14. Near-Death Experiences: What do we know?

Pauline Fritz[1,2] , Nicolas Lejeune[1,2,3], Helena Cassol[1], Steven Laureys[1,2], Olivia Gosseries[1,2], Charlotte Martial[1,2]

[1]Coma Science Group, GIGA-Consciousness, University of Liège, Liège, Belgium

[2]Centre du Cerveau², University Hospital of Liège, Liège, Belgium

[3]William Lennox Neurological Hospital, Ottignies-Louvain-la-Neuve, Belgium

Charlotte Martial
Email: cmartial@uliege.be

Abstract

The notion that death represents a passing to an afterlife, where we are reunited with loved ones and live eternally in a utopian paradise, is common in the anecdotal reports of people who have encountered a "near-death experience" (NDE). These experiences are usually portrayed as being extremely pleasant including features such as a feeling of peacefulness, the vision of a tunnel leading to a brilliant light, the sensation of leaving the body, or the experience of a life review. NDEs are increasingly being reported as a clearly identifiable physiological and psychological reality of clinical and scientific significance. The definition and causes of the phenomenon as well as the identification of NDE experiencers are still matters of debate. The phenomenon has been thoroughly portrayed by the media, but the science of NDEs is rather recent and still lacking rigorous experimental data and reproducible controlled experiments. It seems that the most appropriate theories to explain the phenomenon tend to integrate both psychological and neurobiological mechanisms. It is remarkable to observe the richness and the intensity of the memory despite a critical cerebral context. This challenges our conception of consciousness and offers a unique opportunity to better understand the neural correlates of consciousness. In this chapter, we will attempt to describe NDEs and how to identify them. We will also briefly discuss the NDE experiencers' characteristics. Finally, we will address the main current explicative models and the science of NDEs.

Keywords Near-death experience - Consciousness – Coma

Description of the phenomenon

"This tone of love grows stronger and any negative emotion does not exist. I entered a region just beyond the atmosphere of death. I could feel the earth tones behind me and a new tone in front of me, in this tone I understood everything and the pitch-blackness of space is not a void vacuum enmeshed with stars in the distance as we see from earth through telescopes. This particular tone is in all things and male or female, it is what I call the 'god-force' and space is full of 'life-systems' at many different levels that can only be perceived at this level of consciousness, for I knew I was still conscious of myself in that I still knew that I was! As I passed through, I was sad – and this is important – "Nothing cannot not exist." This statement now made twice surely must confuse you as well as it confuses me, but where I was it made perfect sense."
A part of the narrative (participant nº 509) from our testimonies database. Memory reported after a trauma.

After recovering from a coma caused by brain injury, patients can sometimes report vivid perceptions and memories that have occurred during their period of unresponsiveness. Some of these memories have been popularized under the expression "near-death experiences" (NDEs) (1). NDEs can be defined as an episode of disconnected consciousness (i.e., stimulus-independent mental content) (2) with prototypical features classically occurring in the context of a life-threatening condition (e.g., cardiac arrest, trauma, perioperative complications, intracerebral hemorrhage, septic or anaphylactic shock, near-drowning or asphyxia, electrocution, attempted suicide) (1,3,4). The most common core features of NDEs, ranked by frequency, are a sense of peacefulness/well-being, out-of-body experience (OBE), seeing a bright light, an altered sense of time, and entering a different, unearthly environment (5). Despite their circumstances of occurrence, NDEs are generally experienced as extremely pleasant and can induce life-changing consequences on the experiencers' set of values and attitudes toward death (4).
Without being designated as such, NDEs were already addressed in Plato's Republic (6) and represented in paintings by Hieronymus Bosch during the fifteenth century (7) (Fig. 14.1). The expression was unofficially first formulated in the nineteenth century when Albert von St. Gallen Heim, a Swiss geologist and alpinist, collected "near-death" testimonies from his fellow climbers and himself after climbing accidents in the Alps (8) (See Fig. 14.2. for a timeline of key moments in NDE history). He described these experiences as being similar in their content including an expanded time perception, the review of past episodes of one's life, auditory perceptions containing music and various sounds, visions of idyllic landscapes, and the absence of pain at the moment of impact. Following Heim's work, the equivalent French term "*expérience de mort imminente"* was proposed by the French psychologist and epistemologist Victor Egger. Some decades later, Moody (1) popularized the expression "*near-death experience—NDE*" through his best seller *Life After Life* in which he defined NDEs as "any conscious perceptual experience occurring in individuals pronounced clinically dead or who came very close to physical death." Moody drew a list of the most frequently recounted features by a recruited sample of 150 individual's coma survivors in intensive care who had been hospitalized after a near-death incident of various etiologies. These features included ineffability, being "out of the body" and meeting spiritual entities. Ever since, several definitions have been proposed, and at present most of the researchers agree that NDEs are particular episodes of disconnected consciousness (2) and use the Greyson NDE scale (9) or the very recently developed Near-Death Experience Content (NDE-C) scale (10) to identify and characterize them in research.

