CHAPTER

23

Leaving Body and Life Behind: Out-of-Body and Near-Death Experience

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OUTLINE

ABSTRACT

Out-of-body experiences (OBEs) and near-death experiences (NDEs) are complex phenomena that have fascinated mankind from time immemorial. OBEs are defined as experiences in which a person seems to be awake and sees his body and the world from a disembodied location outside his physical body. Recent neurological and neuroscientific research suggests that OBEs are the result of disturbed bodily multisensory integration, primarily in right temporo-parietal cortex. NDEs are more loosely defined, and refer to a set of subjective phenomena, often including an OBE, that are triggered by a life-threatening situation. Although a number of different theories have been proposed about the putative brain processes underlying NDEs, neurologists and cognitive neuroscientists have, so far, paid little attention to these phenomena. This might be understandable but is unfortunate, because the neuroscientific study of NDEs could provide insights into the functional and neural mechanisms of beliefs, concepts, personality, spirituality, magical thinking, and the self. Based on previous medical and psychological research in cardiac arrest patients with NDEs, we sketch a neurological framework for the study of so-called NDEs.

Out-of-body experiences (OBEs) and near-death experiences (NDEs) have accompanied and fascinated humanity since times immemorial and have long been the province of circles interested in the occult. Many authors have even argued that these experience provide evidence for mind-brain independence or even the persistence of life after death. The neurology of OBEs and NDEs takes a different stance and proposes to study the brain mechanisms that are associated with these experiences. Accordingly, OBEs have been studied by neurologists and cognitive scientists, as they allow to investigate the functional and neural mechanisms of bodily awareness and self-consciousness in specific brain regions. In the present paper we will review these recent neuroscientific data on OBEs. The situation is quite different for NDEs. Although many different theories have been proposed about putative underlying brain processes, neurologists and cognitive neuroscientists have paid little attention to these experiences. This is unfortunate, because the scientific study of NDEs could provide insights into the functional and neural mechanisms of many facets of human experience such as beliefs, concepts, personality, spirituality, magical thinking, and the self. Moreover, as we will review, there is a frequent confusion between OBEs and NDEs (e.g., [1–2]). This is probably due to the fact that OBEs are often associated with NDE, if not one of the NDE key feature [3–5]. In the following, we will describe OBEs and NDEs, providing definitions, incidences, key phenomenological features, and reviewing some relevant psychological and neurocognitive mechanisms.

OBES

Definition

In an OBE, people seem to be awake and feel that their 'self', or centre of experience, is located outside of the physical body. They report seeing their body and the world from an elevated extracorporeal location [6–10]. The subject's reported perceptions are organized in such a way as to be consistent with this elevated visuo-spatial perspective. The following example from Irwin ([11], case 1) illustrates what individuals commonly experience during an OBE: 'I was in bed and about to fall asleep when I had the distinct impression that "I" was at the ceiling level looking down at my body in the bed. I was very startled and frightened; immediately [afterwards] I felt that I was consciously back in the bed again'.

We have defined an OBE by the presence of the following three phenomenological features: the feeling of being outside of one's physical body (disembodiment); the perceived location of the self at a distanced and elevated visuo-spatial perspective (perspective); and the experience of seeing one's own body (autoscopy) from this elevated perspective [10]. In other proposed definitions of OBEs it suffices to experience disembodiment. For example, Alvarado defined OBEs as 'experiences in which the sense of self or the centre of awareness is felt to be located outside of the physical body' ([12], p. 331; see also [13]) and Irwin as experiences in which 'the centre of consciousness appears to the experient to occupy temporarily a position which is spatially remote from his/her body' [11]. Brugger's definition requires disembodiment and a distanced visuo-spatial perspective: 'the feeling of a spatial separation of the observing self from the body' [8]. OBEs therefore seem to constitute a challenge to the experienced spatial unity of self and body under normal conditions, that is, the feeling that there is a 'real me' that resides in my body and is both the subject and agent of my experiences [14–15]. Probably for this reason, OBEs have attracted the attention of philosophers [16–17], psychologists [6, 11, 18], and neurologists [7, 19–21] alike, and many have conceptualized OBEs as an extreme example of deviant bodily self-consciousness arising from abnormal brain processes that code for the feeling of embodiment under normal conditions.

Incidence

How common are OBEs in the general population? This question is still difficult to answer for the following reasons: (1) different investigators have asked quite different questions about the presence of an OBE; (2) have used different methods (mail, phone or personal interviews); and (3) most studies have been carried out in populations of college students, mostly from anglo-saxon psychology departments. Depending on the questions asked, how they are asked, who the samples include and how an OBE is defined, the results are very likely to differ. Accordingly, it is not surprising that questionnaire studies have estimated the OBE incidence in the general population as ranging from 8% to 34% (reviewed in [6]). Also the two key features (autoscopy and distanced visuo-spatial perspective), as used in recent neurobiologically motivated studies by Brugger and Blanke, were not considered as necessary OBE-features in most of these surveys. We thus agree with Blackmore [6] that incidences above 10% are very likely overestimates and we conservatively suggest that ~5% of the general population have experienced an OBE. From a cross-cultural point of view OBEs seem to occur and be part of folklore in many parts of the world, although to date very few studies have investigated this interesting issue [22].

Phenomenology

OBEs have to be distinguished from two other phenomena that also involve autoscopy: autoscopic hallucinations and heautoscopy. Whereas there is no disembodiment in autoscopic hallucinations and always disembodiment in OBEs, many subjects with heautoscopy generally do not report clear disembodiment, but are not able to localize their self unambiguously (self location may alternate between an embodied location and an extracorporeal one, or they might feel 'localized' at both positions at the same time). Accordingly, the visuo-spatial perspective is body-centred in autoscopic hallucinations, extracorporeal in the OBE, and at different extracorporeal and corporeal positions in heautoscopy, with the impression of seeing one's own body (autoscopy) present in all three forms of autoscopic phenomena (Figure 23.1; for further details, see [7–8, 20, 23–24]).

OBEs have been the province of esoteric circles for much of its history. From this literature one may nevertheless find abundant phenomenological details and varieties of OBEs (e.g., [25–27]; for review see [6]). In addition, subjects with repeated OBEs (so-called 'astral travellers') have not just given detailed accounts about their OBEs, but also proposed several procedures to induce OBEs that might be approached more systematically by researchers. These authors also reported about the phenomenological characteristics of the disembodied body, its location with respect to the physical body, the appearance of the autoscopic body, and the vestibular and bodily sensations associated with the experience (see [7]). Yet, only a small minority of subjects with OBEs experience more than one or two in a lifetime. OBEs are therefore difficult to study because they generally are of short duration, happen only once or twice in a lifetime [6, 9] and occur under a wide variety of circumstances that will be reviewed in the following.

Precipitating Factors

Several precipitating factors of OBEs have been identified. We review findings from neurology, psychiatry, drugs, and general anaesthesia. OBEs will also be discussed in the section on the phenomenology of NDEs.

Neurology

Only few neurological cases with OBEs have been reported in the last 50 years. Early reports were by Lippman ([28], case 1 and 2), Hécaen and Green ([29], case 3), Daly ([30] case 5), and Lunn ([31], case 1). More recently, Devinsky *et al*. ([19], case 1, 2, 3, 6, and 10), Maillard *et al.* ([32], case 1), and Blanke *et al*. ([7], case 1, 2a, and 3) reported further cases. OBEs have been observed predominantly in patients with epilepsy and migraine. Thus, Lippman reported two migraine patients with OBEs [28] and Green reported that 11%

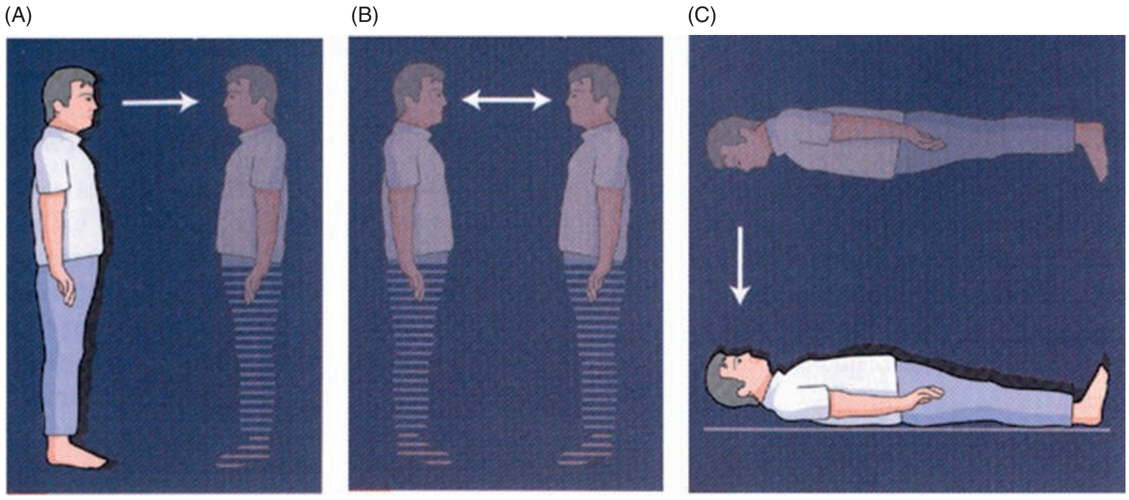

FIGURE 23.1 Illustration of three types of autoscopic phenomena (from Blanke and Mohr [23]). In this figure the phenomenology of (A): autoscopic hallucination (AH), (B) heautoscopy (HAS), and (C) out-of-body experience (OBE) is represented schematically. The experienced position and posture of the physical body for each autoscopic phenomenon is indicated by full lines and the experienced position and posture of the disembodied body (OBE) or autoscopic body (AH, HAS) in blurred lines. The finding that AH and HAS were mainly reported from a sitting/standing position and OBE in a supine position is integrated into the figure. The experienced visuo-spatial perspective during the autoscopic phenomenon is indicated by the arrow pointing away from the location in space from which the patient has the impression to see (AH: from the physical body; OBE: from a disembodied body or location; HAS: alternating or simultaneously from either the fashion between physical and/or the autoscopic body). *Source*: Modified from Blanke *et al.* [7], with permission from Oxford University Press.

of the OBE-subjects that participated in her survey suffered from migraine headaches [9]. Devinsky *et al*. [19] reported the largest study of neurological OBE-patients and described patients whose OBE was associated with non-lesional epilepsy (cases 6 and 10), with epilepsy due to an arteriovenous malformation (cases 2 and 3), or associated to post-traumatic brain damage (case 1). In Blanke *et al*.'s study [7], OBEs were due to a dysembryoplastic tumour (cases 1 and 2a) and in one patient was induced by focal electrical stimulation (case 3). Maillard *et al.* reported epileptic OBEs in a patient with focal cortical dysplasia ([32], case 1).

