CHAPTER 11

# Altered States of Bodily Consciousness

*Sebastian Dieguez and Olaf Blanke*

## Introduction: The Bodily Self

Concepts such as consciousness and the self have proven notoriously difficult to define and have yielded enormous amounts of literature in a large array of disciplines (e.g., Bermúdez, Marcel, & Eilan, 1995; Metzinger, 2003). Recently, these concepts have been approached from the biological side by investigating their neurobiology and more generally how they are grounded in the organism and its physiology (i.e., the body). Neuroscientists, neurologists, experimental psychologists, and philosophers have joined forces and developed several lines of research trying to understand how the central nervous system dynamically represents the body and provides a basis for the sense of self. As the self, in the wider sense, is a manifold concept of staggering complexity, investigating the bodily self is often considered a fruitful approach to break down its minimal constituents and determine how extended aspects of the self are grounded on the body (e.g., Blanke & Metzinger, 2009; Damasio, 1999).

An important strategy has been to exploit the insights offered by the scientific study and phenomenological accounts of persons undergoing altered perceptions of their bodies. Such understanding of the bodily self and its neural mechanisms may also provide clues about the nature of altered states of consciousness (ASC), which often involve bodily manipulations in their induction (e.g., drug intake, exhaustion, fasting, body posture) and a modification of body representations as a consequence (illusions, hallucinations, and delusions involving body parts or the whole body, as well as its spatial location). Before we describe specific cases of alterations of the bodily self in clinical neurology and other states of

altered consciousness, we first discuss the nature of the bodily self and introduce the concept of altered states of bodily consciousness.

The bodily self is a more restricted concept than the notion of embodiment, which can be defined as the idea that cognitive functions such as perception, language, reasoning, and social interaction are grounded on bodily processing (Gibbs, 2006). By contrast, the bodily self as a theoretical concept refers to those aspects of the self that can be associated with the structure and functions of the individual's body. Culture, society, personal memories, and politics can probably be "embodied" to some extent, but the bodily self only relates to an organism's more basic properties, such as how we localize our own body in the environment, perceive its ongoing posture and movement, detect changes in internal homeostasis, experience its actions to be self-generated, and identify its parts as self-belonging (Bermúdez et al., 1995; Legrand, 2006).

The bodily self is historically associated to other concepts such as corporeal awareness, cenesthesia, the body schema, and the body image. Generally, all these notions refer to how the body is consciously or unconsciously experienced and represented. The brain is constantly receiving and sending, as well as updating, information from and to the body. Giving rise to the bodily self thus involves the dynamic integration of visual, tactile, proprioceptive, vestibular, auditory, olfactive, visceral, and motor information, as well as higher-order representations such as beliefs, desires, memories, and knowledge about bodies in general. This integration is achieved not by a single system in the brain but by a wide array of subsystems and bodily representations that, when impaired, can lead to altered states of bodily consciousness.

The very idea of the bodily self is closely tied to clinical neurology. The concept was born out of the observation of neurological disturbances affecting how some patients perceived their own body. French otologist Pierre Bonnier (1905) coined the word *aschématie* in 1905 precisely to refer to such disorders following severe vestibular impairments. The *schema* of the body, according to Bonnier, is a general sense of space, mostly unconscious, that transcends sensory modalities. This sense allows one to locate one's own body in the environment, feel the space it is occupying, know its current posture, and localize tactile sensations on its surface. Some neurological symptoms, Bonnier realized, seemed to suggest that such a sense existed and was disturbed in specific occurrences. Other authors independently presented similar ideas. British neurologists Henry Head and Gordon Holmes (1911–1912) notably highlighted the importance of motor mechanisms and the ability of the body schema to automatically and involuntary

update its representations by integrating ongoing movements and postural changes. These authors located the body schema, or what they called "an organized model of ourselves," in the parietal lobe.[1]

Although terminology has differed widely ever since these early proposals, the bodily self and its neural basis have to a large extent continued to be studied through manifestation of its disorders. Throughout this chapter, we use the term *altered states of bodily consciousness* to refer to disturbances of the bodily self. In such states, the person does not perceive his or her own body accurately, that is, the current state of the physical body is misrepresented (Revonsuo, Kallio, & Sikka, 2009).

Erroneous representations of the body differ widely as to their content. They can involve a specific body part, half of the body, the entire body, or the internal organs. Following neurological damage or interference to one hemisphere, symptoms often tend to be unilateral. Sometimes, however, disorders can extend bilaterally and even to the entire body. It is thus important, from a neuroscientific point of view, to ascertain the exact territory of the altered perceptions of the body, as this can point to the involvement of specific neural mechanisms.

Sometimes, the body is the only aspect undergoing an alteration, while perception of the environment or other persons is spared. On other occasions, however, altered states of bodily consciousness seem to involve an extension of the bodily self to external objects, other persons, or even one's surroundings. Indeed, dissolution of bodily boundaries, loss of ego, oceanic boundlessness, regressive, primitive, and infantile states (e.g., Mogar, 1990/1965) are not infrequent manifestations of mystical states, epileptic seizures, and psychiatric conditions referred to as ego-psychopathology (Scharfetter, 1981) [see Cardeña, this volume]. The distinctions between self and other, self and object, as well as between self and world, and their disturbance during altered states of bodily consciousness, might thus also be associated with specific underlying neural mechanisms (e.g., Maravita & Iriki, 2004).

