

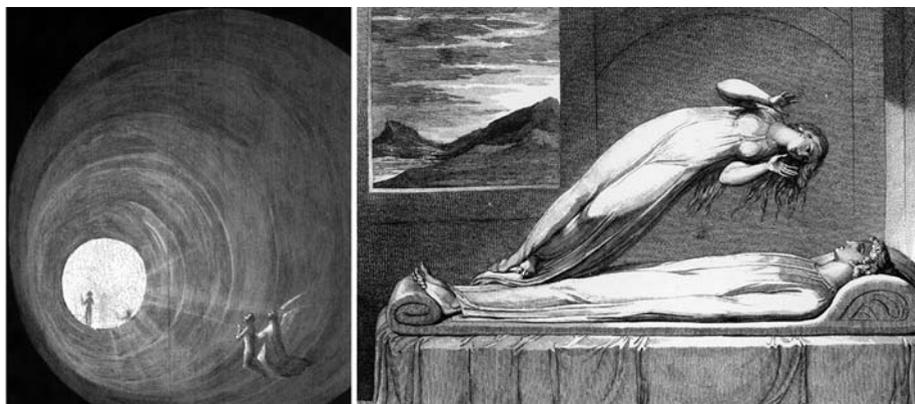
## Towards a Neuro-scientific Explanation of Near-death Experiences?

A. VANHAUDENHUYSE, M. THONNARD, and S. LAUREYS

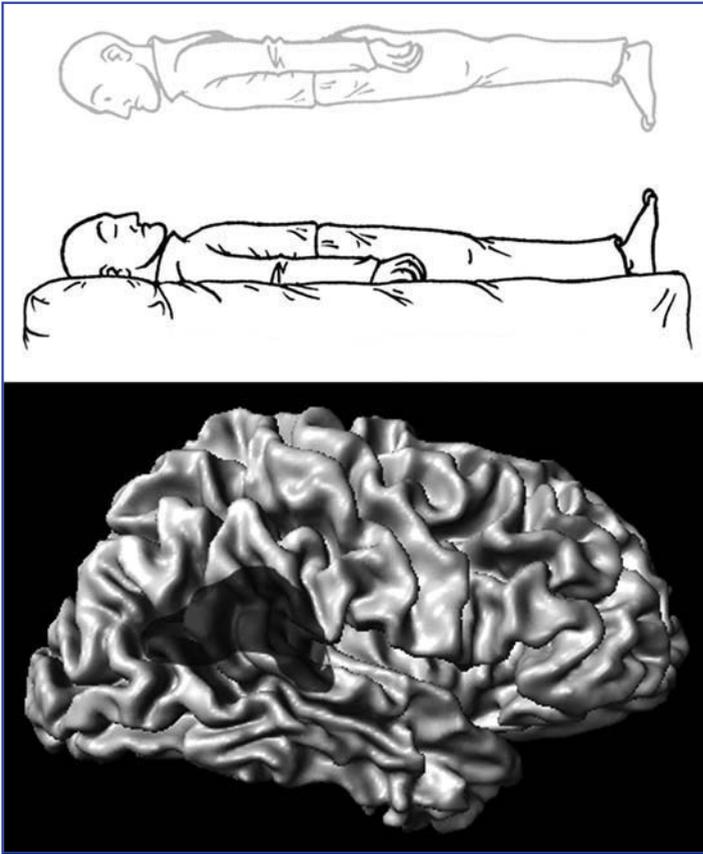
### Introduction

Near-death experiences can be defined as “profound psychological events with transcendental and mystical elements, typically occurring to individuals close to death or in situations of intense physical or emotional danger. These elements include ineffability, a sense that the experience transcends personal ego, and an experience of union with a divine or higher principle” [1]. Common elements recurring in near-death experiences are experiencing a panoramic life review, feelings of peace and quiet, seeing a dark tunnel, experiencing a bright light, or out-of-body experiences [1] (Fig. 1). During an out-of-body experience, people seem to be awake and see their own body and the world from a location outside their physical body [2] (Fig. 2). Some spiritual and psychological theories have been developed in order to explain near-death experiences and out-of-body experiences. Clinical studies have aimed at determining their frequency and assessing precipitating factors. Recent studies have shown the involvement of the temporo-parietal cortex in the generation of out-of-body experiences and offer a neurological account for the phenomenon, rebuffing dualistic, non-physical explanations. In this chapter, we discuss what is and is not known about the neuronal correlates of these extraordinary experiences.