Fig. 14.1

Reproduction of Hieronymus Bosch's work "Ascent of the Blessed" (painted around 1490 in the Netherlands). Palazzo Ducale, Venice. "The image evokes a symbolic imagery, religious or esoteric, where after the end of earthly life, souls saved, helped by angels, throw off the last remains, and reborn in a different plane, rising almost without the support of its heavenly guides, following by a corridor (or tunnel) where an intense light emerges from the darkness and illuminates their path of ascension" (7). Unfortunately, too little is known about the life of the painter to provide a satisfactory explanation of this work on the basis of his biographical background (11). File taken from the Wikimedia Commons (http://en.wikipedia.org/wiki/File:Ascent_of_the_Blessed.jpg#globalusage

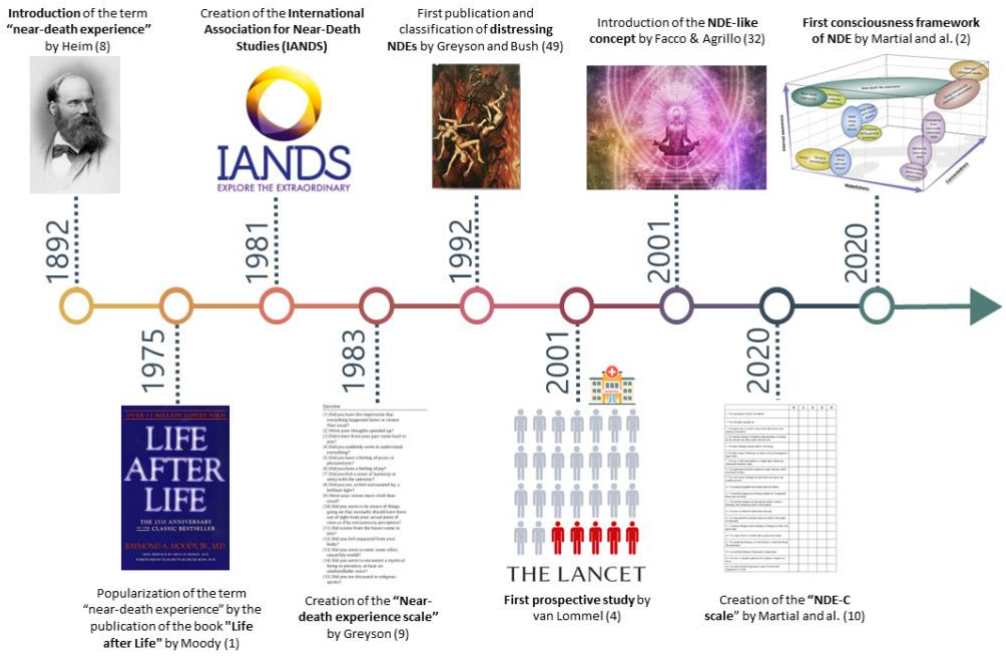

Fig. 14.2 - Chronological Timeline of Significant NDEs Events.

This figure illustrates a chronological timeline highlighting some key events related to NDEs research.

