrounds our body. In the past, various terms have been used to capture some of the heterogeneous functions that guarantee a continuous sense of embodiment. Some of the more frequently used terms are body schema, body image, body self, somesthesia, coæsthesia, and somatognosia. Critchley (1955; 1979) complained about the fact that these terms were employed more or less interchangeably despite the fact that they had originally been introduced to designate specific facets of bodily perception and representation. He therefore proposed the deliberately less definitive term corporal awareness as an all-encompassing descriptor of the experience of having a body.

The present chapter provides a phenomenological account of those borderlands of corporal awareness in which subjects experience a discrepancy between the spatial extents of their physical and phenomenal bodies. Such discrepancies may occur at the level of single limbs but also at the level of the entire body. This chapter begins with brief reviews of selected clinical and experimental findings pertaining to various manifestations of the phantom-limb phenomenon. This is followed by a discussion of what is referred to as
the hemiphantom or phantom half-body, that is, the experience of a deafferented/deafferented half of one’s body as an entity living a life on its own. Finally, an overview will be presented of a peculiar class of reduplicative disorders known as autoscopic phenomena in which one’s entire body is experienced as a phantom.

While research on limb phantoms has enjoyed increasing popularity since the 1980s, investigations of whole-body phantoms are still largely a matter of clinical descriptions. However, experimental paradigms that have proven useful in elucidating the neuropsychological mechanisms underlying phantom-limb experiences can be adapted for the systematic study of phantom bodies. Also, the neuropsychology of spatial and conceptual perspective taking and of the experience of agency over one’s actions should be considered for the interpretation of the psychological content of autoscopic experiences.

1. Phantom Body Parts

1.1. Amputation Phantoms

An amputation phantom is the persistent experience of the postural and motor aspects of a limb after its physical loss. The reluctance of the medical community to consider amputees’ reports about such phantom limbs is reflected in the history of the subject. Ridddoch (1841, p. 179) noted that the subjective survival of a limb “must be as old as survival from amputation.” Early accounts of phantom limbs can be traced back at least to the 10th century. These accounts were intermingled with religiously motivated resurrection fantasies (Price & Twombly, 1978) to such a degree that it is difficult to separate keen introspective report from folk psychological interpretation. Later theories (see Finger & Hustwitt, 2003; Halligan, 2002, for historical overviews) about the origins of phantom sensations can conveniently be dichotomized into relating to whether they focus more on peripheral or central processes. The essence of peripheral theories is captured in the words of Gallinek (1919, p. 420): “peripheral stimuli are the blood which the sensory ghost must drink in order to be awakened to its phantom existence.” Such stimuli include random firings of axons in spinal nerves in the stump and irritations by scar tissue and neurons (see, e.g., Katz, 1992). Later theories emphasized involvement of the central nervous system at the level of the spinal cord (Cronholm, 1951). A quarter of a century ago, peripheral and spinal factors were still considered by some authors as sufficient to explain the genesis of phantom sensations (see especially Carlen et al., 1978, who even ridiculed any postulate of a cortical involvement). However, subcortical and cortical reorganization had much earlier been described as essential concomitants of limb amputation. Specifically, it was argued that changes in the corporeal awareness of a lost hand in response to reshipping of the forearm stump would constitute what classical physiology called “sensitization reaction of the sensory cortex and cortico-thalamic system” to the new functional properties of the stump arm (Cronholm, 1950, p. 154; Figure 9.1; see Kallio, 1952, for an alternative, mostly peripheral interpretation of similar observations).

Since the 1980s, the literature on the central correlates of amputation phantoms has grown exponentially. Along with prior animal research (Kasas et al., 1983; Pons et al., 1991), these studies helped to refine an axon within the central nervous system, that is, the claim that the adult human brain is largely resistant to functional reorganization. A variety of behavioral and neuroimaging techniques have been used to monitor the cortical and subcortical reorganization processes following limb amputation in humans (see Ramachandran & Hirstein, 1998, for review). Flor et al. (1995), using magnetic source imaging, described shifts in the cortical hand area (contralateral to amputation) in the magnitude of centimeters that correlated almost perfectly with a subject’s rated severity of phantom limb pain.

However, referred-sensation studies have shown that nonpainful phantom sensations can serve as markers of plastic changes during deafferentation. "Referred sensations" are sensations localized to a phantom body part after stimulation (usually tactile) of a remote site on the subject’s body known as the trigger zone (Aglioti et al., 1997). The most common trigger zone for upper-limb amputees is the subject’s face (see also chapter 8). Clinically, these sensations have been extensively documented (e.g., Cronholm, 1951; Henderson & Smyth, 1948). Ramachandran et al. (1992) described representations of upper-limb phantoms, apparently somatotopically organized, on the face, chest, and axilla of several amputees. These and later authors interpreted the regular correspondence between the face as a trigger zone and the phantom hand as the
site of referral as evidence for an "invasion" of the deafferented hand area into the neighboring postcentral area of face representation (see Clarke et al., 1996, for an inverse relationship between trigger and referral zones in a patient with intact hands but surgical deafferentation of the cheek). The exact neurophysiological mechanisms underlying these re-arranging phenomena are still unclear. The most commonly discussed mechanisms are axonal sprouting (intracortical and/or thalamocortical) and the unmasking of existing synaptic connections (see Kew et al., 1997, for discussion). However, the correspondence pattern between trigger zones and sites of referral does not appear to be stable over time and can change drastically within months (e.g., Halligan, Marshall, & Wade, 1994; Halligan, Marshall, Wade, et al., 1993). Thus, while there was great initial enthusiasm about and emphasis on the apparent somatotopy of referred sensations (Ramachandran et al., 1992), later investigations showed that trigger and reference zones could be located in body parts represented in clearly nonadjacent cortical areas (e.g., Grüsser et al., 2004; Knecht et al., 1996, 1998). Such findings suggest a possible subcortical mediation of sensory referral. For a crossmodal analogue of referred sensations, see Cacace et al. (1999).

Dynamic aspects of phantom limbs have been captured in many experiments. For example, the reality of virtual movements, or the voluntary movement with one's phantom limb, has been elegantly demonstrated in simple behavioral experiments (e.g., Franz & Ramachandran, 1998). Several neuroimaging studies have attempted to shed some light on the functional neuroanatomy of voluntary movements of amputation phantom (e.g., Erlsand et al., 1996; Lotze et al., 2001; Roux et al., 2003). These studies have shown that phantom movement sensations are associated with activations of primary and secondary somatosensory cortical areas, even decades after the loss of a limb.