XXV



**Fig. 1.** Common elements recurring in near-death experiences are seeing a dark tunnel, experiencing a bright light, feelings of peace and quiet, experiencing a panoramic life review or out-of-body experience (from Hieronymus Bosch, 1500s “Paradise and the Ascent in the Empyrean” *left*; and Schiavonetti, 1808 “The soul leaves the body at the moment of death” *right*).



**Fig. 2.** One of the principal components of near-death experiences is out-of-body experiences. An out-of-body experience is defined by the presence of disembodiment, the impression of seeing the world from an elevated and distanced visuo-spatial perspective and the impression of seeing one's own body from this perspective. Studies have shown that electrical stimulation of the temporo-parietal junction (highlighted in gray) can generate out-of-body experiences (with permission from Cliff Laureys)

XXV

## Near-death Experiences

### Definition

It is important to stress that near-death experiences occur in what is considered 'near-death', i.e., the patient being in transitory and reversible cardiac arrest (clinical death). Under the US Uniform Determination of Death Act [3], a person is dead when physicians determine, by applying prevailing clinical criteria, that cardiorespiratory or brain functions are absent and cannot be retrieved. Clinical death is a term to be avoided, referring in popular media to cessation of blood circulation and breathing. Without resuscitation, recovery of brain function more than 3 minutes after a cardiac arrest is rare. This notion of irreversible is reflected in the 'Pittsburgh Protocol' for non-heart-beating organ donation (now called organ donation after cardiac death). Here, patients who are hopelessly brain-damaged (but not brain dead) can have their life-sustaining therapy (e.g., positive-pressure ventilation) with-

drawn. Once their heart stops beating for a period of 3–10 minutes (length varies by protocol), they can be declared dead (and only then can organs be procured) [4, 5].

At present, there are no universally accepted definitions of near-death experiences. Nevertheless, there are many ways of categorizing its phenomenological elements. Moody [6] identified a number of common elements recurring in near-death experiences: Ineffability, hearing oneself pronounced dead, feelings of peace and quiet, hearing unusual noises, seeing a dark tunnel, being ‘out of the body’, meeting ‘spiritual beings’, experiencing a bright light or a “being of light”, panoramic life review, experiencing a realm in which all knowledge exists, experiencing cities of light, experiencing a realm of bewildered spirits, experiencing a ‘supernatural rescue’, sensing a border or limit, coming back ‘into the body’.

Structured interview of individuals who have had a near-death experience have identified five stages occurring in the following order: (1) A feeling of peace and well-being; (2) separation from the physical body; (3) entering a region of darkness; (4) seeing a brilliant light; (5) going through the light and entering another realm. The two scales most commonly used to quantify the subjective experience of near-death experiences are the Weighted Core Experience Index (WCEI) [7] and the Greyson Near-death Experience Scale [8]. The WCEI includes ten components which are scored for their presence or absence (maximum score is 29) (Table 1).

The Greyson Near-death Experience Scale [8] is a revision of the WCEI and has 146 questions (maximum score of 32). In order to consider the subjective report as being a true near-death experience, a minimum score of 7 needs to be recorded (Table 2).

XXV

### Theoretical Approaches: Spiritual, Psychological and Organic Hypotheses

Spiritual interpretations consider the existence of near-death experiences as strong evidence that the mind (i.e., soul) can be separated from the physical body. Supporters of this theory consider that near-death experiences provide a glimpse of the spiritual realm to which the soul migrates after death. The second category encompasses psychological theories according to which near-death experiences are a type of depersonalization, acting as a protection against the threat of death in situations of intense danger, by allowing an engagement in pleasurable fantasies [9]. Others have proposed a concept of psychological absorption, which may be defined as the tendency to focus attention on imaginative or selected sensory experiences to the exclu-

**Table 1.** Characteristics of near-death experiences as reported by 62 cardiac arrest survivors, according to the Weighted Core Experience Index (WCEI) [22].