Grüsser and Landis [21] proposed that a paroxysmal vestibular dysfunction might be an important mechanism for the generation of OBEs. Devinsky *et al*. [19] observed the frequent association of vestibular sensations and OBEs and in Blanke *et al*.'s [7] study, the importance of vestibular dysfunction in OBEs was underlined by their presence in all patients with OBEs and by the fact that vestibular sensations were evoked in a patient at the same cortical site where higher currents induced an OBE [33]. In more detail, it has been suggested that OBEs are associated with specific vestibular sensations, namely graviceptive and otolithic sensations [7, 34–35]. Otolithic sensations are characterized by a variety of sensations including feelings of elevation and floating, as well as 180° inversions of one's body and visuo-spatial perspective in extrapersonal space. They may be associated with brain damage [36–37], but also occur in healthy subjects during orbital and parabolic flight during space missions or the microgravity phase of parabolic flights [38–39]. Interestingly, responses to microgravity may either be experienced as an inversion of the subject's body and visuo-spatial perspective in extrapersonal space (body inversion illusion) or as an inversion of the entire extrapersonal visual space that seems inverted by 180° to the stable observer (room-tilt illusion; [38–39]). Based on these functional similarities Blanke *et al*. [7] suggested that an otolithic dysfunction might not only be an important causal factor for room tilt and body inversion illusions, but also for OBEs (for further details, see [34–35]).

In addition to vestibular disturbances, it has been reported that OBE-patients may also experience paroxysmal visual body-part illusions such as phantom limbs, supernumerary phantom limbs, and illusory limb transformations either during the OBE or during other periods related to epilepsy or migraine [7, 19, 31, 33, 40]. Blanke *et al*. [33] reported a patient in whom OBEs and visual body-part illusions were induced by electrical stimulation at the right temporo-parietal junction (TPJ). In this patient an OBE was induced repetitively by electrical stimulation whenever the patient looked straight ahead (without fixation of any specific object). If she fixated her outstretched arms or legs she had the impression that the inspected body part was transformed, and had an illusory, but very realistic, visual impression of limb shortening and of illusory limb movement whenever the limbs were bent at the elbow or knee. Finally, with closed eyes the patient did have neither an OBE nor a visual body-part illusion, but perceived her upper body as moving towards her legs [33]. These data suggest that visual illusions of body parts and visual illusions of the entire body (such as autoscopic phenomena) might depend on similar neural structures, as argued by previous authors [20, 40]. They also show that visual body-part illusions and OBEs are influenced differently by the behavioural state of the subject (body posture and eye closure).

Another functional link between OBE and disturbed own body perception is suggested by the fact that OBEs and autoscopic hallucinations (and heautoscopy) depend differently on the patient's position prior to the experience. This suggests that proprioceptive and tactile mechanisms influence both phenomena differently [34]. Thus, during neurological OBEs patients are in supine position [7, 23], an observation also made by Green [9] in 75% of OBEs in healthy subjects. Interestingly, most techniques that are used to deliberately induce OBEs recommend a supine and relaxed position [6–11]. This contrasts with the observation that subjects with autoscopic hallucination or heautoscopy are either standing or sitting at the time of their experience [7, 23, 41]. It thus seems that OBEs depend on the subject's position prior or during the experience and that these differential proprioceptive, vestibular, and tactile mechanisms differentiate them from other types of autoscopic phenomena (see 'Summary' below). The observation of OBEs during general anaesthesia and sleep (see 'General anaesthesia' and [10]) also corroborates the notion that OBEs are facilitated by the sensory signals predominating in supine body position. Moreover, rapid bodily localizational changes such as brutal accelerations and decelerations have been associated with OBEs. This has been reported for a long time by mountain climbers who unexpectedly fell [42–46], as well as in car accidents [19, 25] and in the so-called 'break-off phenomenon' experienced by airplane pilots [47]. In this last case, a pilot might initially fail to sense correctly the position, motion, or tilt of the aircraft as well as his own body position with respect to the surface of the earth and the gravitational 'earth-vertical'. These feelings can lead to several experiences grouped under the term 'break-off phenomenon' that are characterized by feelings of physical separation from the earth, lightness, and an altered sense of the pilot's own orientation with respect to the ground and the aircraft [47–49]. Some pilots have even described a feeling of detachment, isolation, and remoteness from their immediate surroundings which they sometimes describe as an OBE with disembodiment, elevated visuo-spatial perspective, and autoscopy [47, 50]. At one extreme, pilots feel being all of a sudden *outside* the aircraft watching themselves while flying, and being 'broken off from reality' [47]. These OBEs are most often experienced by jet aviators flying alone, especially at high altitudes (above 10 000 m), although helicopter pilots can experience this phenomenon already at an altitude of 1500–3000 m [47, 50]. They seem facilitated by mental absorption (the pilot is unoccupied with flight details) and by the length and visual monotony of the mission [48].

With respect to the underlying neuroanatomy, as mentioned above, we can only rely on a few neurological OBE-patients with circumscribed brain damage. In some of Devinsky *et al.*'s [19] patients with OBEs the seizure focus was estimated only by electroencephalographic (EEG) recordings and localized to the temporal lobe or posterior temporal region (standard MRI (magnetic resonance imaging) or computer tomography was normal in most patients). Yet, in one patient the lesion was found in the temporal lobe and in another patient in the frontal and temporal lobes [19]. Lunn [31] described an OBE-patient with post-traumatic brain damage in the parietal lobe and Daly [30] an OBE-patient with damage to the temporal lobe. More recent lesion analysis based on MRI revealed a predominant involvement of the right TPJ in patients with OBEs [7, 23, 32]. Moreover, in the case already described, Blanke *et al.* [33] have shown that OBEs can be induced by electrical stimulation of the TPJ pointing to the importance of this region in the generation of OBEs (Figure 23.2).

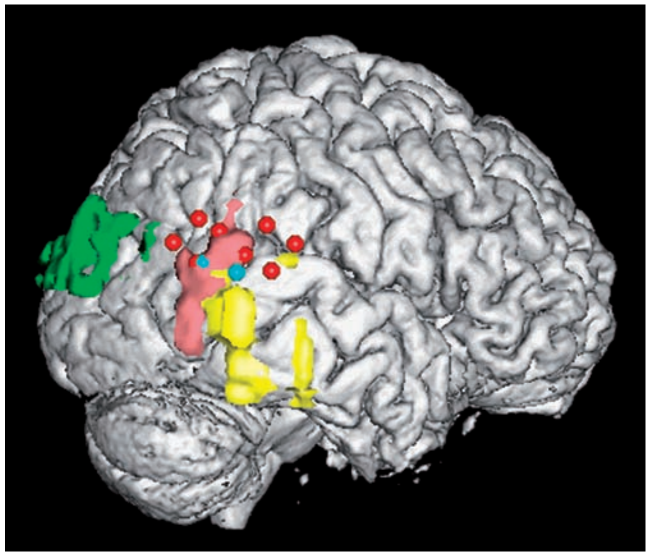

FIGURE 23.2 Lesion analysis of patients with documented brain anomalies and OBE. Mean lesion-overlap analysis of five neurological patients with OBE in whom a lesion could be defined (Patients 1, 2, 3, 5, and 6 from [7]). The MRI of all patients was transformed into Talairach space and projected on the MRI of one patient. Each colour represents a different OBE patient. Mean overlap analysis centred on the TPJ. For details, see [7] and [24]. *Source*: Modified from Blanke *et al*. [7], reproduced with permission from Oxford University Press.

Psychiatry

While reports of autoscopic hallucinations and heautoscopy are not rare in patients suffering from schizophrenia, depression and personality disorders [7, 19–20, 40, 51–52], Bünning and Blanke [10] found only two cases of OBE in psychiatric patients. One had severe depression [29] and the other patient was undiagnosed [53]. Two questionnaire surveys have investigated OBEs in schizophrenia [54–55] and found a similar incidence and phenomenology as in healthy subjects. A study in psychiatric patients suffering from post-traumatic stress disorder found a four-fold increase in prevalence as compared to healthy subjects [56]. Moreover, the personality measure of schizotypy is positively correlated with OBEs in healthy subjects [57–58] and has also been shown to relate behaviourally and neurally (at the TPJ) to OBEs [59–60]. As this trait reflects a continuum between healthy subjects and schizophrenic patients, these data suggest that OBEs might be more frequent in schizophrenic patients than currently thought. Finally, other personality traits such as individuals' somatoform [61–62] (but not general dissociative [60]) tendencies, body dissatisfaction [62], or dissociative alterations in one's body image during a mirror-gazing task [63] have also been linked to OBEs.

Drugs

The administration of different pharmacological substances has presumably been used since immemorial times in ritual practices to induce abnormal experiences including OBEs [22]. These include marijuana, opium, heroin, mescaline, ketamine, and lysergic acid diethylamide (LSD) [6, 21, 52, 64–65]. Concerning marijuana, Tart [64] found that OBE occurred in 44% of a sample of 150 college students who used this drug (see also [10]), that is, a much higher frequency than in the general population. However, a majority of the subjects with OBEs of this study frequently used other drugs such as LSD. It is thus not known whether the higher frequency of OBEs is due to marijuana consumption or the consumption of other drugs. Experiences related to OBEs such as a feeling of floating or of being dissociated from one's body, have also been induced under controlled conditions by marijuana administration compared with placebo administration [66], although similar data with respect to OBEs or other autoscopic phenomena are lacking.