Cortical awareness on the level of single limbs is shaped by interactions with the visual modality. For example, the phenomenon of obstacle shunting refers to the diminished awareness of a phantom limb during the observation of a physical object invading the space that the phantom appears to occupy (Jalavaisto, 1950). Scattered observations and systematic explorations of shunting behavior (e.g., Abbattucci, 1894; Katz, 1920; Pock, 1963; Riechers, 1934; Simmel, 1956) have revealed three major findings: (1) there are large interindividual differences in the degree of shunning as roughly 50% of amputees do not show any pronounced obstacle shunting; (2) among the physical objects used to test for shunning behavior, the human body appears to play a special role (with little data on the specificity of the amputee's own compared to other people's bodies); and (3) pronounced shunting tendencies may elicit unique phantom limb movements, that is, movements specific to the experimental situation (e.g., a wall-approaching test) and not usually experienced in everyday life. One example is the "bending" of a phantom limb beyond regular joint constraints to avoid "contact" with solid matter (Pock, 1963).

More recent experimentation on visual-somatosensory interactions has concentrated on the visual observation of one's own limb, specifically, the one contralateral to the amputated extremity. Critically, the spared extremity is observed in a mirror placed vertically in the parasagittal plane to thus match the purely somatosensory phantom percept with respect to handedness and perceived location in space (e.g., Ramachandran et al., 1995; Ramachandran & Rogers-Ramachandran, 1996). Under these conditions, observed touch applied to the real limb may also be felt in the phantom (but see Hunter et al., 2003). Observed movements of the existing limb may be felt as mirror movements in the phantom, a principle that has found therapeutic applications beyond the treatments of phantom-limb pain (Alischuler et al., 1999; Ramachandran et al., 1999).

In view of these empirical studies, it would appear that what was labeled a "sensory ghost" by Mitchell in 1866 (the term phantom limb was also coined in this work) has completely lost its ghostly character. It is important to note, however, that we still continue to be haunted by considerable misconceptions. First, the literature on phantom limbs is heavily biased toward the analysis of cases after amputation. Second, at least in the popular mind, "phantom sensation" is implicitly equated with "phantom pain." Figure 9.2 illustrates this point with data from 172 people who provided spontaneous associations to the

![Figure 9.2](https://example.com/phantom-limb-association.png)
term phantom as a medical term. Overall, these subjects wrote down an average of 5.8 associations to the term phantom in the allotted 60 seconds. Subjects were categorized as either "medically trained" or "laypersons." The medically trained subjects comprised general practitioners, neurology residents, and qualified nursing staff, as well as 48 fourth-year medical students. Laypersons had, for the most part, academic training in fields other than medicine and psychology. No differences were apparent between women's (n = 87) and men's (n = 85) associations. The population stereotypes somewhat anecdotally communicated in Figure 9.2 were similar for medically trained and untrained subjects. Clearly, amputation and pain are tightly associated with the medical term phantom.

Similar biases can be found in the medical literature. A search for the keyword "phantom sensations"14 (December 2003) in the Web-of-Science for the publication years 1945 to 2003 produced 58 entries, more than 50% accompanied by the keyword "amputation" and more than 60% by "pain." The fact that amputation and phantom are both symptoms shared by many types of phantom limbs and manifestations should become evident in this chapter. The overemphasis of pain among the many sensory qualities of phantom limbs (e.g., posture, temperature, weight, kinesthesia) can probably be explained - to the fact that amputees usually complain about painful phantom sensations spontaneously, but mention painless phantom sensations only after specific inquiry (Egfyd & Janke, 1967). Also, if present, phantom pain is a most distressing condition for which, judged by evidence-based medical criteria, no reliable therapeutic intervention can currently be offered (Stremmel et al., 2002). However, estimates of the prevalence of phantom-limb pain after amputation vary between 80% (Humphrey et al., 1994) and lower than 0.5% (Kolb, 1952, p. 586). In any case, both the tendencies to regard "phantom limb" as synonymous with "amputation phantom" and "phantom sensation" as synonymous with "phantom pain" hamper the recognition of a conceptual similarity between the phantom limb and phantom body.

1.2. Phantoms After Spinal-Cord Injury

Limb phantoms are also experienced after spinal-cord injury and may be defined as the phenomenal perception of postural and, optionally, kinesthetic information about the deafferented and deafferented limbs. Lower limbs are thus affected in paraplegic patients (Connolly, 1973; Figure 9.3) while upper limbs are affected after quadriplegia (Mayer-Gross, 1929), and both lower and upper limbs are affected in tetraplegia (Davis, 1975; Obey et al., 1989). Important early contributions to general phenomenology and individual differences in corporeal awareness after spinal-cord injury can be found in Becker (1949), Bors (1951), Melzack and Loeser (1978), and Riddoch (1941).

A recent population-based study found the prevalence of phantoms after spinal-cord injury comparable to that reported in amputees (Siddall & McClelland, 1999). Yet, "phantom phantoms" often escape the attention of the clinician because they are not specifically inquired about and are usually less vivid and not as persistent as amputation phantoms (Bors, 1951). Furthermore, spinal phantom sensations are often confused with residual sensations, such as pain and paresthesias (Burke & Woodward, 1976). Finally, loss of consciousness during the trauma appears to decrease the chance that phantom limb experiences will be reported (Ettin et al., 1980).

Most important with respect to the modification of corporeal awareness by crossmodal sensory integration is the observation that phantom leg sensations in paraplegia are frequently "suppressed" by visual feedback from looking at one's own paralyzed limbs (e.g., Connolly, 1973). Yet, occasionally, the view of one's existing limb does not suppress the compelling nature of somatic phantom sensations. In a case reported by Reichert and Sewekow (2002), a patient with a phantom arm after resection of an intraspinal tumor could feel his phantom in superposition with objects. This absence of obstacle stunning occurred despite the fact that the patient could clearly see both of his arms. It is possible that the spatial separation between the physical arm and the phantom arm may have prevented the suppression of phantom sensations by visual information.

Neuroimaging studies are paraplegic patients have documented large-scale reorganization of those cortical areas devoted to somatosensory control. These
changes are associated not only with the deafferented and deafferented lower limbs but also with the unaffected upper limbs (Brathelmeyer et al., 1998; Curt et al., 2002; Turner et al., 2001). Importantly, a recent fMRI study of paraplegic patients' motor imagery of the lower limbs showed high correlations between activations specifically in primary and secondary motor areas and the rated vividness of phantom foot movements (Allkadh et al., 2003). Visual observation of simulated hand movements may enhance motor imagery-induced cortical activity in some patients with phantoms after brachial plexus avulsion and may lead to a reduction of phantom limb pain (Giraux & Strigo, 2003).