Independently of the content of the bodily misrepresentation, the person's awareness of such bodily illusions can vary. Patients can also behave quite differently according to how they perceive (or fail to perceive) unusual body experiences. Three broad categories might help disentangle very

[1]Whereas *body schema* is somewhat closer to our use of *bodily self*, the term *body image* has often been used to refer to the conscious apraisal of one's body, involving visual, mnesic, verbal, emotional, sexual, social, and cultural information pertaining to one's own body. Both terms—*body schema* and *body image*—were and still are often used interchangeably (for a recent discussion, see de Vignemont, 2010).

different experiential approaches from each other: A person might be *indifferent* to what he or she is experiencing, *critical* about the illusory or unusual nature of his or her experiences, or *delusional* about certain specific beliefs concerning the bodily self (Dieguez, Staub, & Bogousslavsky, 2007).

Neurological patients who are indifferent do not notice that their perception and experience of their bodily self is anomalous. Such disorders are thus found only when an external person (e.g., the clinician) specifically investigates and detects the disorder. Thus the patient may be asked, for example, to move a limb or to describe her current bodily experience and only then respond in a way that is indicative of an altered state of bodily consciousness. In some cases, patients cannot even be brought to realize that they are misguided about their perceptions and beliefs concerning their bodies. This is the case of neurological patients who ignore their paralysis (anosognosia) or fail to pay any attention to the existence of half of their body (hemiasomatognosia).

In other instances, patients are critical of the alteration of the bodily self they are undergoing, and a rational evaluation as well as a generally accurate perception of the illusory nature of the experience can be achieved. For instance, patients retaining full awareness during migraine or seizure episodes may be able to describe in some detail, even *during* such experiences, how they perceive their bodies as abnormal.

Finally, patients presenting delusional alterations of bodily consciousness hold false beliefs that are impervious to any attempt at correction. Such patients not only perceive and report that something is wrong about their bodies but also claim that the alteration is *actually* happening or *really* has happened. Examples include reduplication of body parts, disownership of one's body parts, and claims of being invaded by bugs or having one's internal organs rotting. In the next sections, we describe in more detail such instances of altered states of bodily consciousness.

## Neurological Alterations of Bodily Consciousness

In what follows, we present selected examples of altered states of bodily consciousness caused by neurological disease. These disorders provide relatively "pure" instances of altered states of bodily consciousness, which have been extensively described and studied since the end of the 19th century, and furthermore allow a unique window into the neurological basis of bodily consciousness (Blanke, Arzy, & Landis, 2008; Dieguez, Staub, & Bogousslavsky, 2007).

### Phantom Limbs, Illusory Movements, Supernumerary Phantom Limbs

The phantom limb phenomenon is present, transiently or permanently, in the majority of amputees (Brugger, 2005; Ramachandran & Hirstein, 1998). Persons with phantom limbs vividly experience the presence of a limb that is physically absent. This is perhaps the clearest demonstration of the existence of a body schema implemented as a cerebral body representation. Indeed, it has been reported that cortical damage can dispel phantom limbs (Appenzeller & Bicknelle, 1969) and that experimental manipulations of the vestibular system (André, Martinet, Paysant, Beis, & Le Chapelain, 2001) or stimulation of premotor cortex (Bestmann et al., 2006) can modify phantom limb experiences. Research on phantom limbs suggests the causal involvement of a plastic reorganization of somatosensory and motor areas, a multilayered and innate network underlying bodily experience dubbed the "neuromatrix," cross-callosal hemispheric interactions, as well as complex multimodal interactions (Giummarra, Gibson, Georgiou-Karistianis, & Bradshaw, 2007).

Nonamputated individuals can also experience phantom limbs in the form of illusory movements. These refer to the experience that some hemiplegic patients have of performing movements without actually moving. When confronted with their failure to move, most patients acknowledge their mistake, but some will vehemently maintain that a movement has been performed despite evidence to the contrary (Ramachandran, 1995). These patients are often unaware of their paralysis (see below, *anosognosia*) or present unilateral neglect (Feinberg, Roane, & Ali, 2000). It is unclear, however, whether these claims reflect a genuine illusory movement or a verbal confabulation. Indeed, illusory movements are sometimes accompanied by delusional claims, such as when a patient not only claims having performed a movement but having seen his arm move or being able to perform and hear sounds of clapping, or even being able to touch the clinician's nose (Ramachandran, 1995). In nondelusional patients with hemiplegia, illusory movements can be induced by providing a false visual feedback using a fake hand placed where the patient thinks his real hand lies, whereas patients unaware of their paralysis tend to perceive self-generated movements in the fake hand even when the latter remains motionless (Fotopoulou et al., 2008). Hemiplegic patients presenting disorders of the body schema also tend to experience movements in their paralyzed limb when looking at mirror-reflected movements of their contralateral healthy limb (Zampini, Moro, & Aglioti, 2004). Lesions associated to illusory movements involve predominantly the right hemisphere

and most often the frontal and parietal but also the temporal cortex (Feinberg et al., 2000). It is also possible to induce illusory movements by stimulating electrically the right temporo-parietal junction (Blanke, Ortigue, Landis, & Seeck, 2002), in which case the illusion may have not only sensorimotor but also visual characteristics such as "seeing" that one's own limbs are approaching one's face.