General Anaesthesia

It has long been known that conscious perceptions may occur under general anaesthesia. As Spitellie *et al*. [67] put it: 'Awareness during anaesthesia is as old as the specialty itself'. Insufficient levels of anaesthesia combined with the application of muscle relaxants seem to be the main cause of this preserved awareness. Another pathophysiological factor might be related to haemodynamic cerebral deficits, most notably in anaesthesized patients undergoing cardiac and post-traumatic surgery [68–69]. OBEs in association with general anaesthesia have been described in retrospective case collections by Muldoon and Carrington [25] and Crookall [70], but also in more recent patient studies ([71] patient 3; [72] 4 of 187 patients). A patient from Cobcroft and Forsdick [72] reports: 'I had the strangest […] sensation of coming out of my self; of being up at the ceiling looking down on the proceedings [of the operation]. After the initial realization that I couldn't communicate at all, came the feeling of acceptance … of being aware of having one hell of an experience'. Several of the patients reported by Osterman *et al*. [73] said that they 'left their body during the operation at some point'. Although it seems that OBEs are quite rare during general anaesthesia, this is probably linked to the relative infrequency of visual awareness during this state, and the much higher frequency of auditory perceptions (89%), sensations of paralysis (85%), motor illusions and bodily transformations (30–40%), and pain (39%). Visual perceptions were reported in only 27% of patients ([74]; see also [72]). Yet, among patients with visual perceptions, many reported disembodiment and seeing the surgeon and other people and/or surroundings of the operating theatre during the actual operation. Thus, if analyzed only with respect to the presence of visual awareness and experiences in the context of general anaesthesia, OBEs and OB-like experiences are not so rare. This is of special interest because paralysis, complex own body perceptions, and supine position are not only frequent during general anaesthesia with preserved awareness, but also key features in subjects with OBEs of spontaneous or neurological origin [6–7, 23, 75]. Concerning haemodynamic cerebral deficits that have been shown to be associated with an increased incidence of awareness during anaesthesia (see review in [10]), it is interesting to note that they may lead to rather selective and initially focal decreases in cerebral blood flow and as a consequence induce transient or manifest brain infarctions that frequently include the TPJ [76], suggesting that OBEs under general anaesthesia might be related to the functional and anatomical pathomechanisms described in neurological patients with epilepsy, migraine, and cerebrovascular disease. We will return to effects of general anaesthesia in the section on NDEs.

Summary

The reviewed data point to an important involvement of the right TPJ in OBEs of neurological origin. The observation that electrical stimulation of this area may induce OBEs and other abnormal own body perceptions further suggests that during OBEs the integration of proprioceptive, tactile, visual, and vestibular information of one's body fails, due to discrepant central own body representations. We have suggested [7, 23] that autoscopic phenomena (including OBEs) result from a failure to integrate multisensory bodily information and proposed that they result from a disintegration in bodily or personal space (due to conflicting tactile, proprioceptive, kinaesthetic, and visual signals) and a second disintegration between personal and extrapersonal space (due to conflicting visual and vestibular signals caused by a vestibular otolithic dysfunction). While disintegration in personal space was present in all three forms of autoscopic phenomena, differences between the different forms of autoscopic phenomena were mainly due to differences in strength and type of the vestibular dysfunction. Following this model, OBEs were associated with a strong otolithic vestibular disturbance, whereas heautoscopy was associated with a moderate and more variable vestibular disturbance, and autoscopic hallucinations were devoid of any vestibular disturbance. Neuroimaging studies have revealed the important role of the TPJ in vestibular processing, multisensory integration as well as the perception of human bodies or body parts and the self (see [10, 24]). This has recently been studied in healthy subjects. Blanke *et al*. [77], performed an evoked potential study and a transcranial magnetic stimulation study with healthy participants as well as intracranial electrode recordings in a patient with OBEs due to epilepsy. The evoked potential study showed the selective activation of the TPJ at 330–400 ms after stimulus onset (see also [60]) when healthy volunteers imagined themselves in the position and visual perspective that is generally reported by people experiencing spontaneous OBEs. The transcranial magnetic stimulation study showed that magnetic interference with the TPJ during this same time period impaired performance in this task, as opposed to stimulation over a control site at the intraparietal sulcus. No such interference was observed for imagined spatial transformations of external objects, suggesting the selective implication of the TPJ in mental imagery of one's own body and OBEs. Moreover, in an epileptic patient with OBEs due to seizure activity at the TPJ, performing the own body imagery task, while evoked potentials were recorded from intracranial electrodes, we found task-specific activation at the TPJ. Together, these results by Blanke *et al*. [77] (see also [60, 78]) suggest that the TPJ is a crucial structure for the conscious experience of the spatial unity of self and body (for detailed reviews, see [10, 23, 34–35, 79]) and that the associated brain processing is disturbed in OBEs. We now turn to NDEs, which as we will see offer more insights into the mechanisms involved in OBEs.

NDEs

Definition

In different life-threatening situations, people can sometimes experience vivid illusions and hallucinations as well as strong mystical and emotional feelings often grouped under the term of near-death experiences (NDEs). These medical situations seem to involve cardiac arrest, perioperative or post-partum complications, septic or anaphylactic shock, electrocution, coma resulting from traumatic brain damage, intracerebral haemorrhage or cerebral infarction, hypoglycaemia, asphyxia, and apnoea. To this date, systematic studies on the incidence of NDEs in verified medical conditions only exist for cardiac arrest patients [80–83]. Other situations that are merely *experienced* as life-threatening have also been reported to be associated with NDEs, although they often are not objectively life-threatening (mild or not life-endangering diseases, depression, minor accidents, falls, and other circumstances [80]).

Several definitions have been attempted for NDEs. Moody [3], who coined the term NDE, defined it as 'any conscious perceptual experience which takes place during … an event in which a person could very easily die or be killed […] but nonetheless survives' ([84], p. 124). Irwin [85] defined NDEs as 'a transcendental experience precipitated by a confrontation with death' and Nelson *et al.* [86] state that 'NDEs are responses to life-threatening crises characterized by a combination of dissociation from the physical body, euphoria, and transcendental or mystical elements'. Greyson [87] proposed that NDEs are 'profound subjective experiences with transcendental or mystical elements, in which persons close to death may believe they have left their physical bodies and transcended the boundaries of the ego and the confines of space and time'. Many more such broad definitions of the NDE have been given [88–89] rendering their scientific study difficult. They seem to include a large variety of phenomena and not all researchers may agree that the investigated phenomenon (or assembly of phenomena) of a given study, may actually concern NDEs or typical NDEs. Below, we have reviewed the most frequent and characteristic perceptual and cognitive features of NDEs (see 'Phenomenology'). To complicate matters NDEs (just like OBEs) are difficult to study as their occurrence is generally unpredictable and they are usually not reported at their moment of occurrence, but days, months or even years later.

Incidence

Early studies of NDEs among survivors of cardiac arrest, traumatic accidents, suicide attempts, and other life-threatening situations estimated an incidence of 48% [4] or 42% [5]. Greyson [90] suggested that this rate is probably too high as these studies were retrospective, often carried out many years after the NDE occurred, were using self-selected populations, and lacked appropriate control populations. He rather estimated the incidence of NDEs between 9% and 18%. More recent and better controlled prospective studies focussed on cardiac arrest patients and confirmed lower estimations, with values ranging between 6% and 12%. Parnia *et al.* [81] found an incidence of 6.3%, Greyson [83] of 10%, and Van Lommel *et al.* [80] of 12%. Yet, as is the case for OBEs, in the absence of a clear and widely accepted definition of NDEs, it will remain difficult to define the exact incidence of NDEs [87–90]. In order to avoid this problem most recent studies have used a score above a certain value on Greyson's scale ([91], see below).

Early studies failed to find demographic correlates of the NDE. Neither age, nor gender, race, occupational status, marital status or religiosity seemed to predict the probability to experience a NDE [4–5]. More recently, both Van Lommel *et al.* [80] and Greyson [83] found that young age is associated with a higher probability of NDEs in cardiac arrest patients, although this finding might be confounded by increased medical recovery rates in younger cardiac arrest patients [80, 83]. Another finding is that women tend to have more intense NDEs than men [4, 80] an observation that might partly be related to Moody's [3] suggestion that women might be less afraid to report NDEs or the fact that women have been found to score generally higher on anomalous-perception questionnaires than male subjects [59]. It is possible that having had a NDE facilitates the reoccurrence of such experiences, as 10% of subjects reported multiple NDEs [80]. NDEs have been described in many different cultures and times. Although some consistency can be found in cross-cultural reports, the specific phenomenology (i.e., the structure and the contents of the experience) may nevertheless vary [92–96].

Phenomenology

Moody [3, 84] initially listed 15 key features in NDEs (see Table 23.1). Yet, not one single NDE in his study included all 15 NDE features. Moreover, none of these 15 NDE features was present in all reported NDEs, and no invariable temporal sequence of features could be established. Due to these difficulties, standardized questionnaires have subsequently been developed to identify and measure more precisely the occurrence of NDEs and their intensity (or depth). Ring [4] developed the Weighted Core Experience Index on the basis of structured interviews of 102 persons who found themselves "near-death". The scale is based on 10 features that he gathered from the literature as well as interviews with people with NDEs. His 10 features were: the subjective feeling of being dead, feelings of peace, bodily separation, entering a dark region, encountering a presence or hearing a voice, experiencing a life review, seeing or being enveloped in light, seeing beautiful colours, entering into the light, and encountering visible spirits. According to the presence or absence of each of these features, the score ranges between 0 and 29. This scale has been criticized because it is largely based on arbitrary selected and weighted features, and seemed to contain several uncommon features of NDEs as estimated by other authors. Ring [4] also elaborated a sequence of 5 NDE-stages, the presence of which he considered to be representative of the 'core NDE' (see Table 23.1). To address the aforementioned limitations, Greyson [91] developed a NDE scale that has been used by many recent investigators. He began by selecting 80 features from the existing literature on NDEs and subsequently reduced these to 33 features. He further arrived at a final 16-item scale with a maximum score of 32. This questionnaire has been shown to have several advantages as compared to other questionnaires, especially good test–retest reliability (even for a follow-up at 20 years; [97]) and item score consistency [98]. In his original study, Greyson [91] defined four components of a NDE – cognitive, affective, paranormal, and transcendental – which he later reduced to a classification of three main types of NDEs, according to the specific dominance of the phenomenological components: cognitive, affective, and transcendental types [99]. See Table 23.1 for these and other classifications of the NDE. In the following we describe the main phenomena that characterize NDEs.