Identifying NDEs

According to a Gallup Poll, it was estimated that approximately 5% of the American population have had such an experience (or at least encountered some NDE features) in the context of a life-threatening situation (12). Surveys conducted in Australia (13) and Germany (14) have indicated a prevalence ranging from 4% to 15%. These findings are supported by a recent study in which approximately 15% of patients reported having experienced an NDE during their stay at the intensive care unit (15). Furthermore, the occurrence of NDEs has been examined according to the underlying causes. After recovery from cardiac arrest, the estimated incidence of experiencing a NDE is approximately 10-23% (4,16–18), whereas it is observed in only 3% of cases following traumatic brain injury (19). However, these values might not reflect the absolute frequency since many NDE experiencers (NDErs) can be uncomfortable with sharing their experience or might have forgotten about those memories (17). Moreover, it is not clear how NDErs were identified in these studies. To facilitate NDE identification, Greyson developed a tool to use in clinical and research settings, the "near-death experience scale—NDE scale" (9). He first selected 80 features from the existing NDE literature and subsequently reduced these to a final validated (20) 16-item multiple-choice tool used to quantify the intensity of the NDE (i.e., total score ranging from 0 to 32) and to assess core content components of 16 NDE features. For each item, the scores are arranged on an ordinal scale ranging from 0 to 2 (i.e., 0 = "not present," 1 = "mildly or ambiguously present," and 2 = "definitively present") (9,20). According to the Greyson NDE scale, a score of 7 or higher qualifies the experience as an NDE (9).

In the continuity of this identification process, and although the Greyson NDE scale is of scientific value, this scale suffers from several limitations. Indeed, its psychometric properties are relatively weak, with incomparable response formats for the multiple-choice items and a small number of possible Likert scale responses. Second, the growing number of very unpleasant or distressful NDEs accounts collected by researchers (21), were not represented in this scale. In fact, none of the items on the Greyson NDE

scale refer to negative emotions. For these reasons, in 2020, Martial et al. re-examined the compositional structure of the NDE scale and, in line with the recent literature, developed a new validated scale, the NDE-Content (NDE-C) scale, to address the current needs of research (2,10). The scale contains 20 items with a total score ranging from 0 to 80. The responses to each item are given on a Likert-type scale ranging from 0 to 4, where 0 corresponds to "not at all; none", 1 corresponds to "slightly", 2 corresponds to "moderately", 3 corresponds to "strongly; equivalent to any other strong experience", and 4 corresponds to "extremely; more than any other strong experience and stronger than 3" (see Table 14.3 for details). According to the NDE-C scale, an individual with a score of 27 or higher qualifies the experience as NDE. For further studies, this cut-off score has been viewed as optimal to detect sufficiently rich and prototypical experiences to be considered as NDEs. Indeed, this scale facilitates empirical research and standardization and, so far, is the most rigorous tool based on the most up-to-date literature allowing to identify NDEs. However, from a clinical standpoint, it is important to emphasize that every self-reported experience, even those with a score below this cut-off value, should be taken into consideration from a clinical point of view when providing care to patients (10).

Table 14.3

NDE-C scale (2020)

We would like you to answer the 20 following statements according to your feelings and thoughts at the time of the experience (not before, nor after) by choosing the answer that seems the most appropriate (only ONE answer by statement is allowed).
Every experience or sensation varies in intensity, which is why we would like you to specify the intensity of your experience using the rating scale (from 1 to 4) described below for each statement. If, on the contrary, you did not experience the phenomenon described in the statement, please choose '0 - Not at all; none'. If you happen to have experienced several times the same phenomenon during the experience, please answer by considering the most striking phenomenon.