	Number of patients (%)
Awareness of being dead	31 (50 %)
Positive emotions	35 (56 %)
Out-of-body experiences	15 (24 %)
Moving through a tunnel	19 (31 %)
Communication with light	14 (23 %)
Observation of colors	14 (23 %)
Observation of a celestial landscape	18 (29 %)
Meeting with deceased persons	20 (32 %)
Life review	8 (13 %)
Presence of border	5 (8 %)

**Table 2.** Characteristics of near-death experiences according to the Greyson Near-death Experience Scale.

	Number of cardiac arrest survivors (%)	
	Parnia et al., 2001 [21] (n = 4)	Greyson, 2003 [24] (n = 27)
<b>Cognitive features</b>		
Did time seem to speed up or slow down?	2 (50 %)	18 (66 %)
Were your thoughts speeded up?	0	12 (44 %)
Did scenes from your past come back to you?	0	8 (30 %)
Did you suddenly seem to understand everything?	1 (25 %)	8 (30 %)
<b>Emotional features</b>		
Did you have a feeling of peace or pleasantness?	3 (75 %)	23 (85 %)
Did you see, or feel surrounded by, a brilliant light?	3 (75 %)	19 (70 %)
Did you have a feeling of joy?	3 (75 %)	18 (66 %)
Did you feel a sense of harmony or unity with the universe?	2 (50 %)	14 (52 %)
<b>"Paranormal" features</b>		
Did you feel separated from your body?	2 (50 %)	19 (70 %)
Were your senses more vivid than usual?	2 (50 %)	4 (15 %)
Did you seem to be aware of things going on elsewhere, as if by extrasensory perception?	2 (50 %)	3 (11 %)
Did scenes from the future come to you?	0	2 (7 %)
<b>Transcendental features</b>		
Did you seem to enter some other, unearthly world?	2 (50 %)	17 (63 %)
Did you seem to encounter a mystical being or presence, or hear an unidentifiable voice?	2 (50 %)	14 (52 %)
Did you come to a border or point of no return?	4 (100 %)	11 (41 %)
Did you see deceased or religious spirits?	1 (25 %)	7 (26 %)

sion of stimuli from the external environment [10]. However, some authors have pointed out that near-death experiences differ from depersonalization in the sense that what is distorted is not one's sense of identity but the association of one's identity with one's bodily sensations. In this view, near-death experiences are considered as a dissociation of self-identity from bodily sensations and emotions [11].

The last category encompasses so-called organic hypotheses. A large number of theories have attempted to account for components of near-death experience in terms of brain dysfunctions. Some authors have considered the possible role of abnormal levels of blood gases. Indeed, anoxia [12] and hypercarbia [13] can produce symptoms including seeing bright lights, having out-of-body experiences, reliving past memories, and inducing mystical experiences. Other authors have suggested that near-death experience can be reported as hallucinatory experiences caused in part by, for example, endorphin [14], serotonin [15], or ketamine [16, 17] release. More recent theories have proposed that temporal lobe dysfunction may explain out-of-body experiences [2] and bodily hallucinations [18]. Finally, it was also shown that individuals who reported having near-death experience had more significant epileptiform electroencephalogram (EEG) activity compared to control patients [19].

An integrative model of these organic theories has proposed that brain stress caused by traumatic events leads to the release of neurotransmitters producing effects such as analgesia, euphoria and detachment. These effects combine with the effect of decreases in oxygen tension to produce epileptiform discharges in the hip-

pocampus and amygdala, possibly leading to hallucinations and life review. After-discharges, propagating through limbic connections to other brain areas, could produce further hallucinations and the sensation of seeing a brilliant light [20]. Finally, there exists no EEG data about brain functions in the critical clinical period that is assumed to be associated with near-death experiences. Indeed, loss of consciousness was diagnosed only by electrocardiogram (EKG) examinations, independent of neurological or EEG records.