OBEs

OBE are considered a key feature of NDEs, although their frequency was found to vary greatly between different studies. Ring [4] found that 37% of subjects with a NDE experienced disembodiment ('being detached from their body') of whom about half also experienced autoscopy (no detailed data were reported on elevation or visuo-spatial perspective). Greyson and Stevenson [102] found an incidence of 75% of disembodiment (without detailing the presence of autoscopy or elevated visuo-spatial perspective). Sabom [5] reported a 'sense of bodily separation' in 99%, a number in stark contrast with the figure of 24% found by Van Lommel *et al.* [80]. Disembodiment during NDEs has been reported to be accompanied by auditory and somatosensory sensations [85]. NDE subjects with OBEs characterized by disembodiment and elevated visuo-spatial perspective often report seeing the scene of the accident or operating room. Greyson [103] mentions the example of an NDE in a 26-year-old patient with pulmonary embolism: 'I (the real me, the soul, the spirit, or whatever) drifted out of the body and hovered near the ceiling. I viewed the activity in the room from this vantage point. The hospital room was to my right and below me. It confused me that the doctors and nurses in the room were so concerned about the body they had lifted to the bed. I looked at my body and it meant nothing to me. I tried to tell them I was not in the body (p. 393)'. Future studies on OBEs during NDEs should characterize OBEs with respect to recently defined phenomenological characteristics and enquire systematically about the associated sensations as done in neurological patients (such as visual, auditory, bodily, or vestibular sensations) as well as the presence of disembodiment, autoscopy, elevated perspective permitting to distinguish between autoscopic hallucination, heautoscopy, and OBE. This will allow describing the phenomenology of OBEs during NDEs in more detail and allow relating these data to recent neurological and neurobiological observations on OBEs. Not much is currently known about whether OBEs that are associated with NDEs differ from OBEs without NDE features or whether NDEs with or without OBEs differ. Alvarado [104] found that OBEs in subjects who believed to be close to death were phenomenologically richer than those who did not, with more feelings of passing through a tunnel, hearing unusual sounds, and seeing spiritual entities. Two additional features reached

TABLE 23.1 Phenomenological Features of NDEs According to Several Authors

Moody [3]	Ring [4]	Greyson [91]
Identified 15 common elements in NDEs based on a sample of 150 reports. No statistics were provided.	Identified five stages of a 'core experience', based on structured interviews and a measurement scale (WCEI: weighted core experience index) administered to 102 individuals who have been near death, 48% of whom reported a NDE. These stages tended to appear in sequence, with the earlier ones being more frequent and the latter ones indicating the "depth" of the experience.	Devised a typology of NDEs based on his development of the 16-item NDE scale. On the basis of cluster analysis, he arrived at ones four categories of NDEs each comprising four features.
1. Ineffability 2. Hearing oneself pronounced dead 3. Feelings of peace and quiet 4. Hearing unusual noises 5. Seeing a dark tunnel 6. Being 'out of the body' 7. Meeting 'spiritual beings' 8. Experiencing a bright light as a 'being of light' 9. Panoramic life review 10. Experiencing a realm in which all knowledge exists 11. Experiencing cities of light 12. Experiencing a realm of bewildered spirits 13. Experiencing a 'supernatural rescue' 14. Sensing a boarder or limit 15. Coming back 'into the body'	1. Peace and well-being, reported by 60%. 2. Separation from the physical body (OBE), reported by 37% (half of whom had an autoscopic OBE) 3. Entering a tunnel-like region of darkness, reported by 25% 4. Seeing a brilliant light, reported by 16% 5. Through the light, entering another realm, reported in 10%	1. Cognitive features – time distortion – thought acceleration – life review – revelation 2. Affective – peace – joy – cosmic unity – encounter with light 3. Paranormal – vivid sensory events – apparent extrasensory perception – precognitive visions – OBEs 4. Transcendental – sense of an 'otherworldy' environment – sense of a mystical entity – sense of deceased/religious spirits – sense of border/'point of no return'
Sabom [5]	**Noyes and Slymen [100]**	**Lundahl [101]**
Proposed from his investigation of 48 subjects with NDE three main types of experiences.	Conducted a factor analysis of questionnaire responses from 189 victims of life-threatening accidents, and found the following three factors of subjective effects that accounted for 41% of the variance.	Summarized the NDE literature and extracted what he saw as the 10 main stages.
1. 'autoscopic' (i.e., the NDE is essentially an OBE) 2. transcendental (apparently entering another 'dimension' through a tunnel and meeting a personified light) 3. combined (involving an OBE and transcendental features)	1. Depersonalization (loss of emotion, separation from the body and feelings of strangeness or unreality) 2. Hyperalertness (vivid and rapid thoughts, sharper vision and hearing) 3. Mystical consciousness (feeling of great understanding, vivid images, life review)	1. peace 2. bodily separation 3. sense of being dead 4. entering the darkness 5. seeing the light 6. entering another world 7. meeting others 8. life review 9. deciding to or being told to return to life 10. returning to the body

statistical significance, namely seeing one's physical body and seeing lights (see also [105]). Of course, it might be the case that due to the very presence of these features these subjects *believed* they had been close to death (there were no medical data available in this study). Owens *et al.* [106] compared the phenomenology of NDEs in subjects being medically close to death with NDEs where subjects only *believed* to be close to death (as established from medical records). They found that former patients tended to report more often seen lights and enhanced cognition than the latter group [106]. There were no significant differences between both groups in seeing a tunnel (see below), having an OBE and a life review (see below). Finally, Nelson *et al.* [107] found that 76% of subjects with NDEs also experienced an OBE. ~40% of these patients had their OBE only as part of the NDE episode, ~33% also had OBEs in other circumstances, and ~26% had an OBE only in other circumstances, that is, not associated with the NDE. This last number was significantly higher than non-NDE-related OBEs in an age-matched control group of healthy subjects [107]. Further links might exist between rare, so-called supernaturalistic OBEs [11], and OBEs during NDEs. Collectively, these data suggest that OBEs and NDEs may share some functional and brain mechanisms, but also point towards the involvement of distinct mechanisms.

The Tunnel and the Light

Experiencing a passage through some darkness or a tunnel is experienced by ~25% of subjects with NDEs [4–5, 80]. This may be associated with the sensation of movement of one's own body such as forward vection, flying or falling, at varying speeds. Drab [108] and Owens *et al.* [106] suggest that the experience of a tunnel is associated with the presence of severe medical conditions (such as cardiac arrest, drowning, trauma, profuse blood loss), as opposed to mild injuries, fear, or fatigue. Woerlee [109] provides the following example: 'After I had floated close to the ceiling for a short time, I was sucked into a tunnel … It was black and dark around me, somewhat frightening, but this did not last long: at the end of the tunnel I saw a clear light towards which I travelled.' (p. 211). The tunnel experience or darkness may thus be associated with the subsequent experience of an intense light. Drab [108] found this to be the case in half of the subjects with NDEs who reported the experience of a tunnel. Ring [4] and Sabom [5] found that 30% and Van Lommel *et al.* [80] that 23% of subjects with NDE reported seeing a light, but did not specify if this was associated with the experience of a tunnel. The light is usually white or yellow, very bright, but not experienced as painful. It seems to cover a larger area in the visual field when subjects experience vection [108].

The Life Review

The life review has been defined as the perception of 'unusually vivid, almost instantaneous visual images of either the person's whole life or a few selected highlights of it' ([85], p. 204). Heim [42] reports the following life review during a mountain fall: '… I saw my whole past-life take places in many images, as though on a stage at some distance from me. I saw myself as the chief character in the performance. Everything was transfigured as though by a heavenly light and everything was beautiful without grief, without anxiety, and without pain.' Life reviews were found in 13–30% of subjects with NDEs [4, 80, 91, 100, 110]. Stevenson and Cook [111] analysed 122 subjects with NDEs and reported that the number of distinct life memories may range from a few images (one or two) to the impression of a rapid flow of countless images depicting their entire life. Some subjects reported that the life review unfolds with an infinite number of images, simultaneously ('all at once'). It is usually experienced very vividly, associated with bright colours and can occur as moving in chronological order or in the opposite order (i.e., ending or starting with childhood; [96]). It can also purportedly involve elements of the future [112]. Two studies speculated that life reviews are especially frequent in drowning victims, as compared to other situations [110, 113]. Conversely, it seems that suicide survivors [114] and children with NDEs [115–116] rarely report life reviews.

Meeting of Spirits

People often report seeing or feeling different entities or people during NDEs. Greyson [117] gives the following example from the report of a man admitted to the hospital due to cardiac disease: '… he experienced an apparent encounter with his deceased mother and brother-in-law, who communicated to him, without speaking, that he should return to his body' (p. 315). The encounters are sometimes identified as supreme beings, pure energy, spiritual guides, angels, helpers, or familiar people, but also as demons or tormentors [118–120]. These encounters are reported frequently during NDEs (40% of the subjects in Ring's study [4]; 52% in Greyson's study ([83]: 'sense of deceased/religious spirits', see Table 23.1). Sometimes subjects report to feel (rather than see) the presence of an unfamiliar person, a mystical, or a supreme entity (reported by 26% of NDE subjects in Greyson [83]).

The seen or felt person may also be familiar, but is most often a deceased relative or friend. Ring [4] and Kelly [120] found that 8% (13%) of seen or felt persons were dead relatives, whereas Fenwick and Fenwick ([121], 39%) and Van Lommel *et al.* ([80], 32%) found this more frequently. Kelly [120] analyzed this feature further by comparing 74 people with NDEs who reported to have perceived one or more deceased relatives with 200 people with NDE who did not. She found that deceased relatives are more frequently reported than deceased friends or children (in this study only 4% of people with NDEs reported seeing persons that were alive at the time of the NDE [120]). Encounters of dead relatives have long been reported in the occult literature as 'apparitions' and are supposed to be frequent in so-called 'deathbed visions' [92, 122]. Sometimes verbal or thought communication (often described as 'telepathic') has been reported to take place between the subject and the encounters. Physical interactions such as touch or embraces are sometimes described as well [117]. Some of these features have also been reported in neurological patients with heautoscopy [23].