Such phenomena should be distinguished from supernumerary phantom limbs, a condition defined as the perceptual experience of an additional body part, felt as an entity sharing properties of a real body part and occupying a different place in space. Unlike patients with illusory movements, patients with supernumerary phantom limb distinctly experience a "third arm." Some can critically evaluate the feeling as an illusion, but others will entertain the delusion that they actually own an additional limb or even experience more numerous duplications of arms or legs and perceive these multiple limbs as real. In the latter case, the term *delusional reduplication of body parts* has been proposed (Weinstein, Kahn, Malitz, & Rozanski, 1954). Most supernumerary phantom limbs involve a somesthetic perception of an immobile limb, localized separately but on the same side as the paralyzed limb (Antoniello, Kluger, Sahlein, & Heilman, 2009). Movements of such phantoms are usually rare and most often automatic or involuntary. It can also happen that the "extra limb" simply mimics the movements of the contralateral real limb or follows with some delay the movements of the ipsilateral real limb (McGonigle et al., 2002). There are, however, two cases in the literature describing intentional supernumerary phantoms in which the patients, paralyzed on one side, nevertheless experienced the movement of a phantom limb whenever (and only when) they wished to move it (Khateb et al., 2009; Staub et al., 2006). What is more, one of these patients also claimed to be able to *see* the phantom and "use" it to scratch her own face (Khateb et al., 2009), pointing to multimodal pathomechanisms [mechanisms by which a pathological conditions occurs] and similarities to heautoscopy, exosomesthesia, and asomatoscopy (see below). Lesions have involved the right basal ganglia (Halligan, Marshall, & Wade, 1993), the right subcortical capsulolenticular region (Khateb et al., 2009), the left anterior choroidal artery territory (Staub et al., 2006), the right frontomesial cortex (McGonigle et al., 2002), and parietal structures in the case of delusional reduplications (Weinstein et al., 1954). A few functional neuroimaging studies have been conducted in such patients, showing activity in the supplemental motor area during phantom movements mimicking movements of the duplicated limb (McGonigle et al., 2002), abnormal activity in subcortical thalamocortical loops during intentional movements of the phantom (Staub et al.,

2006), and activity in somatosensory and visual areas correlating with the patient's claim of being able to feel and see her intentionally moved supernumerary phantom limb (Khateb et al., 2009). Given the variety of phenomenological profiles, it is unlikely that a single explanation can account for all cases of supernumerary phantom limb. Purely postural phantoms probably can be explained as the result of a conflict between impaired current proprioceptive afferences, caused by thalamo-cortical disconnections, and a spared internal representation of the body. Kinesthetic phantoms may best be conceptualized as the result of preserved motor efferences and action planning in the context of defective multimodal integration (Khateb et al., 2009). Additional pathomechanisms involving other modalities and higher cognitive functions could be involved in cases with delusional beliefs.

The diversity of phantom limb phenomena, whether arising from amputation or brain damage, points to a complex and highly efficient network of body-related brain functions that smoothly provide a coherent bodily self in healthy persons.

### Tactile Hallucinations and Mislocalizations

Whereas visual and auditory hallucinations have been defined according to the absence of an external object giving rise to a percept, tactile hallucinations have led to conceptual problems, as it is not easy to objectively ascertain the absence of itches, numbness, and aches (Berrios, 1982). For instance, amputees can feel so-called "referred sensations" in a nonexisting limb concomitantly with a brush to specific body parts (Cronholm, 1951; Ramachandran & Hirstein, 1998). Although the sensation is felt in a nonexisting limb, the regularity of the phenomenon argues against a hallucination.

Unusual or altered tactile experiences have frequently been reported in the neurological literature. Like visual hallucinations, tactile misperceptions range from the simple to the elaborate. Parkinson's disease and related disorders are a frequent etiology of simple tactile hallucinations (Fénélon, Thobois, Bonnet, Broussolle, & Tison, 2002), whereas in advanced dementia, psychiatric conditions, substance abuse, and cerebrovascular disease, patients sometimes present with delusional parasitosis, the type of abovementioned "bugs" hallucinations, also called Ekbom's syndrome or dermatozoic hallucination (de Leon, Antelo, & Simpson, 1992).

The absence of tactile awareness from one body part is a frequent accompanying feature of many disorders discussed in this chapter. So-called paresthesias, most notably, are a frequent first alert to patients undergoing a neurological event. These involve tinglings, pins and

needles, numbness, and alterations in the experience of weight, size, temperature, and motricity, even in the absence of motor disorders. In turn, such feelings can lead to an experience of alienation from one's body parts and even partial depersonalization, perhaps underlying rare cases of apparently healthy persons who wish to be amputated (Blanke, Morgenthaler, Brugger, & Overney, 2009).