### Clinical Studies

Parnia et al. [21] prospectively studied cardiac arrest patients over a one year period. Of the 63 survivors interviewed within a week of cardiac arrest, 7 (11 %) reported memories of their period of unconsciousness, 4 of whom (6 %) had near-death experiences according to the Greyson Near-death Experience scale [8]. All patients reported that the near-death experience was pleasant. Due to the small number of patients, it was not possible to draw any clear conclusions regarding possible causative physiological factors such as hypoxia, hypercarbia, electrolyte disturbances, specific cardiac dysrhythmia, carbon dioxide, sodium and potassium obtained from arterial blood gas and peripheral blood, or the administration of drugs around the period of arrest. Only the partial pressure of oxygen was reported to be higher in the near-death experience group as compared to non-near-death experience survivors.

Another prospective study was conducted by Van Lommel et al. [22] and involved 344 cardiac arrest survivors. Sixty-two (18 %) patients reported a near-death experience, 41 (12 %) of whom reported a “core near-death experience experience” (i.e., scoring 6 or more on the WCEI [7]). No patients reported distressing near-death experiences. Duration of cardiac arrest, medication, fear of death before cardiac arrest, and the duration between the near-death experience and the interview were not related to the occurrence of near-death experiences. However, people younger than 60 were more likely to report a near-death experience than older people, as were those suffering their first myocardial infarction. More vivid near-death experience (i.e., higher WCEI scores) were reported by patients surviving cardiac arrest outside the hospital, and were more frequently reported by women and those reporting being afraid of death before the cardiac arrest. Two and eight years after the near-death experience, patients were re-interviewed and compared with a control group (cardiac arrest survivors who did not report a near-death experience). This longitudinal follow-up showed that near-death experiences produce long-lasting effects in terms of increased belief in an afterlife and decreased fear of death, increased interest in the meaning of one’s own life, and increased social awareness such as showing love and accepting others.

Schwaninger et al. [23] prospectively studied 174 cardiac arrest patients (of whom 119 [68 %] died). Of the remaining 55 patients, 30 (17 %) were interviewed using the Greyson Near-death Experience scale [8] (25 were excluded due to neurological impairment or intubation until discharge). Seven patients reported a near-death experience (13 % of survivors). A 6-month follow-up confirmed previous findings of long-lasting transformational effects of near-death experiences with regard to personal understanding of life and self, social attitudes, and changes in social customs and religious or spiritual beliefs.

Finally, Greyson [24] prospectively studied 1595 cardiac survivors patients, of whom 27 (2 %) scored 7 or more points on the Greyson Near-death Experience scale

**Table 3.** Frequency of near-death experiences in cardiac arrest survivors according to the Weighted Core Experience Index (WCEI) or the Greyson Near-death Experience Scale [8].

Authors	Scale	Total number of patients	Number of patients having reported near-death experience (%)
Van Lommel et al. (2001) [22]	WCEI	344	41 (12 %)
Parnia et al. (2001) [21]	Greyson scale	63	4 (6 %)
Schwanger et al. (2002) [23]	Greyson scale	55	7 (13 %)
Greyson (2003) [24]	Greyson scale	1595	27 (2 %)

[8]. Near-death experiencers, comprising 2 % of the entire sample, included 10 % of patients admitted with cardiac arrest, 1 % of those with myocardial infarction, 1 % of those with unstable angina, and 1 % of those with other cardiac diagnoses. Patients who reported a near-death experience were younger, more likely to have lost consciousness, and more likely to report prior so-called “paranormal experiences” but not extrasensory perceptions. Religious beliefs prior to the near-death experience were not related to the frequency of near-death experiences.

In summary, these studies report incidence rates of near-death experiences in survivors from cardiac arrest ranging from 2 % to 13 % (Table 3) and show a higher incidence in younger patients. The reported experiences suggest that features of near-death experiences are similar among patients (Tables 1 and 2).