Positive and Negative Emotions

NDE reports often consist of feelings of peace and calm (and sometimes ecstasy), despite the experienced severity of the situation. Whereas Ring [4] found that 60% of subjects with a NDE reported feelings of peace (56% in [80]), Sabom [5] noted such feelings in all of his subjects with NDE. Greyson [83] analyzed the feelings of peace and joy separately and found 85% for peace and 67% for joy. A related feature might be the loss of pain sensations as subjects with NDE often report to be relieved from the unbearable pain they were enduring minutes earlier. Heim [42] reports his own experience when falling from a cliff: 'There was no anxiety, no trace of despair, nor pain; but rather calm seriousness, profound acceptance, and a dominant mental quickness and sense of surety …' Many subjects also report feelings of absolute love, all encompassing acceptation, often by a supreme entity which is associated with a radiant light. Nevertheless, NDEs may also be associated with negative emotions, 'hell'-like features, encounters with tormentors or frightfully devoid of any meaning [123]. The exact incidence of such negative NDEs is not known, but is assumed to be rather low [117].

Other Features

In this section we have listed other NDE features about which less is known concerning their phenomenology, frequency, and association with other features. These features are realness, mental clarity, sense of time, mystical features, and the experience of border and return.

Realness and mental clarity: Although NDEs are often described as highly realistic sensations, we were not able to find detailed estimates. In the literature we found reports that NDEs are often experienced as 'real' or 'realer than real' [124]. Some authors have argued that NDEs are qualitatively different from dreams or drug-induced hallucinations (e.g., [3]). As one subject wrote: 'For many years, it was the most real thing that ever happened to me. Yes, far more real and vivid than any real-life incident. It was so real, detailed and so vivid and consistent …; in fact, so totally un-dreamlike!' ([96], p. 137). Thus, many subjects with NDEs believe them to involve *actual* disembodiment, meeting of spirits, seeing of lights, or being in the afterworld rather than mere *experiences* thereof. These subjects are often reluctant to refer to NDEs in psychological or neurophysiological terms [82]. Realness is sometimes also reported as mental clarity or cognitive enhancement. Owens *et al.* [106] found that the report of clear experience, perception, and cognition was more frequent in subjects who suffered serious life-threatening conditions than those who only thought themselves in great biological danger. Greyson [83] found that 44% of NDE subjects reported accelerated thought with their NDE. Heim [42] also refers to this aspect during his mountain fall: 'All my thoughts and ideas were coherent and very clear, and in no way susceptible, as are dreams, to obliteration … The relationship of events and their probable outcomes were viewed with objective clarity, no confusion entered at all'.

Sense of time: A distorted sense of time is a frequent feature of NDEs, but has not been described in detail in statistical and phenomenological terms. Heim [42] reported that 'time became greatly expanded' during his fall. Greyson [83] found that 67% of NDE subjects reported an alteration of the sense of time, whereas this was much less frequent in a control group of subjects without NDEs (4%). Based on the reviewed phenomenology we suggest that the presence of a distorted sense of time, mental clarity, and life review might co-occur in subjects with NDEs.

Mystical and transcendental features. A feeling of 'oneness' with the universe or of 'cosmic unity' was present in 52% of subjects with NDEs in Greyson's study [83]. Twenty per cent of Ring's [4] subjects and 54% of Sabom's [5] subjects with NDEs reported the 'visit' of a supernaturalistic environment. This value is considerably smaller in people reporting OBEs (~1%; [11]), but more frequent in subjects who report multiple OBEs. Descriptions here vary considerably, but most often seem to involve the experience of seeing pleasant sights like cities of light, green and flowered meadows, and vivid colours. Sometimes, images reminiscent of religious iconography are perceived [125].

Border and Return. A symbolic or concretely perceived limit or border is sometimes reported by subjects with NDEs. Greyson [83] found this in 41% and Van Lommel *et al.* [80] in 8%. NDEs (and OBEs) are often reported to end abruptly without the experience of intentional control [85]. A patient, resuscitated by electrical defibrillation after an anterior myocardial infarction, reported: 'It appeared to me … that I had a choice to re-enter my body and take the chances of them [the medical staff] bringing me around or I could just go ahead and die, if I wasn't already dead. I knew I was going to be perfectly safe, whether my body died or not. They thumped me a second time. I re-entered my body just like that' ([126], p. 65). The immediate aftermath is frequently the return of pain and the realization that one is alive (similar observations have also been reported in neurological patients with OBEs and related experiences such as heautoscopy; see below and [7] case 4).

Folk-psychological Accounts and Psychological Aspects

Following psychoanalytic theory, several researchers consider NDEs as a defence mechanism unfolding in a hopeless, life-threatening situation. Noyes and Kletti [110, 127] were influential with their suggestion that the experience during a NDE may reflect a form of depersonalization, whereby the endangered subject 'separates' from the body and the current events in order to be 'dissociated' from the unsupportable consequences of death and pain. Pfister [128] was perhaps the first to propose a psychoanalytic theory of NDEs. Following Heim's [42] accounts of NDEs in fall survivors, he suggested that 'persons faced with potentially inescapable danger attempt to exclude this unpleasant reality from consciousness and "replace" it with pleasurable fantasies which protect them from being paralysed by emotional shock' ([129], p. 613). By this process, it was then argued that subjects 'split' into an observing self and a body. The OBE component of many NDEs, in particular, has been seen as the prototypic experiential correlate of this detachment [1, 130]. However, this psychoanalytic account has been criticized on several grounds, mostly because of the lack of empirical evidence for it and the differences between the symptoms of dissociation in psychiatric populations and the reports of NDE subjects (for more details, see [131–132]), as well as many methodological and scientific concerns about psychoanalysis itself. Other psychological authors suggested that NDEs are the consequence of a human tendency to deny death [1, 130], the release of archetypical concepts of death [133], or the (symbolic or literal) regression to the experience of coming to life ([134–135]; but see [96]). These approaches of NDEs suffer from the same methodological and scientific concerns as psychoanalytical propositions.

More quantitative approaches have proposed to analyze psychological variables of people with NDEs, as estimated by interviews and questionnaire surveys. Yet, as with OBEs, no clear psychopathological features have been found [117, 131] and subjects with NDEs and without NDEs do not differ with respect to measures of intelligence, extraversion, neuroticism, or anxiety. Unfortunately, only a small number of subjects with NDEs have been studied in this systematic manner [136–137]. People with NDEs were also found to report more often so-called paranormal experiences prior to their NDE [83, 112], as well as other complex experiences such as OBEs, feelings of being united with the universe, feeling the presence of God and otherworldly entities, or having past-life memories [102]. Kohr [138] found similar tendencies in people with NDEs: they reported repeated OBEs and higher interest in dreams, past-lives, and meditation. This suggests that subjects with NDEs might differ from other subjects in being more open to unusual experiences (and also willing to report these) and being attentive to the so-called inner-states [129]. It might also be that this personality trait is linked to the larger concept of 'magical thinking', which has been shown to depend on right hemispheric activity and affinity to 'paranormal' thought [139]. People with NDEs as well as people with OBEs [11] also score higher than control subjects on absorption (a measure that refers to the tendency to immerse in imagination and internal states) and the related trait of fantasy proneness (a tendency to have vivid hallucinations, blurred distinction between reality and imagination, enhanced sensory experiences and heightened visual imagery) [117, 137]. The fact that this personality factor is shared among subjects with OBEs and NDEs again suggests common predisposing factors. On a related note, Ring [140] suggested that subjects with NDEs are more likely to have suffered abuse, stress, illness, and social problems during childhood than a control group (see also [132]). Measures of dissociation (and depersonalization) have also been associated with NDEs. Subjects with NDEs scored higher than controls, but were below the range of pathological conditions on this measure [141]. Britton and Bootzin [142] also found significantly higher scores in their group of NDE subjects on the Dissociative Experiences Scale (DES) than in their control group (again these scores were different between both groups, but within the normal range).

Neurology of NDEs

Although several authors have speculated on the neurology of NDEs, there is an almost complete absence of neurological data. Medical and neurological conditions that have been associated with NDEs and that are associated with brain interference or brain damage are cardiac arrest, general anaesthesia, temporal lobe epilepsy, electrical brain stimulation, and sleep abnormalities (e.g., REM intrusions). As more systematic studies have focussed on the investigation of the frequency and intensity of NDEs in cardiac arrest patients [80–83] we will start by reviewing these studies with respect to potential neurological mechanisms (see also [143]).

Brain Anoxia in Cardiac Arrest Patients

The data reported in the large prospective study by Van Lommel *et al.* [80] describes several clinical characteristics of patients that are likely to report a NDE after cardiac arrest. In most of these patients cardiac arrest occurred in the hospital ($n = 234$; 68%) and resuscitation was initiated within 2 minutes after cardiac arrest ($n = 190$; 81%). Loss of consciousness lasted less than 5 minutes ($n = 187$; 80%). Yet, loss of consciousness was diagnosed independently of a neurological or electroencephalographic examination and estimated only by electrocardiogram records. We therefore do not have detailed neurological and EEG data about brain function in the critical clinical period that is frequently assumed to be associated with NDEs. This is likely due to the medical emergency situation and the lack of time to evaluate neurological function during resuscitation. Nevertheless, Van Lommel *et al.* [80] 'defined clinical death (independent of neurological data) as a period of unconsciousness caused by insufficient blood supply to the brain because of inadequate blood circulation, breathing, or both.' The remaining patients were resuscitated outside the hospital ($n = 101$; 29%) and probably suffered from longer periods of cardiac arrest ($n = 88$; 80%) and probably unconsciousness for more than 10 minutes ($n = 62$; 56%) as estimated by the authors. 36% ($n = 123$) of all investigated patients were unconscious, as defined above, for over an estimated period of 60 minutes.