Neurologists have also observed mislocalizations of touch following brain damage. The phenomenon of alloesthesia refers to the perceptual transfer, usually from left to right (in the case of right-sided brain damage), of tactile sensations (Bender, 1970). Such patients are usually not aware of their mistakes. Although alloesthesia is most often caused by large lesions in the temporo-parietal areas of the right hemisphere, similar tactile mislocalizations are easily induced in about a quarter of healthy participants under laboratory conditions (Marcel et al., 2004).

Perhaps more strikingly, touch can sometimes be experienced *outside* of one's body. This is what some rare reports have referred to as exosomethesia. This experience can happen under a variety of conditions, for instance during testing for alloesthesia (Shapiro, Fink, & Bender, 1952) and in Tourette's syndrome (Karp & Hallett, 1996). As mentioned earlier, amputees sometimes report tactile sensations in their phantom limbs. However, there is at least one instance of "phantom exosomesthesia" in which an amputee has reported a referred touch as arising from slightly *outside* of the phantom (Cronholm, 1951). Some persons otherwise healthy also report feeling touch when they see someone else being touched, a synesthetic experience related to empathic tendencies (Banissy & Ward, 2007). However, it does not seem that these individuals actually feel touch as if it arose *in* the other person (i.e., they feel it in their own body concomitantly to the touch they see on the other person). It is nevertheless relatively easy to induce the experience of touch as arising from objects or fake body parts, usually by inducing visuo-tactile conflicts (Botvinick & Cohen, 1998), but also after practice with an extended tool (Maravita & Iriki, 2004) and the induction of spatially contiguous tactile inputs (Miyazaki, Hirashima, & Nozaki, 2010). A feeling of numbness seemingly arising from someone else's finger can also be achieved simply by simultaneously touching one's own finger together with another person's finger (Dieguez, Mercier, Newby, & Blanke, 2009).

### Bodily Transformations (Illusory Amputation, Size Changes, Disconnections)

Some neurological patients can experience the sensation that a part of their body has vanished. These are cases of "sensation of absence" or "true

sensation of amputation" (as opposed to amputees who feel a phantom limb and have an experience of bodily completeness and therefore do not feel their amputation as an absence), and are part of what Frederiks (1963a) named *conscious hemiasomatognosia* (see below, *hemiasomatognosia and anosognosia*), meaning a critical awareness that something is lacking from one's bodily experience. This symptom has also been described in the visual modality, whereby a patient reports being unable to *see* a specific part of her body (asomatoscopy) following restricted damage to the right premotor and motor cortices (Arzy, Overney, Landis, & Blanke, 2006). Similar phenomena involve the feeling that a limb is detached from the body, as if it were floating at some distance from the trunk (Podoll & Robinson, 2002), or that the body is split in two halves (Heydrich, Dieguez, Grunwald, Seeck, & Blanke, 2010). Such experiences are usually short lived and happen mostly during epileptic seizures, migraine events, or vascular stroke (Hécaen & Ajuriaguerra, 1952) affecting premotor, primary motor, or parietal cortex, as well as subcortical structures of either hemisphere. These illusions can appear in isolation, without any accompanying neurological symptoms.

Other phenomena are characterized by more diffuse sensations of alienness, disconnection, or absence of body parts from the rest of the body, which are felt as numb, anesthetized, or empty. These forms have been called *hemi-depersonalization* (Heydrich et al., 2010; Lhermitte, 1939), as an analogy to full-fledged depersonalization, which usually involves the entire bodily self.

The terms *micro-* and *macrosomatognosia* refer to alterations in the perception of size and weight of certain body parts (Frederiks, 1963b). Thus, a limb can be experienced as shrunken to the size of a baby's hand or grotesquely immense (sometimes also referred to as Alice in Wonderland Syndrome; Todd, 1955). Again, such illusions are typically found in migraine and epilepsy, as well as damage to sensorimotor structures in either hemisphere.

### Hemiasomatognosia, Anosognosia

The term *hemiasomatognosia* was coined by French neurologist Jean Lhermitte (1939) to refer to unawareness of a body part or a hemibody. Frederiks (1963a) tried to clarify some conceptual issues by distinguishing between conscious and "nonconscious hemiasomatognosia. "Conscious" hemiasomatognosia refers to patients who perceive their body as incomplete or amputated while realizing that what they experience is an illusion (see above, *Bodily transformations*), whereas "nonconscious" hemiasomatognosia

refers to the disappearance of body parts from one's awareness, the patient being unable to notice or report this disappearance.

Subforms of nonconscious hemiasomatognosia are currently known as personal neglect, motor neglect, or anosognosia for hemiplegia. In all these conditions, there is indifference, forgetfulness, or unawareness for parts of one's own body. Personal neglect refers to the classical picture where a patient forgets to comb, shave, or make up the left side of his or her face. Motor neglect refers to patients who underuse or fail to use altogether their left limbs despite having no motor impairment. Conversely, patients with anosognosia for hemiplegia behave as if they were not paralyzed, as they ignore their left hemibody altogether and/or deny that there is anything wrong with it. Nevertheless, anosognosia for hemiplegia is a complex phenomenon, with patients differing widely as to their explicit and implicit insight of being paralyzed (Cocchini, Beschin, Fotopoulou, & Della Sala, 2010). For instance, some patients deny their impairment but nevertheless never act as if they were not paralyzed, while others might admit being paralyzed but still attempt actions that are impossible for them.