As in the literature on amputation phantoms, the issue of referred sensations has received special attention. While most reports found a referral of stimuli applied to nonesthetic parts of the body to phantoms or deafferented body parts (e.g., Bons, 1979; Strinivasan et al., 1998), referral as an opposite direction does also occur (e.g., Nathan, 1956). An fMRI study of referred sensations after spinal-cord injury (Moore et al., 2000) provided clear evidence for a coactivation of regions widely separated from one another, both on the body surface and as representa-tional loci within the postcentral gyrus.

1.3. Supernumerary Phantoms After Brain Damage

Given that the critical factor for the genesis of a phantom limb is a partial or full deafferentation and/or deafferentation of the corresponding real limb at any level of sensorimotor integration, phantoms are also experienced after damage to subcortical or cortical brain regions. The term supernumerary phantom thus refers to the awareness of having an "extra limb" in addition to the regular set of two arms and two legs. In the nomenclature of the early 20th century, such awareness was referred to as "pseudopolyneuia" or a "reduplication of body parts," (see Weinstein et al., 1954, for a review of this early literature). Although the etiology of brain damage is commonly a vascular incident or a space-occupying lesion (Donnet et al., 1997; Halligan, Marshall, & Wade, 1993; Miyazawa et al., 2004; Sellal et al., 1996; Vuilleumier, Reverdin, et al., 1997), supernumerary phantoms have also been described after traumatic brain injury (Rogers & Franzen, 1992), during the course of a demyelinating disease (Mayeux & Benson, 1979), or as an epileptic manifestation (Hécan & de Arajiguera, 1952; Riddoch, 1941). Typically, postural and movement qualities are reported whereas painful sensations are rather exceptional (e.g., Canavero et al., 1999). Movements of and tactile stimuli applied to a real limb can occasionally be transferred to the phantom (Hari et al., 1998: Figure 9.4A).

The key difference between supernumerary phantoms after brain damage and phantoms after the loss of a limb or in disconnection at the spinal level concerns the patient's insight into the reality of the phenomenon. As "real" as the latter may feel, they are always recognized as illusory percepts. In contrast,

Figure 9.4. (A) Experience of supernumerary "ghost limbs" in a patient with a bilateral and anterior spinal lesion (drawing by the patient). While the posture of the phantom hand mimicked the one of the left hand with a time lag of up to one minute, its movements copied those of the right hand. Tactile stimuli to either left or right hand were transferred also to the other two hands, such as the patient would feel carrying these bags, or having three dogs on a lead, when in actuality only one object was present. Reproduced from Hari et al. (1998, Fig. 2), with permission from Elsevier. (B) The Australian artist Stella during a 1982 "Handwriting" performance. His project "Third Hand" involved the incorporation of an artificial supernumerary hand whose movements were controlled by abdominal and leg muscles. Avant-garde in the domain of art, Stella's experimentation could also contribute to the evolution of our scientific understanding of corporeal awareness. Photograph by K. Oki, with permission by Stella.
and phantoms after spinal-cord injury are almost never seen by mentally healthy autopsy or paraplegics, some patients with supernumerary phantoms have reported both visual and postural-kinesthetic awareness of their "extra" limb (e.g., Critchley 1953, pp. 244-245; Halligan & Marshall, 1995; Halligan, Marshall, & Wade, 1993; Todd & Dewhurst, 1955, p. 54). The patient of Miyazawa et al. (2004) who felt a supernumerary set of left upper and lower extremities (after left thalamic hemorrhage without anosognosia), could clearly see arms and legs but not hands and feet. This "spilling over" of corporeal awareness into the visual domain is unique to cases in which the deafferentation occurred on a highly integrated level. It should be noted, however, that visualization of amputation phantoms was reported in the early literature (e.g., Menninger-Lerchenhal, 1948; Price, 1976; Remy, 1899). These observations may be indicative of the powerful top-down effects of belief systems on lower-level sensory functions. Indeed, they give testimony to relatively neglected interactions between neurophysiological mechanisms and factors hitherto considered purely "social psychological" (see Brugger, 2001).

1.4. Phantoms of Congenitally Absent Limbs

Another type of phantom is known as congenital phantom limb or aplastic phantom limb. These terms refer to the corporeal awareness of a limb that has been missing since birth, that is, in congenital limb aplasia. While the number of cases reports of congenital phantoms is impressively large, there remains a relative paucity of experimental investigations. This underrepresentation of empirical research within the huge literature on phantom limbs may explain the absence of a generally accepted theory of congenital phantoms. In fact, the genuineness of congenital phantoms is not unequivocally appreciated. Some authors are still inclined to dismiss the possibility of phantom awareness of a limb that has never physically developed (e.g., Flor et al., 1998; Montoya et al., 1998; Skyes, 1990). In this context, reference to Pick (1915) is usually provided. This author authoritatively stated that congenital phantoms could not exist because the respective limb "had never been part of the body schema." (p. 260). Among the speculations offered to account for congenital phantom limbs are the following:

Speculation 1: Stump Characteristics

In many persons reporting congenital phantoms, absence of proximal limb structures is accompanied by at least some rudimentary preservation of distal body parts ("intercalary aplasia"); O'Reilly, 1951). Based on an analysis of such cases, it was suggested that phantom sensations comprised kinesthetic illusions resulting from an abnormally enhanced motility of these distal body
parts (Simmel, 1961). This idea may make sense in the context of a very particular subset of limb dysplasia. Obviously, however, it cannot explain the occurrence of phantoms for limbs missing in their entirety nor the highly specific features of distal phantom parts, such as entire sets of properly ar ranged fingers. Furthermore, phantom temperature sensations in a limb absent since birth (Lacruz et al., 1992) can hardly be encompassed by abnormally represented movement information for residual body parts.