XXV

## Out-of-body Experiences

### Definition

One of the principal components of near-death experiences is the out-of-body experience. Out-of-body experience is defined by the presence of three phenomenological characteristics: Disembodiment (i.e., location of the self outside one’s body); the impression of seeing the world from an elevated and distanced visuo-spatial perspective; and the impression of seeing one’s own body from this perspective (i.e., autoscopia) [25] (Fig. 2, upper part). Understanding how the brain generates the abnormal self during out-of-body experiences is particularly interesting since out-of-body experiences are not only found in clinical populations, but also appear in approximately 10 % of the healthy population [25, 26]. The out-of-body experience can also be present in various situations, such as psychiatric disorders, drug abuse, general anesthesia, and sleep.

### Neuroanatomical Correlates

There is increasing evidence showing that out-of-body experiences may result from a deficient multisensory integration at the temporo-parietal junction area [2, 18, 27]. Focal electrical stimulation of this area in a patient who was undergoing evaluation for epilepsy treatment induced repeated out-of-body experiences and illusory transformations of the patient’s arm and legs [18]. In a study of six neurological patients (with epilepsy or migraine), Blanke et al. [2] showed that out-of-body experiences were always described from one visuo-spatial perspective, which was localized in a second body outside the physical body (e.g., inverted by 180° with respect to the extra personal visual space and the habitual physical body position). All patients

showed immediate self-recognition and their lesion overlap was centered on the temporo-parietal junction, including the anterior part of the angular gyrus and the posterior temporal gyrus. De Ridder et al. [27] induced an out-of-body experience in a 63-year-old man with an implanted electrode over the right temporo-parietal junction. Using a positron emission tomography (PET) scan, these authors also showed that the out-of-body experience was related to increased activity in the right temporo-parietal junction, superior temporal, and right precuneal cortices. They suggested that the induced altered spatial self-recognition was mediated by the temporo-parietal junction, which is involved in vestibular-somatosensory integration of body orientation in space. Similarly, Blanke [28] suggested a model to explain out-of-body experiences proposing that “out-of-body experiences are related to a disintegration within personal space (multisensory dysfunction) and disintegration between personal space (vestibular) and extrapersonal (visual) due to interference with the temporo-parietal junction”. In these models, the experience of seeing one’s body in a position that does not coincide with the felt position of one’s body is assumed to be related to temporo-parietal junction dysfunction (Fig. 2, lower part).

## Conclusion

Near-death experiences and out-of-body experiences remain fascinating phenomena which are abundant in popular beliefs, mythology, and spiritual experiences of many ancient and modern societies. Clinical studies suggest that characteristics of near-death experiences are culturally invariant and can be investigated neuroscientifically. The frequency of near-death experiences in cardiac arrest survivors varies from 2 to 13 % and near-death experiences seem to be more common in younger patients. Longitudinal studies have shown profound long-lasting transformational effects of near-death experiences with regard to personal understanding of life and self, social attitudes, and changes in social customs and religious or spiritual beliefs. One of the principal components of near-death experiences is the out-of-body experience that is associated with partial impairments in consciousness and disturbed own body processing. Recent studies employing deep brain stimulation and neuroimaging have demonstrated that out-of-body experiences result from a deficient multisensory integration at the temporo-parietal junction. Ongoing studies aim to further identify the functional neuroanatomy of near-death experiences by means of standardized EEG recordings.

**Acknowledgements:** This research was funded by the Belgian National Funds for Scientific Research (FNRS), the European Commission, the James McDonnell Foundation, the Mind Science Foundation, the French Speaking Community Concerted Research Action (ARC-06/11-340), the Fondation Médicale Reine Elisabeth, and the University of Liège. A.V. was funded by ARC 06/11-340 and S.L. is senior research associate at the FNRS.