Recent lesion-mapping analyses comparing patients with right-hemispheric damage with and without anosognosia have highlighted the specific involvement of the right posterior insula (Baier & Karnath, 2008; Karnath, Baier, & Nägele, 2005) and an additional network of sensorimotor areas including the somatosensory, primary motor, and premotor cortices, as well as the inferior parietal lobule (Berti et al., 2005). Anosognosia is a multifaceted syndrome involving defective awareness of motor control, impaired integration of multimodal information, and disturbances of attentional and cognitive monitoring (Orfei et al., 2007).

### Somatoparaphrenia

German neurologist Joseph Gerstmann sought to distinguish between particular cases of hemiasomatognosia and used the term *somatoparaphrenia* for strongly delusional instances (Gerstmann, 1942). *Somatoparaphrenia* thus refers to false beliefs concerning a body part or a hemibody, the most frequent being disownership of one's hand (whereby patients repeatedly claim that their own left hands do not belong to them, or more explicitly that they belong to someone else, the doctor, a nurse, a roommate, or some undetermined person; review in Vallar & Ronchi, 2009). However, such delusions can vary considerably, suggesting that the notion covers various disorders. Some patients will deny the ownership of a limb without attributing it to someone else explicitly. Others will state spontaneously that their

limb belongs to someone specific, even someone altogether absent from the current environment or already dead. Some patients will elaborate their claim by stating that their limb has vanished or has been stolen, sometimes leading to complaints to the hospital staff. The strength of the delusion can also vary, some patients being able to acknowledge that there is something bizarre about their belief and others maintaining their claims despite overwhelming counter-evidence.

Moreover, there are two types of misattribution in somatoparaphrenia: Parts of one's own body can be attributed to someone else or, conversely, parts of someone else's body can be attributed to oneself (Gertmann, 1942). Patients with somatoparaphrenia can display strong emotional reactions—for instance, they can fall from their bed after trying to "kick out" what they think is an alien limb. Similarly, patients presenting with misoplegia can display hatred of the paralyzed limb that borders on the delusional but without presenting explicit feelings of disownership (Loetscher, Regard, & Brugger, 2006).

Some cases of somatoparaphrenia suggest an association with other disorders of the body schema such as supernumerary phantom limbs, when a limb is disowned while an "extra" one is present, or the feeling of a presence, when the disowned limb is perceived as a whole person lying nearside in the bed.

Most of the reported cases of somatoparaphrenia involve the left side of the body following a right-sided stroke. Lesions generally involve an extended fronto-temporo-parietal network, with a predominance of posterior areas, such as the temporo-parietal junction, the posterior insula, as well as subcortical structures (Vallar & Ronchi, 2009). Involvement of medial frontal and orbitofrontal areas seems to distinguish delusional types of disownership from mildest types of limb estrangement (Feinberg et al., 2010). Interestingly, the posterior insula is the most commonly involved area in both somatoparaphrenia and anosognosia for hemiplegia (Baier & Karnath, 2008). Although these two disorders can be separated, this finding nevertheless suggests that, at both the clinical and anatomical level, awareness of action and ownership of body parts are tightly linked (Baier & Karnath, 2008).

### Whole-body Hallucinations, Vestibular Hallucinations, Autoscopic Phenomena

We now turn to altered states of bodily consciousness involving the entire body. Most of the disorders described in the previous sections, as well as others we haven't addressed here, can conceptually be extended to the entire body (see Blanke et al., 2008; Dieguez et al., 2007).

Almost four centuries ago, Descartes was greatly impressed by accounts of phantom limbs in amputees, which might have led him to wonder about the potential results of a "radical amputation" in the fourth part of his *Discourse on the Method* (1637) (as suggested by Ferret, 1998, pp. 161–162). Would amputation of the whole body unleash a "phantom body," just like an amputated arm "releases" a phantom limb (see also Mitchell, 1905/1866)? Later, Lhermitte (1939) proposed the concept of "complete asomatognosia" to refer to an extreme form of depersonalization (sometimes called Cotard's syndrome) as a full-body analogy to his concept of hemiasomatognosia. In such cases, patients may go as far as to claim to be nonexistent or dead (Young & Leafhead, 1996).

The extension of altered states of bodily consciousness from body parts to the whole body seems to require the involvement of the vestibular system. Vestibular disturbances are indeed known to induce dissociations between the experienced and the actual posture, movement, and orientation of the body. In the tilt-room illusion, for instance, patients might feel a complete disconnect between the actual position of their bodies and the orientation of their surroundings, which can appear tilted as far as 90° (Tiliket, Ventre-Dominey, Vighetto, & Grochowicki, 1996). More diffuse disturbances are also found in patients with vestibular disturbances and healthy participants undergoing caloric vestibular stimulation [water or air irrigation into the auditory canal], a procedure that stimulates the vestibular system and induces symptoms comparable to depersonalization (Sang, Jáuregui-Renaud, Green, Bronstein, & Gresty, 2006). Interestingly, caloric vestibular stimulation has been shown to activate brain areas involved in several altered states of bodily consciousness, including the right temporo-parietal junction and posterior insula (Fasold et al., 2002) and also to alleviate such symptoms (Bisiach, Rusconi, Vallar, 1991).