Speculation 2: Spared Representation of the Contralateral, Intact Limb

Early case reports of congenital phantoms frequently involved persons missing only one limb (see Scatena, 1990; Vetter & Weinstein, 1967, for comprehensive reviews). Accordingly, the phantom sensations of these individuals were interpreted as transpositions of sensorimotor imagery from the intact limb of one hemisphere to the other (e.g., Burchard, 1965; Grousios, 1996). The core idea here was most clearly summarized by Grousios (1996) in his introduction of the case of a 12-year-old boy born without his right forearm (5 cm above the elbow). The child experienced phantom fingers of his missing hand. Grousios (1996) concluded:

It seems that the upper and lower limbs in people with congenital limb deficiency are linked in the brain as a result of frequent co-activation. Hence, sensory input of the left upper limb, for example, projects not only to the somatosensory cortex of the right cerebral hemisphere but—by identification of unidentified commissural pathways—also to mirror-symmetrical points in the left cerebral hemisphere. It thus contributes to a weak formation of the cortical representation of the right upper limb. (pp. 503–504)

It is most evident that, as convincing as such a theory may appear for cases of unilateral limb absence, it fails to account for the situation where both upper and/or both lower limbs are missing. Such cases are not unique (e.g., Brugger et al., 2000; Pook, 1964; Saada & Melzack, 1994; Weinstein & Seers, 1961), and their theoretical importance was recognized early on (Valenstein, 1836, p. 643). Importantly, the phantom sensations reported by persons with bilateral limb aplasia are not qualitatively different from those described after unilateral defect.1

Speculation 3: Hand-Mouth Coordination

Behavioral and ultrasound data on the thumb-sucking behavior of human fetuses have demonstrated a functional link between hand movements and anticipatory mouth opening. Based on these data, Gallagher et al. (1998) proposed that an innate motor schema of hand-mouth coordination may be responsible for phantoms of congenitally absent limbs. In the absence of a hand, the cortical areas involved in face representation may invade the cortical areas involved in hand representation. "Activation of the expanded face-representing neural map may also reactivate the indigenous limb-representing neurons and thus cause the phantom experience" (Gallagher et al., 1998, p. 59). As thoughtful as these speculations are in the struggle to explain the genesis of upper-limb congenital phantoms, they obviously cannot be used to explain the formation of phantoms of feet and legs that have never physically developed. Indeed, as if anticipating such a critique, Gallagher and colleagues (1998) included only cases of upper-limb phantoms in their tabular overview of previously published cases of congenital phantoms.

To test the various predictions outlined above, we recently presented the case of A. Z., a 44-year-old woman born without forearms and legs (Brugger et al., 2000; Figure 9.5A). As long as A. Z. can remember, she has experienced phantom forearms including hands and fingers. The symmetric bilateral absence of her upper extremities ruled out the possibility that representations of an intact limb were responsible for the genesis of her phantom hands. Since her conically shaped upper limbs were free of any appendages (i.e., rudimentary fingers), we could also reject Simmel's (1963) proposal that congenital phantom limbs reflect the increased mobility of distal appendages. Finally, the fact that A. Z. reported a distinct awareness of phantom legs and feet, including first and fifth toes (Figure 9.5A), cannot be explained by referring to an innate schema for hand-mouth motor interactions (Gallagher et al., 1998). In contrast, behavioral data indicated an intact postural representation of hands. Specifically, A. Z.'s performance in hand/foot alternation tasks (which require a speeded motor decision as to whether picture of a hand or foot display a left or a right limb) showed a reaction time pattern that replicated the pattern produced by subjects born with intact bodies (e.g., Parsons, 1987). Most convincing was a regular "medial-lateral gradient" for palm views of left and right hands (Funk, 2001; Figure 9.5B). The significant reaction time advantage for mediolaterally oriented hands indicated that A. Z.'s visual recognition of hands was constrained by biomechanical joint constraints in the same way as that of normal subjects (Parsons, 1994) and that of person born with only one upper extremity but no phantom sensations of the missing limb (Funk & Brugger, 2002). When A. Z. performed self-paced movements with her phantom fingers while lying in an MR scanner, phantom finger movements consistently activated cortical areas similar to those described in comparable studies with amputees (e.g., Ersland et al., 1996), without however involving the primary sensorimotor cortex (Figure 9.5C). Finally, transcranial magnetic stimulation (TMS) over the sensorimotor cortex, but also at premotor and parietal stimulation sites, elicited specific phantom hand and finger sensations (Brugger et al., 2000).
On first consideration, the results obtained with A. Z. appear to constitute unequivocal evidence for an innate representation of the human body or at least its extremities. Melzack (1990; Melzack et al., 1997) proposed the concept of a neuronautics, or a neural network integrating different components of corporeal awareness across modalities and extending throughout selective areas of the whole brain while mainly comprising the posterior parietal lobes and thalamocortical and limbic loops. According to his view, the rough spatial distribution of the neuronautics is genetically prewired while the specific synaptic connections are later modulated by sensory experience (see Abramson & Feibel, 1981; Miletic 1952; Poeck, 1964, 1969; and Weintraub & Sengem, 1961, for earlier related proposals). We have noted, however (Brugger et al., 2000, 2001) that there still remains the theoretical possibility that a somatic (postural and kinaesthetic) limb representation could have been built up by the regular visual observation of other people moving their limbs. We are currently exploring the functionality of A. Z.'s "mirror system" (Buccino et al., 2001; Rizzolatti et al., 2001) and wish to compare it with that of people born with a similarly incomplete body, but with an "americorpal awareness," that is, no history of phantom sensations (see Funk et al., in press, for preliminary findings).

2. The Phantom Half-body: Personification in Somatoparaphrenia

Among the agnosias, anosognosia undoubtedly provides the most challenging puzzle to behavioral neurologists. Patients with this disorder fail to recognize those symptoms of an illness that are most obvious to any third person. In the narrow sense, anosognosia refers to the nonrecognition, or even active denial, of hemiplegia, that is, the paralysis of one half of the body (Babinski, 1914). Almost always associated with a neglect of the contralateral side of space, anosognosia is a typical parietal lobe disorder (Gastaut & Gall, 1955), more frequently observed after right-sided than left-sided lesions. Several hypotheses have been proposed to account for anosognosia for sensorimotor hemisindrome (for an overview, see Vellutini, 2004), but none can fully explain the diversity of symptoms displayed by different patients.

One condition frequently associated with anosognosia is somatoparaphrenia (Greimowski, 1942), that is, the delusional rejection of the ownership of the disabled side of the individual's own body (commonly, the left side). Somatoparaphrenia involves a productive elaboration that reflects a breakdown in the distinction between oneself and others (Boisson & Lanoue, 2004; Paulin et al., 2000). It is this awareness, distorted as it may be, of one side of one's body that we here conceptualize as a phantom half-body. Patients may conceive of their paralyzed limbs as belonging to the examiner, a family member, or some unknown human being. Some reports describe a restriction of the disownership to a single limb, mostly the hand, but it is unclear how far this "restriction" actually results from the structure of the interview itself.