## References

1. Greyson B (2000) Near-death experiences. In: Cardena E, Lynn SJ, Krippner S (eds) *Varieties of Anomalous Experiences: Examining the Scientific Evidence*. American Psychological Association, Washington, pp 315–352
2. Blanke O, Landis T, Spinelli L, Seeck M (2004) Out-of-body experience and autoscopia of neurological origin. *Brain* 127: 243–258.
3. Uniform Determination of Death Act (1997) 598 (West 1993 and West Supp. 1997.) *Uniforms Laws Annotated (ULA)*, 12.
4. Bernat JL, D'Alessandro AM, Port FK, et al (2006) Report of a National Conference on Donation after cardiac death. *Am J Transplant* 6: 281–291
5. Laureys S (2005) Science and society: death, unconsciousness and the brain. *Nat Rev Neurosci* 6: 899–909
6. Moody RA (1975) *Life After Life*. Bantam Books, New York
7. Ring K (1980) *Life at Death: A Scientific Investigation of the Near-Death Experience*. Coward, McCann, and Geoghegan, New York
8. Greyson B (1983) The near-death experience scale. Construction, reliability, and validity. *J Nerv Ment Dis* 171: 369–375
9. Noyes R, Jr., Klettli R (1976) Depersonalization in the face of life-threatening danger: a description. *Psychiatry* 39: 19–27
10. Tellegen A, Atkinson G (1974) Openness to absorbing and self-altering experiences ("absorption"), a trait related to hypnotic susceptibility. *J Abnorm Psychol* 83: 268–277
11. Irwin HJ (1993) The near-death as a dissociative phenomenon: An empirical assessment. *J Near Death Stud* 12: 95–103
12. Whinnery J (1997) Psychophysiological correlates of unconsciousness and near-death experiences. *J Near Death Stud* 15: 231–258
13. Meduna L (1950) *Carbon Dioxide Therapy*. Charles Thomas, Springfield
14. Carr DB (1982) Pathophysiology of stress-induced limbic lobe dysfunction: A hypothesis relevant to near-death experiences. *Anabiosis: J Near Death Stud* 2: 75–89
15. Morse ML, Venecia D, Milstein J (1989) Near-death experiences: A neurophysiologic explanatory model. *J Near Death Stud* 8: 45–53
16. Jansen KLR (1989) Near death experience and the NMDA receptor. *BMJ* 298:1708
17. Jansen KLR (1997) The ketamine model for the near-death experience: A central role for the N-methyl-D-aspartate receptor. *J Near Death Stud* 16: 79–95
18. Blanke O, Ortigue S, Landis T, Seeck M (2002) Stimulating illusory own-body perceptions. *Nature* 419: 269–270.
19. Britton WB, Bootzin RR (2004) Near-death experiences and the temporal lobe. *Psychol Sci* 15: 254–258
20. Saavedra-Aguilar JC, Gómez-Jerías JS (1989) A neurobiological model of near-death experiences. *J Near Death Stud* 7: 205–222
21. Parnia S, Waller DG, Yeates R, Fenwick P (2001) A qualitative and quantitative study of the incidence, features and aetiology of near death experiences in cardiac arrest survivors. *Resuscitation* 48: 149–156
22. Van Lommel P, van Wees R, Meyers V, Elfferich I (2001) Near-death experience in survivors of cardiac arrest: a prospective study in the Netherlands. *Lancet* 358: 2039–2045
23. Schwaninger J, Eisenberg PR, Schechtman KB, Weiss AN (2002) A prospective analysis of near death experiences in cardiac arrest patients. *J Near Death Stud* 20: 215–232
24. Greyson B (2003) Incidence and correlates of near-death experiences in a cardiac care unit. *Gen Hosp Psychiatry* 25: 269–276
25. Bünning S, Blanke O (2005) The out-of-body experience: precipitating factors and neural correlates. *Prog Brain Res* 150: 331–350
26. Faguet RA (1979) With the eyes of the mind: autoscopic phenomena in the hospital setting. *Gen Hosp Psychiatry* 1: 311–314
27. De Ridder D, Van Laere K, Dupont P, Menovsky T, Van de Heyning P (2007) Visualizing out-of-body experience in the brain. *N Engl J Med* 357: 1829–1833
28. Blanke O (2004) Out of body experiences and their neural basis. *BMJ* 329: 1414–1415