Bodily mislocalizations, hallucinations of body parts, and supernumerary phantom limbs have recently been linked to autoscopic phenomena (Blanke, Landis, Spinelli, & Seeck, 2004; Brugger, 2002). This group of disorders involves multimodal illusions inducing the experience of more or less complete duplicata of one's own body. An autoscopic hallucination is one where experiencers perceive a visual double of themselves in extrapersonal space. However, such visual perception of one's body can also involve mislocalizations of the bodily self. Thus, during heautoscopy, a person can experience the bodily self alternatively, or even at the same time, in the physical and the seen body. In neurological patients undergoing this *Doppelgänger* experience, an involvement of the left temporo-parietal junction and the left mesiobasal temporal lobe has been found (Blanke & Mohr, 2005). In an out-of-body experience, a person feels her

self as spatially localized outside of the physical body and experiences seeing the latter from an elevated perspective (*see below*).

Another related illusion, referred to as the feeling of a presence, is characterized by a closely "projected" double that is not visible (Brugger, Regard, & Landis, 1997). The "presence" of a person can be felt sideways, behind, or in front of one's physical body, and may even involve multiple "presences" (Brugger, Blanke, Regard, Bradford, & Landis, 2006). Such a feeling of presence has been induced by cortical electrical stimulation of the posterior part of the left superior and middle temporal gyrus (Arzy, Seeck, Ortigue, Spinelli, & Blanke, 2006). For both heautoscopy and the feeling of presence, damage to or abnormal activity in parietal and temporal-limbic structures, and a resulting vestibular dysfunction, have been posited as plausible pathomechanisms underlying such complex experiences.

### Out-of-body and Near-death Experiences

The out-of-body experience (OBE) can be defined as a waking experience combining disembodiment, elevated perspective, and autoscopy. However, specific features, such as how the "disembodied self" is perceived, the modalities involved, the ability to move, and so forth, can vary widely across persons (Alvarado, 2000), suggesting multiple etiologies and mechanisms. The neural correlates of such extraordinary experiences are beginning to be understood, highlighting the roles of multisensory integration and vestibular processes. An OBE was recently induced by cortical electrical stimulations during presurgical investigations for intractable epilepsy (Blanke et al., 2002). At lower intensities, stimulation of the right temporo-parietal junction (rTPJ) induced simple vestibular illusions, whereas stronger intensities at the same region induced an OBE (see also De Ridder, Van Laere, Dupont, Menovsky, & Van de Heyning, 2007). The rTPJ, and especially the angular gyrus and posterior superior temporal gyrus, was later found to be the critical overlapping region in a group of brain-damaged and epileptic patients with OBE (Blanke et al., 2004; Blanke & Mohr, 2005), and was involved in a task where healthy participants had to mentally project themselves out of their body to resolve a task of laterality (Blanke et al., 2005).

Studies of persons with sleep paralysis reporting OBE-like experiences and related disorders, as well as healthy persons with an experience of OBE (about 5–10% of the general population report at least one such experience during a lifetime; Alvarado, 2000), suggest that neural mechanisms related to REM intrusion (Nelson, Mattingly, & Schmitt, 2007), the vestibular and motor system (Cheyne & Girard, 2009), emotions (Nielsen,

2007), synesthetic tendencies (Terhune, 2009), as well as personality factors such as absorption, dissociation, schizotypy, and body image dissatisfaction (reviewed in Blanke & Dieguez, 2009) are associated with the experience of disembodiment and altered states of bodily consciousness involving the whole body.

Such mechanisms are also likely involved in OBEs that occur under stressful events or extreme medical situations, so-called "near-death experiences" (Blanke & Dieguez, 2009; Holden, Greyson, & James, 2009). In addition to disembodiment, such experiences may be associated with the experience of a passage through darkness or a "tunnel," the perception of a "divine" light, a "panoramic" review of one's life memories, and encounters with "spirits" or deceased relatives. As one early observer put it, the NDE, by its very nature, seems "made to astonish; fast, unexpected, extraordinary, usually poorly understood, it takes the appearance of an internal marvel; it gives rise to illusions and legends" (Egger, 1896, p. 367). Mild disturbances of the temporal lobe and altered sleep patterns have been found in a restricted sample of persons with NDE (Britton & Bootzin, 2004), as well as a higher prevalence of REM intrusions in waking life than in a control group (Nelson, Mattingly, Lee, & Schmitt, 2006), pointing to similar sleep-related mechanisms as for OBEs. Nevertheless, at this stage it is difficult to envision a neurocognitive account of NDEs as there is a dearth of systematic empirical neuroscientific research on this class of phenomena, perhaps due to its paranormal overtones and the lack of a consistent and operational definition. Indeed, a number of conditions have been reported to induce similar experiences, most often involving some alteration of the bodily self and not being necessarily life-threatening, such as syncope (Lempert, Bauer, & Schmidt, 1994), intracranial brain stimulation (Vignal, Maillard, McGonigal, & Chauvel, 2007), the perception of danger (Noyes & Kletti, 1977), and psychological stress (Siegel, 1984).