In any case, somatoparaphrenia has also been labeled a personification anosognosia (Juba, 1949), and this label points out a key link among supranumerary phantom limbs, phantom half-bodies, and the repudiations of one's entire body. Specifically, each of the above conditions can be described as a gradually increasing personification of one's own body parts. Indeed, the split-off, para"body" half-body is sometimes designated as a "hemiplegic twin"; yet, hemiplegia is not a necessary condition for the experience of one's hemibody as a phantom. Besedek and von Angst (1959) described a patient with only a mild hypnosynthesis, that is, an impaired tactile sense of the left side of his body. Nevertheless, this patient denied ownership of his left side. He referred to it as "his brother" for whom he felt pity because he appeared to be paralyzed. This tendency to attribute one's own deficits to other people, whether real or imaginary, was termed transvestism by Wiener (1900). Transvestitic reactions demonstrate that a deficit in one's own corporeal awareness may be well.
recognized at an implicit level, without evoking, however, an overt emotional concern about one's own place ofity for "the other's anger" may be expressed if, for instance, patients complain about having to eat and breathe for themselves as well as for the one lying beneath (Ley & Stoadder, 1950; von Stockert, 1944). Such "residual identification" with the part of the body that is claimed to be someone else is also evident in the patients' frequent emphasis that the literary person looks similar to themselves, is a family member, carries a similar name, or has the same occupation.

Published attempts to experimentally manipulate a patient's experience of somatoparaphrenia are relatively rare. It is known that the delusional interpretation, along with anosognosia proper, may temporarily be abolished by caloric vestibular stimulation (Ramschandran, 1995; Rode & Rode, 1992). This procedure activates the vestibular cortex contraalaterally to the stimulated ear and arguably restores sensory and attentional functions (Bottini et al., 1994), especially those of the right hemisphere (Denscher et al., 2003). On the other hand, somatoparaphrenic delusions about left-sided limbs can be extended to involve also the right side of the body when that right side is experimentally rendered "paralyzed" by transient immobilization (Guthrie & Grossman, 1952). The influence of visual self-observation on claims about limb disownership was investigated by Vermet and Lapresle (1978). These authors introduced the case of a woman with anosognosia who claimed that her medical doctor was continuously lying along her left side, and she was concerned about his frequent touching her body with his hand. When this doctor showed her his two hands, she was prepared to believe that he had three hands rather than acknowledge that something was wrong with her own left hand. These authors showed that their patient's delusion was dependent on visual perception of her own body. When this was prevented, she immediately recognized her left side as belonging to herself. Interestingly, visual observation of herself in a mirror (while direct view of her own body was still shielded) also restored self-recognition, ruling out the possibility that the personification of her left side could have been conceived of as a "filling-in" process in the course of a severe left-sided neglect. In another patient with somatoparaphrenia and neglect, Daprati et al. (2000) found no influence of visual observation of one's own moving hand on ownership judgments.

An important contribution to the mechanism of "incorporation" of non-body parts into the self was provided by Aglioti et al. (1996). In a patient with somatoparaphrenia, claims about disownership of the left hand spread to several rings she still wore on that hand. Temporarily moved over to her right hand, the same rings were immediately recognized. Other objects, never previously associated with the left hand, were normally commented on when placed on the left hand. In a review of this work (Berthelucchi & Aglioti, 1997, p. 561; italics added) the authors concluded that "somatoparaphrenia suppresses both the me and the mine experiences of the disowned body part and related paraphernalia." They further emphasized the importance of their case for the understanding of an "extended corporeal awareness," that is, one that includes inanimate objects such as tools, vehicles, prostheses, and so on.

It is also worth noting that one clinical feature sometimes associated with somatoparaphrenia, exosomesthesia (Roth, 1944; Shapiro et al., 1952), provides another, more vague example of extended body boundaries. Exosomesthesia refers to the feeling of touch localized in objects in peripersonal space and is possibly related to the phenomenon of "extracorporeal phantom tics" as reported in a different context (Karp & Hallett, 1996). An intriguing dissociation between tactile sensitivity and ownership of a body part was described by Botmimi et al. (2002). The authors applied tactile stimulation to the hands of a blindfolded stroke patient with anosognosia whose somatoparaphrenic delusion involved the personification of her left side as her niece. Each touch stimulus was announced as being applied to (1) the patient's right hand, (2) the patient's left hand, or (3) the niece's hand. Right-hand stimuli were recognized 100% correctly, left-hand stimuli with 0% accuracy as long as attention was directed to the paralyzed hand, but left-hand stimuli were recognized 80% correctly after directing the patient's attention to a delusion-compliant representation of the same body part. This finding shows that top-down expectations may temporally boost tactile sensitivity in a hypothesis of the body. At the same time, it elegantly proves that spared tactile sensitivity in a body part does not necessarily lead to a sense of ownership for this particular part.

More systemic experimental studies comparing patients' interpretations of superimposed phantoms with somatoparaphrenic delusions are needed to justify the conceptualization of somatoparaphrenia as the experience of a "phantom hemibody." As yet, such a notion rests primarily on clinical grounds. Especially in the German and French neurological literature of the first half of the 20th century, the phantom half-body was placed somewhere halfway between the supernumerary phantom limb and the various phantoms of the entire body, to which we now proceed.

3. Whole-Body Phantoms: Autoscopic Phenomena

Autoscopic phenomena involve the visualization of one's entire body in extracorporeal space or the feeling that "another body" (by inference, one's own) is lying, standing, or walking close by. This class of phenomena can thus be conceived of as a duplicative experience of one's own body. The duplication may be restricted to the visual modality, in which case an image of one's own body is seen as if one watched oneself in a mirror (autoscopic hallucination). Phenomenologically more similar to the experience of phantom body parts is the "feeling of a presence," a mere somatosensory illusion that lacks visual features and must be viewed as an extension of corporeal awareness into extracorporeal space.
space. Visual and somesthetic senses merge in what is usually referred to as a doppelgänger. Haptotaxis is defined as an experience in which one sees another person who is clearly identified as one’s own self and whose body is also felt to be a duplication of one’s own (see section 3.3 and Figure 9.5B). A similar merging of visual and bodily duplication occurs in an out-of-body experience (OBE). The difference between haptotaxis and an OBE is the following: in haptotaxis, the person reports an encounter with another emboiled self, while in OBE one experiences a shift in spatial perspective, that is, a detachment from one’s own body, which is then viewed as if from a location in extraspacial space. This shift in spatial perspective may be accompanied by a psychological perspective shift, that is, a shift in the transitive function of “altered” felt presences is sometimes obvious (Bychowski, 1943). Thus, exhausted mountaineers frequently overcome hopeless situations by caring for “the other,” who climbs with them and whose presence is felt compellingly enough to be offered food (e.g., Smythe, 1934).