Twelve per cent of the total of 344 patients investigated in that study [80] reported an NDE. The data showed that younger patients with a first myocardial infarction and with a previous NDE reported NDEs more frequently, while prolonged reanimation was associated with less frequent NDEs. Moreover, male patients and patients who were reanimated outside the hospital reported less NDE features. Van Lommel *et al.* [80] argue that the diminished frequency of NDEs in patients with prolonged reanimation might be due to memory loss or deficient short-term memory in these patients. This statement seems premature since no quantitative and detailed neurological or neuropsychological assessment on short- or long-term memory was carried out or reported in the acute or later phases of the study. Furthermore, no EEG records and neuroimaging examinations (MRI or computer tomography) were studied and compared between cardiac arrest patients with and without NDEs. We believe that neurological and neuropsychological data as well as EEG and neuroimaging data in cardiac arrest patients with NDEs will be crucial in describing eventually some of the neurocognitive mechanisms of NDEs. Several recent studies have reported neurological data about brain function and brain damage in patients suffering from more serious consequences of cardiac arrest such as prolonged loss of consciousness in coma, vegetative state, minimally conscious state, as well as milder associated neurological conditions (see Chapter 3). Unfortunately, we were not able to find similar studies reporting such data for cardiac arrest patients with NDEs, who are most often considered to have maintained pre-morbid brain functions (although this has never been confirmed by neuropsychological testing). Given the common aetiological origin, we suggest that patients with NDEs following cardiac arrest may suffer from brain damage that is milder, but anatomically similar, to the brain damage reported in patients with mild forms of post-anoxic brain damage of cardiac or pulmonary origin, as for example, reported by Ammermann *et al.* [144]. This study showed that brain damage in such patients is symmetrical and predominantly affects grey and white matter in several cortical and subcortical regions without affecting the brainstem (Figure 23.3). These regions include the frontal and occipital cortex (including the optic radiation) as well as the hippocampus, the basal ganglia, and the thalamus confirming earlier results that have also revealed damage to watershed regions such as the TPJ [145–147]. Importantly, damage or interference with these regions may be linked to several key features of NDEs (see below).

In the same year than Van Lommel *et al.*'s publication, a smaller prospective study on NDEs in cardiac arrest survivors was reported [81], but again did not present any neuroimaging data or results of neurological,

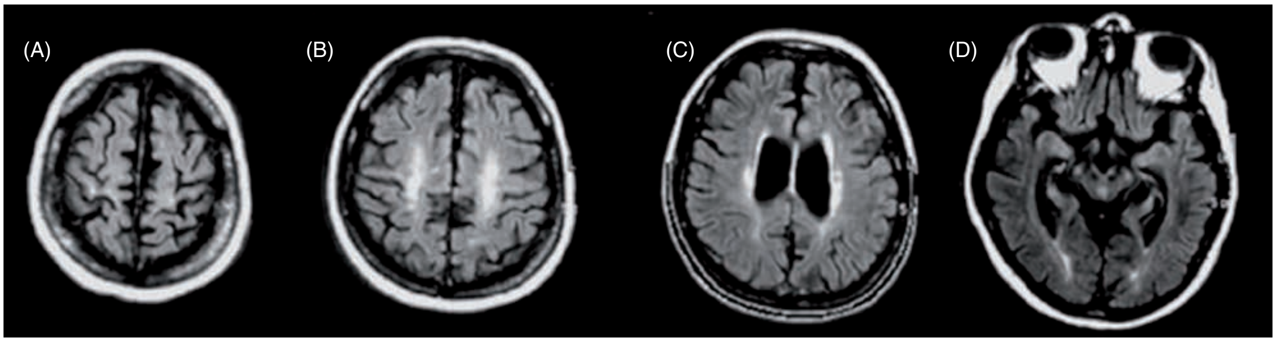

FIGURE 23.3 MRI of the brain of a cardiac arrest patient with excellent recovery. MRI reveals a distinct pattern of brain damage including white matter damage in three brain areas: In proximity of the primary motor and premotor cortex (A and B), periventricular white matter lesions (C), and in proximity of primary visual cortex including the optic radiation (D). *Source*: Modified from Ammermann *et al*. [144] reproduced with permission from Elsevier.

neuropsychological, or EEG examinations. We reiterate that EEG records during or immediately after the cardiac arrest period will be important, as well as multichannel EEG recordings during later periods that would allow detecting or excluding subtle potential abnormalities and correlating them with potential neurological, neuropsychological, and neuroimaging abnormalities. In addition, the patient sample was small [81] and only four cardiac arrest patients (6%) reported NDEs (as defined by the Greyson's scale [91]). A third study [82] found that NDEs occurred with a frequency of 23% in the same clinical population, but also did not report neurological, neuropsychological, EEG, or neuroimaging data. Finally, Greyson [83] found a frequency of 10% and found no differences in cognitive functions between cardiac arrest patients with and without NDEs. For the cognitive examination the investigators applied the mini-mental status that is often used for brief clinical pre-evaluations of patients with dementia [148]. Although, the latter test revealed normal performance in cardiac arrest patients with and without NDEs (score of ~27) this examination does not permit detailed testing of memory, language, spatial thought, visual, auditory, attention, and executive functions as is done with standard neuropsychological examinations. Despite the variability in frequency estimations of NDEs in cardiac arrest survivors in these four studies, the two larger ones seem to agree on 10–12%, but unfortunately do not provide any empirical data on the neurology of NDEs.

Other MRI-based techniques might allow describing potential brain damage in cardiac arrest patients with NDEs. Thus, diffusion-weighted MRI allows the detection of focal cerebral infarctions in the acute phase [149–150], due to its sensitivity for ischaemia-induced changes in water diffusion [151]. Els *et al.* [152] have shown that diffusion-weighted MRI may allow to reveal correlates of cerebral anoxia in cardiac arrest patients independent of severity of anoxia, that is, even in patients who recover very well (Figure 23.4). Moreover, standard T1 and T2 weighted MRI may not always reveal brain damage in these patients. It thus seems that different techniques of MRI in the acute as well as the chronic phase in such patients will be necessary to reveal potential functional and structural lesions causing distinct features of NDEs.

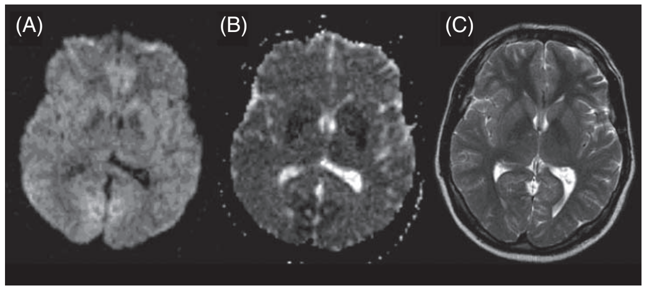

FIGURE 23.4 MRI of the brain of a cardiac arrest patient with excellent recovery. Whereas standard T2-weighted MRI (Figure 23.4C; compare to Figure 23.3) did not reveal any abnormalities, diffusion-weighted MRI in the acute phase (15 hours after resuscitation) revealed MRI abnormalities that are compatible with bilateral brain damage. These are shown in Figure 23.4A and consist of bilateral hyperintense damage in proximity to primary visual cortex and the optic radiation (compare also with Figure 23.3D). In addition, the apparent diffusion coefficient (ADC; Figure 23.4B) maps showed prominent signal decrease in the same locations as DWI, compatible with ischemic brain damage. *Source*: Modified from Els *et al*. [152] with permission from Blackwell Publishing.

Several authors have argued that brain anoxia may account for the auditory, visual, and memory aspects of NDEs (heard noises, perceived lights and tunnels, life review, encounters). The mechanisms involved have been proposed to occur as a cascade of events, beginning by a neuronal desinhibition in early visual cortex, spreading to other cortical areas and leading to NDE-features such as tunnel vision and lights [96,109,153–154]. However, the actual sequence of NDE features remains an unexplored area. Based on the reviewed data, it seems clinically plausible that cardiac arrest patients with NDEs may suffer from acute and/or chronic damage or interference with a subset of widespread cortical and subcortical areas, including grey and white matter, that have been described in cardiac arrest patients. Especially, damage to bilateral occipital cortex and the optic radiation (Figure 23.3D and 4C) may lead to the visual features of NDEs such as seeing the tunnel or surrounding darkness (i.e., bilateral peripheral visual field loss) and lights (damage to the optic radiation is often associated with macular sparing and hence centrally preserved vision), whereas interference with the hippocampus may lead to heightened emotional experiences and experiential phenomena due to epileptogenic interference, including memory flashbacks and the life review (see below). Moreover, interference with the right TPJ may lead to OBEs [7, 23, 33] whereas interference with the left TPJ may cause the feeling of a presence, the meeting of spirits, and heautoscopy [155–156]. This proposition extends previous post-anoxic accounts of NDEs by linking the different features to different brain regions that may be damaged in cardiac arrest patients with rapid recovery of consciousness and neuropsychological functioning. These speculations have to be regarded with caution, as to date, no neurological, neuropsychological, EEG, and neuroimaging data exist to corroborate this claim empirically. We also note that models only based on the pathophysiology of brain anoxia do not account for NDEs occurring in situations that are not related to cardiac arrest such as polytraumatism, general anaesthesia, and hypoglycaemia. Nor do they account for NDEs occurring during mountain falls as well as other fearful situations leading to NDEs [96,129]. As stated by Blackmore [96], brain anoxia is probably one of several, related, mechanisms that lead to NDEs.

Experimental Brain Hypoxia in Healthy Subjects

Lempert *et al.* [157] have experimentally induced syncopes in 42 healthy subjects using cardiovascular manipulations (hyperventilation, orthostasis, Valsalva manoeuvres) with the aim of investigating the symptoms of transient cerebral hypoxia. They found that many of their subjects reported NDE-like sensations. Thus, 16% had OBEs, 35% feelings of peace and painlessness, 17% saw lights, 47% reported entering another world, 20% encountered unfamiliar beings, and 8% had a tunnel experience. Two subjects were even reminded of previous spontaneous NDEs. These data suggest that NDEs may be approached experimentally in healthy subjects (although anxiety, vagal effects, as well as other non-hypoxia-related mechanisms may also play an important role [157]).