All in all, it seems that the OBE in neurological patients, healthy persons, and under life-threatening situations, is associated with a disintegration of sensory modalities, notably vestibular, visual, and proprioceptive information, together with a variety of factors reflecting cognitive, emotional, and perhaps cultural factors, leading to failures of self-localization and displacement of the first-person perspective.

### Behavioral and Experimental Alterations of Bodily Consciousness

We cover in this section a variety of "classical" altered states of consciousness and how they affect the bodily self, as well as experimental methods developed to study the bodily self in the laboratory.

### Mystical States

Altered states of consciousness associated with mystical states or meditation have been reported to induce alterations of bodily consciousness from times immemorial. In these states, "dissolution of the ego" or "pure consciousness" are often reported, referring to an experienced merging of the self and bodily self with external space and accompanied by a felt transcendence from spatial and temporal constraints, a sense of sacredness and ineffability, and an overall positive mood (Pahnke & Richards, 1990/1966; Wulff, 2000). Such states can also be close to, or even cause, OBE- and NDE-like episodes. An involvement of the limbic system, associated to a sudden release of endorphins (Prince, 1982) or in the form of ecstatic epileptic seizures of temporal lobe origin (Picard & Craig, 2009), has been highlighted as a neurobiological correlate of such experiences. A recent investigation of the impact of brain damage on the personality trait "transcendent self" also suggests the importance of the temporo-parietal junction (Urgesi, Aglioti, Skrap, & Fabbro, 2010), an area also involved in other cases of altered bodily awareness of body parts (such as anosognosia and somatoparaphrenia) as well as illusory full-body perceptions (such as out-of-body experiences). Physical and environmental factors can also be involved, as experiences of bodily dissolution and separation of the self and body have been reported during physical exhaustion of runners (Morgan, 2002) and in high-altitude mountaineers (Brugger, Regard, Landis, & Oelz, 1999).

### Hypnosis

Hypnosis is perhaps the most compelling area of overlap between neurology and ASC, at least historically [see Cardeña & Alvarado, Volume 1]. Early investigation of "hysteric" patients suggested an influence of hypnosis on bodily function and experience. At least in certain persons, neurological-like symptoms have been relieved or induced by different methods of hypnosis. Most notably, anaesthesia/analgesia and paralysis during hypnosis have been the focus of much attention and recently been revived in neuroscientific research (Cojan et al., 2009). Hypnotic induction of altered states of bodily consciousness has also been incorporated as a tool in the cognitive neurosciences of belief formation in healthy participants (e.g., Cox & Barnier, 2010). We also note that hypnosis has been used to induce OBEs (Irwin, 1989). Although the mechanisms underlying hypnosis are far from understood, these findings point to the importance of suggestibility and higher-order belief systems, as well as the influence

of conducive bodily states (e.g., quiescence, Cardeña, 2005), as part of the etiology of altered states of bodily consciousness.

### Drugs

Drugs have probably been the most salient artificial inducer of ASC throughout history, and complex alterations of the bodily self have long been reported following intoxication by a wide array of substances [see Presti, this volume]. For instance, Havelock Ellis vividly described the bodily experiences of a mescal user, who reported feelings of heaviness in one leg while the rest of the body seemed to dematerialize, the back of his head splitting in two and releasing flows of vivid colors, wind rushing through his hair, sensations of lightness and contraction, visual hallucinations of parts of his own body, and the feeling of being inside his own body and looking through it as through a thin transparent skin (in Lhermitte, 1939, pp. 167–168). In addition to feelings of "dissolution" and various forms of transformations, "getting high" often involves the sensation of levitating and flying, as well as leaving one's body, as described by French poet and painter Henri Michaux in his monograph on the effects of marijuana (Michaux, 1967, pp. 132–135).

Indeed, apart from well-known effects such as distortion of sense of time, increase in self-confidence, heightened awareness, and complex mental associations (Hastings, 1990/1969), marijuana is also well known to influence bodily consciousness. Charles Tart (1971) conducted a survey of marijuana users that showed a very wide range of bodily self alterations: Users sometimes experience their whole body as bigger or smaller than usual, the shape of their body as strangely altered, the body felt as numb, as well as full-blown OBEs.

The "Good Friday" experiment conducted by Pahnke in 1962 (see follow-up by Doblin, 1991) demonstrated that psilocybin, unlike a placebo, allowed inducing mystical states along with alterations of bodily consciousness sometimes similar to OBEs and NDEs. More recently, Griffiths and collaborators replicated this finding in a better-controlled setting, and participants likewise reported experiences of unity with their surroundings, loss of self, somaesthetic hallucinations and sensations similar to OBEs and NDEs (Griffiths, Richards, McCann, & Jesse, 2006). Reporting on the effects of LSD, Pahnke and Richards (1990/1966) also described a wide range of bodily effects, such as "intriguing somatic sensations, feeling as though [the] body is melting, falling apart, or exploding into minute fragments" (p. 493), "changes in kinesthetic and cutaneous reception" and "claims of merging with floorboards or feeling unity with the walls of a

room" (p. 497). Finally, anesthetics are also known to induce alterations of bodily consciousness for body parts (including feelings of disownership; Paqueron et al., 2003), as well as OBEs and NDEs (Corazza & Schifano, 2010).