Together, these observations suggest that the feeling of a presence rests on postural and kinesthetic representations of one’s own body that are falsely localized in extraspacial space. Ownership over these nonvisual components of corporeal awareness does not need to be acknowledged, not even by those persons who explicitly note distinct changes in bodily awareness during the experience (such as sensorimotor weaknesses or feelings of depersonalization; Brugger et al., 1999). The illusion must thus be considered an invisible, purely “phantom-like doppelgänger” (Grüsser & Landis, 1991). For auditory variants of the illusion in the presence of temporal lobe dysfunction, see Glinning, Glotting, and Hopp 1957, case 2).

3.2. Visual Doppelgänger (Autocopy)

In contrast to the feeling of a presence, autocopies hallucinations lack any somesthetics component. Originally labeled “mirror hallucinations” (hallucina-
tions specularis: 1936, 1991; Nisbet, 1923), they involve the seeing of one’s own body or only one’s face as if reflected in a mirror (Zamboni et al., 2005). Unfortunately, most modern reviews of autocopie hallucinations (e.g., Dening & Berrios, 1994; Devinsky et al., 1989; Leichter, 1963) interfere with autocopies hallucinations and multimodal doppelgänger experiences. Yet, in the French neurologic literature of the turn of the 19th century, the unmodal visual character of autocopie hallucinations was clearly recognized (Sollier, 1903). This visual variant of autocopie hallucinosis is the only one that occurs exclusively after overt brain damage. Occipital areas are primarily involved in the visual symptoms that often accompany autocopies hallucinations (e.g., light flashes, colored photisms) are typicallly of elementary nature and thus indicative of low-level visual processing deficiencies. Correspondingly, autocopie localization of the felt being is commonly precise, despite the lack of confirmation of any presence by the visual modality; (3) there is a synchrony of movements such that the invisible being walks along with the present and often imitates arm and leg movements, either simultaneously or with a time lag (as in Hari et al’s 1998 case of a supernumerary phantom arm); (3) in cases of focal brain lesions, the parietal lobes are most frequently affected while visual areas are usually spared; (4) after unilateral parietal lobe lesions, the phantom presence is confined to the contralateral space. If strictly lateralized presentations are reported after bilateral lesions, the right side of space is more often mentioned (Brugger et al., 1996), and (5) in cases of a personification of one’s own phantom half-body (see above), a transitive function of “alien” felt presences is sometimes obvious (Bychowski, 1943). Thus, exhausted mountaineers frequently overcome hopeless situations by caring for “the other,” who climbs with them and whose presence is felt compellingly enough to be offered food (e.g., Smythe, 1934).
3.3. From Seeing to Being One’s Own Doppelgänger: Heautoscopy and Out-Of-Body Experiences

Heautoscopy means “seeing one’s self” and thus implies the existence of two selves, one who observes and one who is observed. Unlike in autoptic hallucinations, visual aspects of bodily reduplication do not predominate. On the contrary, one’s doppelgänger is typically described as a pale, foggy, ghostlike, and transparent figure. More important are feelings of psychological affinity toward one’s double. As in the feeling of a presence, the doppelgänger is experienced as a space-occupying entity, which is, however, always recognized as “another me,” even if the visual features do not match one’s own (“dissimilar heautoscopy”: Grotstein, 1983; Issler, 1903; “heteroexperiential heautoscopy”: Corp, 1932; Lenaurerie et al., 1958). Increasing ownership over the one encountered in extra-personal space, that is, the doppelgänger, is paralleled by increasing feelings of depersonalization and a sense of “hollowness” of or detachment from one’s real body. In many instances, patients are at a loss to decide where in space to localize the “real me,” within the boundaries of the physical body or beyond (Figure 9.6B).

As is evident from this unstable perspective, the transition between heautoscopy (seeing a doppelgänger) and an OBE (being the doppelgänger) is necessarily blurred. The defining feature of an OBE is the illusory perception of one’s own body from outside (Figure 9.6C). The term doppelgänger and the perspective is clearly body-centered. Heautoscopy, or “seeing one’s self”, imparts the existence of two selves. Corporal awareness spreads to the doppelgänger, and the perspective may shift between ego-centric and alter-ego-centric. In an out-of-body experience, the observing self appears to pen-sieve the body from a location in extrapersonal space (self, but not necessarily, from a vantage point. Modified from Figure 5 of Blanke et al. (2004).

hallucinations, such as the appearance of one’s face or body against a background, are most frequently seen after visual cortex damage with occasional simultaneous impairment of the temporal lobes (Maximov, 1973). Involvement of the “extra-striate body area” (Downing et al., 2001) in the lateral occipito-temporal cortex seems likely. If the image of oneself is lateralized, it is usually to the left visual field (Brugger et al., 1997), reflecting, perhaps, the dominance of the right hemisphere in the recognition of one’s own face (e.g., Kircher et al., 2001; see Keenan, 1999, for review). Consistent with the absence of aspects of corporal awareness, other than visual representation, in an autoptic hallucination, is the point in phenomenal space on which the observer’s perspective rests. This perspective is always body-centered, that is, the patient describes the hallucination as observed from a regular within-body perspective (Figure 9.6A).
order to stop the "intolerable feeling of being divided in two" he finally jumped out of a window of his third floor apartment [sic]: A large bush saved his life.

The issue of perspective taking may provide a springboard for the fusion of physiological and psychological theories of autoscopic phenomena. The physiology of the maintenance of and shifts in first-person perspective is no longer beyond our grasp (see Vogele & Fink, 2003, for review). Indeed, there is reason to believe that the ability to shift one's spatial perspective may be a prerequisite for higher-order transformations in perspective related to imitation and empathy (Gallese, 2001; Hatfield et al., 1994; Ruby & Decety, 2003).