General Anaesthesia

NDEs may also occur during general anaesthesia. Thus, Cobcroft and Forsdick [72] have reported patients who during general anaesthesia experienced OBEs (see 'General anaesthesia' in the OBE section) as well as sensations of moving in a tunnel, seeing people and operating theatre details, seeing bright lights and surrounding whiteness. This was found in 4% of a large sample of patients having undergone general anaesthesia [72] and was confirmed by other investigators [73–74]. There is also a report of a NDE in a 12-year-old boy (known for mild cerebral palsy) who underwent general anaesthesia for elective uncomplicated surgery [158]. Monitoring during general anaesthesia did not reveal any signs of awakening, hypoxia, ischaemia, or hypoglycaemia. Yet, this young patient, who did not know about NDEs, reported the following 'strange dream': 'I was sleeping and suddenly I felt awake and had the impression that I was leaving my body … I could see from above my whole body lying on the back on the operating table … and surrounded by many doctors … I felt as being above my physical body … I was like a spirit … and I was floating under the ceiling of the room. … but then I had a sensation of lightness … and I felt relaxed and comfortable … I had the impression that everything was real … I then saw a dark tunnel in front of me … and I felt attracted to it … I passed through the tunnel very fast and at its end I saw … a bright light … I heard noises … [and] voices … [158]'. Interestingly, anaesthetic agents such as propofol (as applied in this patient) are known to have neuroexcitatory effects [159] inducing in some patients seizure-like activity and decreased metabolism in the dorsolateral pre-frontal cortex, posterior parietal cortex (including the TPJ), and temporal lobe [160]. Lopez *et al.* [158] speculated accordingly that interferences of anaesthetic agents in these areas may lead to the induction of some features of NDE, such as OBEs, seeing lights, being dragged through a tunnel and peace of mind.

Independent of general anaesthesia, substances such as Ketamine, LSD and cannabinoids, as well as many others [161–163] may also lead to experiences resembling some of the NDE features, like the feelings of joy and bliss, visual hallucinations (including tunnels, lights and people), transcendental features

[163–164], and OBEs [10–64]. Feelings that the experience is veridical are not rare when using such substances, as well as the impression of 'mental clarity' and enhanced cognition [163]. Other authors, however, argued that drug administration, instead of facilitating NDEs, may also diminish their frequency [4–5] or have no effect on the frequency of NDEs (in cardiac arrest patients; [80, 83]).

Epilepsy and Brain Stimulation

Many observations link NDEs to epilepsy and especially to complex partial seizures. This evidence includes (i) interictal EEG signs (spikes and spike-waves) in subjects with NDEs; (ii) interictal manifestations such as the interictal temporal lobe syndrome; (iii) similarity of NDEs with several known sensory and cognitive ictal symptoms; (iv) experimental induction of some of these symptoms by electrical cortical stimulation in awake humans; (v) and frequent damage to the hippocampus, a major epileptogenic region, in cardiac arrest patients.

Whereas the neurological examination is frequently normal in patients with temporal lobe epilepsy, neuropsychological examinations often reveal mild to moderate memory impairments characterized by deficits in learning, recognition, delayed recall, or fluency tasks either for verbal or visuo-spatial material [165–166]. Moreover, these distinct memory deficits have been correlated with hippocampal sclerosis, decreased volume, and metabolic changes of this structure, as shown by functional MRI, magnetic resonance volumetry, and magnetic resonance spectroscopy [167–168]. Such examinations in cardiac arrest patients with NDEs might thus reveal similar circumscribed deficits and brain damage, at least in some of these patients.

Britton and Bootzin [142] performed EEG recordings via 19 scalp electrodes in healthy subjects who have reported a previous NDE. They were able to demonstrate the presence of abnormal epileptic interictal EEG activity over the left mid-temporal region in 22% of these subjects (one subject had bilateral abnormal activity). No epileptic seizures were recorded in or reported by any of the subjects. Abnormal activity was most prominent over mid-temporal regions and characterized by spikes and spike-waves, as well as sharp waves (Figure 23.5). The authors added that subjects with NDE also reported more often than the control group several temporal lobe symptoms (TLS) (Figure 23.6) compatible with the interictal temporal lobe syndrome [169]. These include deepened emotionality, nascent religious interest, enhanced philosophical preoccupation, moralism, sense of personal destiny, as well as others (although patients with temporal lobe epilepsy

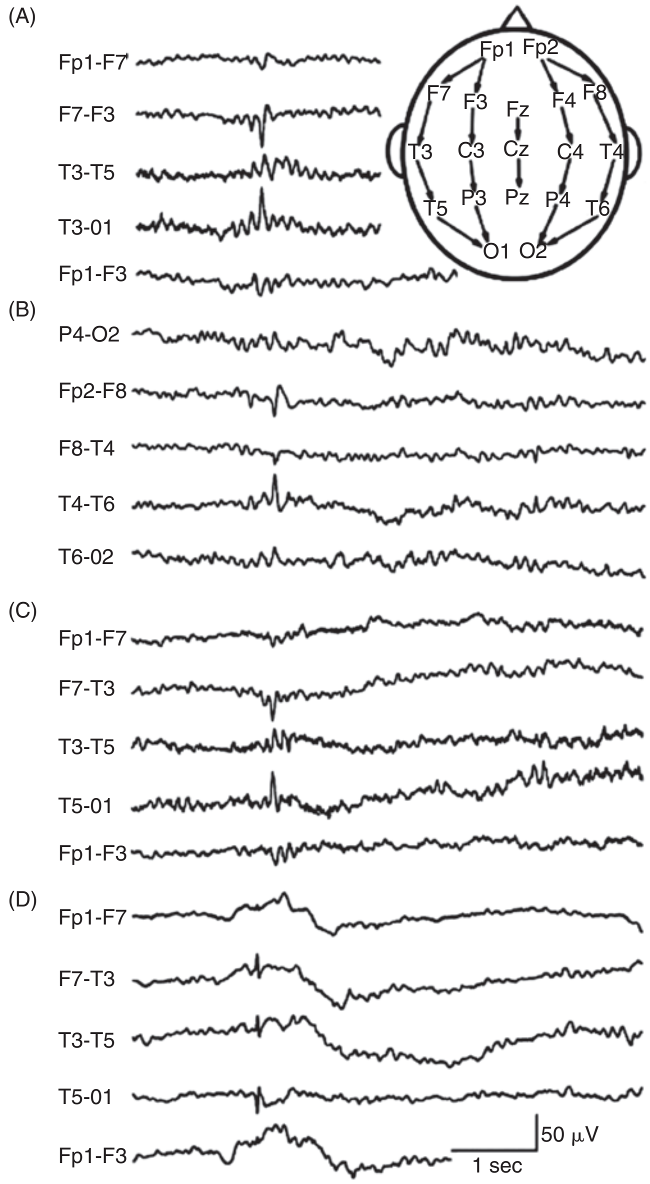

FIGURE 23.5 Examples of interictal epileptiform discharges in the temporal lobe of subjects with NDE. (A), (B), and (C) Stage 2 sleep; (D) REM sleep. The illustration of the head shows the placement of the electrodes in the 10–20 system with an anterior–posterior bipolar reference scheme. Each tracing shows the localized brain activity from the area of the two electrodes indicated. *Source*: From Britton and Bootzin [142]; with permission from Blackwell Publishing.

may not always show these signs [170–172]). Finally, Britton and Bootzin [142] report that abnormal epileptic activity in subjects with previous NDEs was correlated with their score on an NDE scale [91], but not with trauma-related measures such as post-traumatic stress disorder, dissociation, or previous head trauma.

Many features of the NDE have been described as symptoms of epileptic seizures and have also been

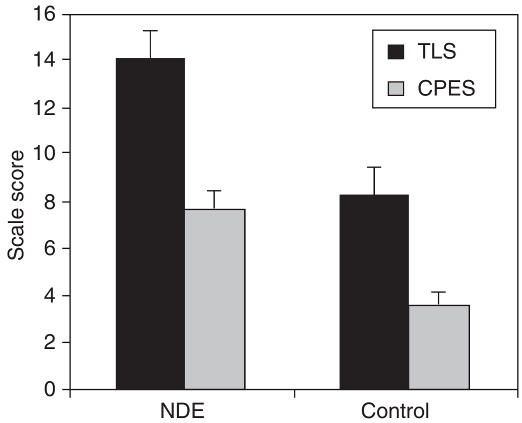

FIGURE 23.6 Symptoms evocative of interictal and ictal temporal lobe syndrome in subjects with NDE. Scores on the temporal lobe symptoms (TLS) and complex partial epileptic signs (CPES) subscales of the Personal Philosophy Inventory [197] in subjects with NDE and a control group of age- and gender-matched participants with no history of life-threatening event. Items include experiences of sleepwalking, olfactory hypersensitivity, hypergraphia, feelings of intense personal significance and unusual perceptions. *Source*: From Britton and Bootzin [142]; with permission from Blackwell Publishing.