### Experimental Procedures

Experiments in sensory deprivation have been used as a powerful scientific tool for investigating the interactions between bodily awareness and cognition. In such studies, participants lie in an isolation tank, deprived of as many sensory signals as possible (Zubek, 1969). The effects of such experiments have been compared to medical conditions involving sensory and motor impairments (Jackson, Pollard, & Kansky, 1962) and more recently to the effects of mind-altering drugs (Mason & Brady, 2009). Altered states of bodily consciousness have also been reported during such conditions, with illusory movements, complex tactile hallucinations, feelings of a presence, depersonalization, and OBEs (Heron, 1957).

As is the case with other ASC, it is known that OBEs are favorably induced when lying down or relaxing (Zingrone, Alvarado, & Cardeña, 2010), an important observation in the light of accounts of the OBE in terms of vestibular hallucination (Schwabe & Blanke, 2008). Individuals claiming to be able to deliberately self-induce OBEs have also used a variety of sensory deprivation and meditation methods (reviewed in Blackmore, 1982). More recently, laboratory investigations have delineated controlled approaches to induce, or at least mimic, some aspects of OBEs. Most notably, visuo-tactile conflicts have been exploited to investigate the OBE (Ehrsson, 2007; Lenggenhager, Tadi, Metzinger, & Blanke, 2007). These studies have used virtual reality as a method to provide participants with visual perceptions of their own bodies (via a recording camera feeding a head-mounted display) while experiencing tactile sensations congruent or incongruent with those applied to their visual double. Measures of self-location and subjective reports about self-identity in such experiments have revealed the importance of congruent visuo-tactile information for the bodily self (review in Aspell & Blanke, 2009).

These paradigms have been inspired by experimental approaches to modify bodily consciousness of body parts. The rubber-hand illusion, for instance, operates under similar visuo-tactile conflicts, whereby a person looks at a fake hand being stroked by a brush while feeling the same sensation on her real (and hidden) hand. In such circumstances, it is often reported that the felt brushes seem to be located onto the fake hand, and objective measures reveal that participants experience their real hand to

be located closer to the fake hand than it really is (Botvinick & Cohen, 1998). Interestingly, feelings of illusory ownership during the rubber-hand illusion have been found to correlate with objective changes in temperature in the real hand (Moseley et al., 2008), suggesting that similar processes underlie experimentally-induced illusory ownership in healthy persons and a number of psychiatric and neurological conditions involving altered states of bodily consciousness (reviewed in Moseley et al., 2008). Coupled with clinical investigations, the experimental study of full-body illusions provides a very promising approach for understanding the neurocognitive processes underlying the bodily self and altered states of bodily consciousness.

## Conclusion

In this chapter, we have covered a wide array of altered states of bodily consciousness. Perhaps most striking is the sheer phenomenological variety of these bodily experiences. Misrepresentations of the physical body can involve selected body parts, half of the body, or the entire body and self. Whereas some of them are critically perceived as illusory by the experient, even sought after in some cases, others can be outright delusional. Their content can involve varied phenomena such as mislocalizations, illusory movements, presence of nonexistent body parts, disappearance of body parts, size and shape transformations, denial of ownership, incorporation of external objects, merging of boundaries, complete disembodiment, and denial of impairment.

At this stage, an encompassing theoretical framework to explain and reliably induce such states is not available. It is indeed difficult to assess to what extent these complex misrepresentations, which can occur after neurological damage or in psychiatric conditions but also spontaneously and under experimental circumstances, are comparable. Nevertheless, the distinction between altered states of bodily consciousness involving body parts and the whole body (Dieguez et al., 2007) and the segregation of the bodily self into three core constituents (namely, the first person-perspective, self-location, and self-identification) suggest preliminary frameworks (Blanke & Metzinger, 2009). Notably, a network in the right hemisphere involving the temporo-parietal junction, the posterior insula, and the basal ganglia, as well as premotor and primary sensory structures, has been identified to be crucially involved in the integration of body parts and representations of the whole body, as well as the calibration of an egocentric spatial frame of reference allowing one to coherently locate one's

body with respect to gravity and the surrounding environment. Future work should allow scientists to fine-grain these observations and disentangle the systems underlying specific alterations of the bodily self. A worthwhile question, for instance, would be whether body parts and whole-body alterations can be mapped unto an anatomo-functional continuum or whether they arise from different processes altogether.

Most importantly, any insights have been and will be the result of investigations carried out from a wide range of perspectives, including analytical philosophy, phenomenology, clinical neuropsychology, experimental psychology, and the cognitive neurosciences. New therapeutic methods and creative experimental paradigms, incorporating pharmacological improvements, brain–computer interfaces, as well as robotic and virtual reality technology, will also emerge in the near future. Merged with the insights offered by approaches and traditions often considered as outside the reach of science, such as hypnosis, shamanism, mysticism, religious rituals, and the use of mind-altering drugs, the study of altered states of bodily consciousness holds the potential to offer important scientific insights about the brain processes involved in creating our everyday experience of the self. Conversely, careful theoretical and conceptual work on the bodily self can guide our understanding and the development of experimental approaches to ASC at large.

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