In autoscopic phenomena, the shifts in spatial perspective illustrated in Figure 9.6 are systematically related to changes in the subject's psychological perspective toward the phantom double. During autoscopic hallucinations, maintenance of a body-centered perspective is unshakable. The visual doppleganger is observed with amazement but never elicits confusion about "being in two places at once." In contrast, the unstable spatial perspective experienced during heautoscopy is frequently perceived as threatening and may be accompanied by self-destructive behaviors (Carp, 1952; Maack & Muller, 1983; Wigan, 1884). Finally, the subjectively unverifiable spatial detachment from one's own body in an OBE is almost always paralleled by an emotionally detached attitude toward a serious illness or a life-threatening danger. The role of denial in OBEs has been repeatedly emphasized (Eisenberg, 1974; Menz, 1984), and transinitic reactions are the rule. Subjects during an OBE in the context of a near-death experience (Grayson, 2000) are subjectively convinced that it is their body that faces danger, not their selves. The description of an OBE during a near-drowning, taken from the belleristic literature, may illustrate this point:

In his mind, Fialdaisy had already escaped from the boat, and was circling high in the air to find a rest for the sole of his foot. His body—was really sorry for its gross helplessness—lay in the stern, the water rushing about its knees. "How very ridiculous!" he said to himself. "...The poor beast is going to be drowned....I am on shore already. Why doesn't it come along?" (Kipling, 1893/2003, "The Bridge Builders," p. 19)

One phenomenological detail common to both heautoscopy and OBEs concerns the illusionary perception of nonbodily parts during bodily reduplication. While this issue has received some attention in the older literature, its treatment is underrepresented in more recent work. Gurewitsch (1933) mocked Menninger-Lerchenhals' (1932) analysis of Goethe's heautoscopy experience, in which he saw himself sitting on a horse. Gurewitsch argued that, according to Menninger-Lerchenhals' view of the doppleganger as an externalized body schema, Goethe would have reduplicated not only his own body schema, but also that of the horse. Menninger-Lerchenhals (1935, pp. 164-166) rejected the validity of this critique, pointing out that, for a person on horseback, the horse transtently becomes a part of his own body schema. In fact, the reduplication of body-related paraphernalia such as clothes, tools, or vehicles is the rule both in heautoscopy and OBEs and is reminiscent of the incorporation of hand-related paraphernalia in amputation phantoms and their reduplication in cases of supernumerary phantom arms (Hall et al., 1998; see Figure 9.4A). The view, from an apparent out-of-body location, of environmental objects beyond grasping space poses a different problem. There are many indications, especially from scattered observations in the parapsychological literature, that vision in an OBE involves the synesthetic integration of auditory environmental cues, much like the phenomenal visual experience of patients who deny their cortical blindness (Goldenberg et al., 1995). For the role of the vestibular system in shaping complex visual phenomenology, see Skowroz (1931) and Blanke (2004).

4. Research Perspectives

Encounters with a phantom of one's own body and self or experiences of oneself as a phantom are incomparably more complex than are sensations of a single phantom limb. To equate a (supernumerary) phantom arm with "an autoscopic double of the real arm" (Todd & Dewhurst, 1935, p. 54) or the heautoscopic doppleganger with a "phantom of the entire body" (Michorey, 1952) and an OBE with a "generalized version of the phantom limb experience" (Metzinger, 2003, p. 488) may be considered oversimplifications, if not mere metaphors. After all, whole-body amputations do not occur, nor are patients reporting autoscopic reduplications in a state of complete bilateral deafferentation/deafferentation (but see Bekkikiewicz, 1969; and Wisdom, 1953, for thought-provoking speculations). Yet, from a phenomenological perspective, subjects' descriptions of the perceived lawfulness of out-of-body states are highly reminiscent of those of subjects describing out-of-limb experiences.

One example concerns the phenomenon of obstacle slumping, repeatedly mentioned above in connection with phantom limbs. If, during an OBE, subjects walk around a virtual environment, their reactions to contact with solid matter vary greatly. Some report being unable to "penetrate" (imagined) objects; others easily pass through furniture and walls (Figure 9.7A); while still others do so only with considerable reticence (e.g., Bruce, 1999; Leaning, 1928; Monroe, 1971). It would be untrue to dismiss such metacritical descriptions just because most of them originate from the parapsychological literature. Taking phenomenology seriously does not imply accepting parapsychological interpretations. It rather opens up the possibility of investigating phenomena
that have retained a "ghostly" character solely because they have not yet been subject to experimental scrutiny.

The case of obstacle shunning is a neat illustration of the modifications of corporeal awareness by "intuitive physics," that is, top-down influences by knowledge about the behavior of physical objects. Paradigms to quantify the strength of such interactions between perception and knowledge exist. Most elegant is a method introduced by Stiffner and Freyd (1990), who showed that visual apparent motion of body parts is influenced by the depiction of a solid object along with two rapidly alternating pictures of a limb at slightly different locations (Figure 9.7B). As long as the temporal interval between the two pictures is brief (typically <300 ms), the apparent motion trajectories of the body part pass right through the solid object. However, with longer inter-stimulus intervals, obstacle shunning manifests itself as an adjustment of these trajectories such that the path of apparent motion becomes curved and thus avoids the location of the solid object. This methodology should be applied to

![Diagram](image)

Figure 9.7. (A) During an out-of-body experience, some individuals report an ability, others an inability, to "penetrate" solid matter. The decreased ability to maintain corporeal awareness at a position in space seen or imagined to be occupied by a solid object is reminiscent of obstacle shunning in amputees (see section 1.1). (B) Solidity constraints in the perception of apparent motion of the human body (Stiffner & Freyd, 1990). Individual differences in obstacle shunning may reflect individual differences in the susceptibility to visual-somatic interactions. Reproduced from Vieria (1986, Figure 282), with the permission of the author.

From Phantom Limb to Phantom Body

subjects with phantom limbs or phantom bodies who vary in their shunning behavior. We would predict stronger solidity constraints in those subjects who report shunning behavior in their spontaneous phantom experiences as compared to subjects who do not. Such a finding would provide a plausible basis to a phenomenon as yet considered too bizarre to be investigated.

Unjustified neglect of phenomenological detail is not restricted to reports from parapsychological sources. The neurological literature on hemiphenomena and phantoms of the entire body is replete with clinical observations whose meaningfulness for a neuropsychologist: understanding of corporeal awareness could only be appreciated after further experimentation. Among the relatively low-level somesthetic aspects of such phantoms, we mention a consistent bias not present for amputation phantoms, for a more salient representation of the upper parts of the body. In fact, meaningful interactions with one's hemiphenomena in somatosensory examinations are more often reported for the "action dominant" upper limbs. Consistent with this, in autoscopic phenomena, visualization is sometimes restricted to head, arm, and chest (Blanke et al., 2004; Conrad, 1953; Gennari, 1947; but see Blanke et al., 2002).