induced in a controlled setting by electrical cortical stimulation. Thus, direct electrical cortical stimulation [33, 173] and focal epileptic activity at the TPJ [7, 19] may induce OBEs as well as vestibular sensations [7, 33, 173–174]. Memory flashbacks and life reviews have long been known to occur as a symptom of temporal lobe epilepsy and are generally referred to as experiential phenomena [175–180]. Experiential phenomena have also been induced by electrical cortical stimulation of the temporal lobe, the hippocampus, and the amygdala [177–180], as well as the frontal and the parietal cortex [181–183]. One of Hughlings Jackson's [175] patients with temporal lobe epilepsy describes an ictal life review: 'The past is as if present, a blending of past ideas with present … a peculiar train of ideas of the reminiscence of a former life, or rather, perhaps, of a former psychologic state.' ([184], p. 1741). Recently, Vignal *et al.* [185] re-investigated memory flashbacks and life reviews in patients with pharmacoresistant epilepsy during spontaneous seizures and by electrical cortical stimulation with intracranial electrodes. Among a population of 180 subjects, they found 17 patients that described 55 memory flashbacks. These were quite variable, but could be repeatedly evoked in a given subject by the electrical stimulation of specific areas. Within the temporal cortex, Vignal *et al.* [185] evoked memory flashbacks and life reviews by electrical stimulation of the amygdala, the hippocampus, and the parahippocampal gyrus. One evoked memory flashback was: '… it is always thoughts from childhood, it is always visual, it is a place behind the house, the field were my father put his car, near a lake … Yes, it is pleasant because we were going to get the car from behind the house, it is a happy memory, it is never unpleasant' ([185], p. 92). Similar observations have been reported earlier by Penfield and Jaspers [176] by electrical stimulation of the lateral temporal cortex. This suggests that both the stimulation of the medial and the lateral temporal structures can be at the origin of experiential phenomena, including memory flashbacks and life review. Another feature of the NDE that can be observed in epileptic seizures and by electrical cortical stimulation is the feeling of a presence, namely the experience of feeling and believing that someone is nearby, without being able to see this person [155, 186–189]. Arzy *et al.* [156] were able to induce the feeling of a presence by electrical cortical stimulation in a patient with pharmacoresistant epilepsy undergoing pre-surgical epilepsy evaluation. The patient reported an 'illusory shadow', who mimicked her body position and posture when her left TPJ was stimulated. She also reported a negative feeling about the experience, sensing hostile intentions from this unfamiliar 'shadow'. The feeling of a presence (in neurological or psychiatric patients) may also be quite elaborated and the felt person may be identified or interpreted as a mystical or supreme entity, or guardian angel ([7] (case 5), [31, 155]). The seen double during heautoscopy has also been linked to the left TPJ [23] and may also be experienced as a mystical or supreme entity ([7] (case 4), [23]). The experience of such a heautoscopic double may be of great emotional and personal relevance [8, 155]. Also, heautoscopy is often associated with the experience of sharing of thoughts, words, or actions with the double or other people. Thus, patients with heautoscopy (but not OBEs) experience to hear the autoscopic body talk to them [190] or experience that they communicate with the illusory body by thought ([7], case 5), a finding reminiscent of people reporting about the meeting of spirits during NDEs. Other patients with heautoscopy stated that the autoscopic body is performing the actions they were supposed to do ([19], case 9) or fights with other people that could be of potential danger to the patient ([7], case 5).

To summarize, many NDE features (OBE, feeling of presence, meeting with spirits, memory flashbacks, and life review) are known symptoms of epileptic discharge or electrical stimulation of hippocampus, amygdala, and parahippocampal gyrus as well as more lateral, neocortical temporal areas including the TPJ. The most common cause of temporal lobe epilepsy is hippocampal dysplasia and sclerosis following brain anoxia, as the hippocampus is one of the most anoxia-sensitive brain regions in humans, and is damaged in almost all patients with cardiac arrest (as well as the TPJ which is a classical watershed region). Although more empirical investigations on this issue are clearly needed, interference and damage to hippocampus and TPJ and consequent clinical and subclinical manifestations of partial epileptic seizures thus seem likely candidates as major pathomechanisms of NDEs.

Sleep Abnormalities and Brainstem Mechanisms

Recently it has been suggested that subjects with NDEs report more frequently symptoms that might be associated with a sleep disorder associated with REM intrusions (or rapid eye movement intrusions) as compared to age-matched control subjects without NDEs [86, 107] (see chapter 8 for more details on REM sleep). This was especially the case in subjects who had NDEs with OBEs (whether as part of their NDE or occurring at a different time [107]). REM intrusions were estimated based on questions such as 'Just before falling asleep or just after awakening, have you ever seen things, objects or people that others cannot see?' and 'Have you ever awakened and found that you were unable to move or felt paralyzed?'. Both items were reported significantly more often in subjects with NDEs. Visual and auditory hallucinations were also reported to be more frequent in subjects with OBEs during NDEs. Nelson *et al.* [86, 107] suggest that NDEs and OBEs may be related to muscular atonia during REM intrusions due to abnormal brainstem processing. REM intrusions are relatively frequent in the normal population and associated with sleep paralysis (a temporary paralysis of the body during sleep–wake transitions) in about 6% of the population. Symptoms similar to NDEs are also found in other medical conditions involving sleep or brainstem disturbances such as narcolepsy (a disorder involving excessive daytime sleepiness; [191]), peduncular hallucinations [192], hypnagogic and hypnopompic hallucinations [193], as well as sleep paralysis [194]. Finally, patients with Guillain-Barré syndrome (an acute autoimmune disturbance of the peripheral nervous system leading in some cases to severe peripheral sensorimotor deficits that may require intensive care) have also been reported to have OBEs as well as NDE-like features [195]. In a series of 139 such patients, mental disturbances have been found in 31% and included vivid and unusual dreams, visual illusions and hallucinations, as well as paranoid delusions. Interestingly, REM sleep was highly abnormal in these particular patients. The investigators did not inquire about OBEs directly, but some patients reported relevant phenomena such as vivid or dreamlike sensations of losing the sense of one's body, meeting people, hovering or floating weightlessly over their body, or having the impression to have left one's body. Moreover, patients with the Guillain-Barré syndrome also reported complex own body illusions that have been linked functionally to OBEs such as illusory body-part dislocations, the inversion-illusion, and room-tilt illusion [7, 34–35].

COGNITIVE NEUROSCIENCE OF NDE PHENOMENA

The reviewed data suggest that many functional and neural mechanisms are involved in the generation of the wide range of phenomena grouped under the term NDE. These mechanisms include mainly visual, vestibular, multisensory, memory, and motor mechanisms. Concerning brain regions the reviewed studies suggest damage to and/or interference with different cortical, subcortical, and brainstem mechanisms, as well as the peripheral nervous system. Interference with the functioning of this extended network also seems to occur in situations characterized by stress, physical exhaustion, rapid accelerations or decelerations, and deliberate relaxation. Although the neural mechanisms of many illusions and hallucinations have been described in detail, there are – at this stage – not even preliminary data on the neurology of the different phenomena associated with NDEs. Systematic neurological research is needed to fill this gap as has already been done for related experiences (such as the OBE) or related medical conditions in cardiac arrest patients (coma, vegetative state, minimally conscious states). Although abnormalities in brainstem and peripheral nervous system may lead to NDE phenomena, we argue that major insights into these experiences will be gained by applying research techniques from cognitive neurology and cognitive neuroscience to NDE phenomena in order to reveal their cortical and subcortical mechanisms. We have reviewed evidence that suggests that some NDE phenomena can be linked to distinct brain mechanisms. This was shown for the OBE (damage to right TPJ), tunnel vision and seeing of foveal lights (bilateral occipital damage including the optic radiation with macular sparing and/or foveal hallucinations), feeling of a presence and meeting of spirits (damage to left TPJ), as well as memory flashbacks, life review, and enhanced emotions (hippocampal and amygdala damage). All structures have been shown to be frequently damaged in those cardiac arrest patients that show excellent recovery and who are so far the best studied patient group with NDE phenomena.

Based on the selective sites of brain damage in cardiac arrest patients (with excellent recovery) and the associations of key NDE phenomena to some of these same areas we would like to suggest that two main types of NDEs exist, depending on the predominantly affected hemisphere. We propose that type 1 NDEs are due to bilateral frontal and occipital, but predominantly right hemispheric brain damage affecting the right TPJ and characterized by OBEs, altered sense of time, sensations of flying, lightness, vection, and silence. Type 2 NDEs are also due to bilateral frontal and occipital, but predominantly left hemispheric brain damage affecting the left TPJ and characterized by feeling of a presence, meeting of and communication with spirits, seeing of glowing bodies, as well as voices, sounds, and music without vection. We expect emotions and life review (damage to unilateral or bilateral temporal lobe structures such as the hippocampus and amygdala) as well as lights and tunnel vision (damage to bilateral occipital cortex) to be associated with type 1 and type 2 NDEs. Unfortunately, the few existing empirical studies on NDEs in patients with well-defined medical conditions lack neurological, neuropsychological, neuroimaging, and EEG data and to our knowledge no phenomenological analysis of case collections has tried to differentiate the two different types of NDEs in the way we are proposing here. Our proposition remains therefore speculative. We are confident that future neuroscientific studies in cardiac arrest patients with NDEs are likely to reveal the functional neuroanatomy of several NDE phenomena, likely implicating distributed bilateral cortical and subcortical brain mechanisms. There are also the promising experimental results by Britton and Bootzin [142] and previous earlier suggestions by Persinger [196] that link NDE phenomena to symptoms of temporal lobe epilepsy. We therefore also expect additional insights into the neural mechanisms of NDE phenomena through studies investigating the incidence of NDE phenomena (by carrying out detailed interviews and questionnaires) and neuropsychology in patients with focal epilepsies as well as other neurological patients suffering from focal brain damage.

CONCLUSION

The present review has summarized findings on the functional and neural mechanisms of OBEs and NDEs. Whereas OBEs and their underlying brain mechanisms are currently investigated by several research groups and point to the importance of bodily multisensory integration at the right TPJ, the data on the neural mechanisms of NDEs are extremely sparse or altogether absent. We have argued above that the investigation of NDEs in cardiac arrest patients as well as neurological patients may be one possibility to start investigating the functional and neural mechanisms of NDEs. We agree with French [143] who suggested that 'given the heterogenous nature of the NDE … [t]here is no reason to assume that a single comprehensive theory will explain the entire phenomenon'. We add that there is also no reason to assume that an NDE is just one phenomenon, as opposed to a group of loosely associated experiences due to interference with different brain functions and brain mechanisms. Yet, after countless studies and speculations that have focussed on 'life after life' and 'survival of bodily death' in 'survivors' of life-threatening situations, we propose that future studies on NDEs may want to focus on the functional and neural mechanisms of NDE phenomena in patient populations as well as healthy subjects. We speculate that this might eventually lead to the demystification of NDEs, just as that of OBEs is well under way. More importantly, the scientific study of these varied complex experiences may allow studying the functional and neural mechanisms of beliefs, personality, spirituality, and the self, that have and will continue to intrigue scientists, scholars, and laymen alike.

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