Interestingly, work with healthy subjects has produced evidence for a similar relative overrepresentation of the upper extremities. Reed and Farah (1995) explored the perception of changes in another person's limb positions as influenced by simultaneous movements of the observer's own limbs. Changes in arm positions were easier to detect than those in leg positions. The pattern of results further suggested that information about one's own body is used in a mandatory way when judging another person's visually perceived body posture (for additional discussion, see chapters 7 and 11). Reed and Farah's work is thus an early contribution to a growing body of literature on the intimate relationships of action observation and action execution (see Gallace & Goldman, 1998; Rizzolatti et al., 2001, for overviews). The system matching these two processes should be one central focus of future research concerning the variability of individual phantom experiences. Potential contributions of this system to the genesis of phantoms could be of particular theoretical importance in the discussion of innate components of corporeal awareness, both for body parts (see above) and for entire bodies (e.g., Ring & Cooper, 1999).

Among the "higher-order" phenomena of phantom experiences are those pertaining to the distinction between self and nonself. While phantoms after peripheral or spinal deafferentation are always considered an integral part of one's own body and self (except in cases of psychotic elaboration; Gallin, 1959; Stip & Perrenault, 1993), this distinction may get blurred in the face of hemi- or whole-body phantoms. Maintenance of a body-centered perspective appears to prevent one's reduplicated body from taking an autonomous role and thus becoming out of control of one's own intentions (Brugger, 2002). This clinical observation is consistent with a view of a continuum from motor to
conceptual cognition (Amorim, 2003; Ruby & Decety, 2001). The psychologi-
cal content of autoscopic reduplications may thus be shaped by a patient’s awareness, more or less compromised, of the true source of action plans. On the one hand, currently popular experimental designs to investigate agency attributions in normal subjects use selected patient groups (e.g., Farrer & Frith, 2002; Knoblich, 2003; see Blaisemore & Decety, 2001; and Wegner, 2002, for overviews) show the importance of autoscopic phenomena. On the other hand, once-popular but apparently forgotten clinical concepts, such as that of transvestism should be revised. Intriguingly simple experiments have shown that the projection of one’s own disturbances of corporal awareness onto other people depends on the alignment of one’s own body axis with that of others (Gloning, Hilt, et al., 1957), an observation highly relevant to trans-
vestitive own-body projections onto mentally hallucinated bodies (Schilder, 1919).

Certainly, in addition to promoting studies with special populations, more efforts should be undertaken to refine the methods to evoke phantoms sensations in healthy subjects. These comprise the provocation of a transient limb deaf-
ferentation, for example, by intravenous regional or by pressure-cuff-induced anesthesia (e.g., Brasil-Neto et al., 1992; Gross & Melzack, 1978; Melzack & Bogduk, 1973) and its application to vestibular stimulation (Crane, 1977; Jones, 1988; see also chapter 8 for discussion). The latter technique allows the transient dissociation of objectively realized and subjectively felt positions of one’s limbs to tendon vibration. Clever elaborations of this basic technique have been introduced to elicit the experience of various null limb phantoms. Most famous is the “Pinocchio illusion,” i.e., the experience of a phantom nose (Lackner, 1988; for the use of tendon vibration to produce a phantom of one’s entire body, see Lackner, 1992).

Both phantoms of paraplegic patients and vibration-induced phantoms in healthy subjects typically disappear upon looking at the real limb. Little is known about the precise nature of this visual-somatetic interaction. It is known, however, that vision and somatosensation are highly cooperative areas (e.g., Newport et al., 2001; see also chapters 3, 4, and 5). Although under certain conditions, vision will “capture” proprioception, under other conditions the brain is more inclined to believe proprioceptive information rather than vision (e.g., Man-Williams et al., 1997; Wann & Brabham, 1992). Understanding the processes that regularize these shifts in visual-proprioceptive dom-
inance is especially important for a better understanding of transitions from seeing to being one’s own dopplegänger. As feeling a phantom hand can be induced by watching the mirror image of one’s existing hand (Ramachandran et al., 1995), continuous observation of an online image of one’s entire body can produce an effect of whole-body visual capture (Stratton, 1999), just as the person immersed in a virtual-reality environment actually feels herself to be at the place where her own body is seen (Rheingold, 1991, p. 264).

Notes
1. The keyword phantom alone would have included also articles using the term in a completely different meaning. These include the definition of a dummy used for auto-
nomizations during medical training or for simulation purposes. In our 1-minute experi-
ment, subjects who produced associations to this type of phantom (medical students, exclusively) were not considered for the analyses.

2. According to this definition, phantom limbs after stroke-cord injury would also appear to belong to the category of "phantom sensory phantoms." Traditionally, however, the term is reserved for the awareness of extra limbs after brain lesions (Brugger, 2003a).

3. In direct opposition to this "bilateral representation" hypothesis (Grosen, 1996), Kinsbourne (1995) proposed an attentional model of congruent phantoms that views intact representations of one spared limb as inhibitory to the genesis of phantom sen-
sations. This made him overestimate the actual incidence of bilateral (as opposed to unilateral) limb agraphia (p. 217).

4. It should be noted here that individual patients’ reactions to the sight of para-
phantasia vary greatly. One patient of Sandfort (1946) accused his doctor of wearing his (the patient’s) ring when urged to look at his left hand, which he claimed to be the doctor’s. Confabulatory "incorporation" of a nurse’s arm, including her waistwatch, was reported by Critchley (1953, p. 239). On the other hand, mere visual observation of a scar on the left, subjectively disowned arm could restore ownership for a patient dis-
cussed by Johns (1949, case 2).

5. An example of exotomesthesia can be produced in normal subjects who watch an examiner touch a rubber hand aligned with their own hand, which is not actually touched but remains concealed from vision (Botvinick & Cohen, 1998; Patmii et al., 2000; chapter 8). The tips thus delivered are felt "out there" in an apparent out-of-body loca-
tion. This rubber-hand effect has generated significant secondary research, in par-
ticular in connection with clinical disorders involving unilateral somatosensory deficits (Friston et al., 2000; Rossouw et al., 1999).

6. This latter author reports the absence of shaming behavior during an OBHE. Trajectories of phantom body motion were nevertheless constrained by higher-order conceptual knowledge about physical objects: "I went out into the corridor, and I just went through the door (for habit I suppose, for my exit might just as well have been through the wall, because I did not open the door at all but just went through it)" (Leaming, 1928, p. 27).

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References


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