	0 *Not at all; none*	**1** *Slightly*	**2** *Moderately*	***3*** *Strongly**	**4** *Extremely***
1. Your perception of time was altered					
2. Your thoughts speeded up					
3. You heard one or several voices which did not have any material incarnation					
4. You had the feeling of suddenly understanding everything about yourself, the others and/or the universe					
5. You had a feeling of peace and/or well-being					
6. You felt a sense of harmony or unity, as if you belonged to a larger whole					
7. You saw or felt surrounded by a bright light without any determined material origin					
8. You experienced unusual sensations (sight, hearing, smell, touch and/or taste)					

9. You were aware of things beyond what your senses can usually perceive					
10. You gained insightful knowledge about the future					
11. You had the impression of being outside of, or separated from your own body					
12. You had the sensation of leaving the earthly world or entering a new dimension and/or environment					
13. You saw or relieved events from your past					
14. You encountered a presence and/or an entity (who might be deceased)					
15. You had a feeling of non-existence, of being in a total void and/or fear					
16. You came close to a border and/or point of no return					
17. You made the decision, or were forced, to come back from the experience					
18. You had the feeling of dying and/or being dead					
19. You saw or entered a gateway (for instance a tunnel or a door)					
20. You sense that the experience cannot be described adequately in words					
Strongly: equivalent in degree to any other strong experience lived so far* *Extremely**: more than any other time in my life and stronger than 3*					

NDE characteristics

NDEs are fascinating and complex subjective experiences characterized by a series of psychological and physiological phenomena. One of the most striking features of NDEs is the vividness of the subsequent memories, while the experiences typically arise in a critical context. Indeed, the report of NDE memories is extremely vivid, rich, and detailed compared to any other memories (22). More specifically, a recent study showed that NDE memories stand out by containing a greater overall amount of details, particularly in terms of internal/episodic aspects, when compared to flashbulbs and autobiographical memories (23). Moreover, the intensity of the NDE seems to vary according to the personal importance the NDEr attaches to the experience, suggesting that the more intense the NDE, the more important the NDE can be considered as a milestone in the experiencer's life. It has been hypothesized that the importance attached to the NDE could potentially enhance characteristics of NDE memories (21). Thus, it can be hypothesized that as the NDE becomes richer, the encoding of the memory becomes deeper and more specific, resulting in a higher prevalence of phenomenological characteristics within the memory. As such, NDEs may provide insight into how memories of extremely rich experiences are encoded and processed (24). Finally, and interestingly the intensity of NDEs does not seem to increase or decrease with the time elapsed and the memories seem to be stable over time

and persist for years, even decades, after the experience (25). These findings align with existing literature that highlights the distinctiveness of NDE memories (23). Several empirical studies have focused on the startling memory feat of these experiences (22,24,26), however, so far little has been done to test underlying neurophysiological hypotheses (26).

In the field of NDEs, most studies agree on the predominant features reported, namely a sense of peace and well-being, OBEs and seeing a bright light (5,16,17,27,28). Other commonly experienced features of NDEs include encounters with bright lights, tunnel experiences, encounters with people or spirits, and heightened senses (i.e., heightened sensory perception) (5,16,17,29,30). However, certain features such as precognitive visions (perception of future events), life review, or extrasensory perception (acquisition of information without the use of the physical senses, such as telepathy) are less commonly reported (5,17,30). Text mining analysis conducted by Charland-Verville et al. (2020) sheds further light by identifying the most frequent words in NDErs' narratives. The three most frequently mentioned words are "light," "well," and "see." Interestingly, these words align with the predominant features commonly reported in NDEs (31). Moreover the same study identified word clusters in NDE accounts that were related to visual perceptions, emotions, and spatial components (31). In another complementary study employing qualitative thematic analysis, specific themes were identified within NDEs narratives (32). These themes encompassed two distinct types. The first type is a transversal theme characterized by altered time perception, which permeates the narrative as a retrospective commentary. The second type consists of time-bounded themes such as light, return, reunion, and encounter, which are separate and distinguishable from other events within the NDE (32). Finally, a recent publication by Martial et al. introduces a novel prototypical feature of NDEs: the experience of ego dissolution, which has received limited investigation in previous research (33). The above-mentioned studies collectively demonstrate the recurrence of certain phenomenological aspects in NDEs, highlighting common themes and structures within individual accounts suggesting the presence of consistent patterns in NDEs.

NDEs Not "Near Death"

Unlike these "classical" NDEs associated with impeding death or coma, "NDE-like" experiences have also been reported in situations where there was no genuine threat to the individuals' life. Only a few studies have assessed "NDE-like" phenomena in non-life-threatening situations (34–38). Such accounts have notably been reported in epileptic patients (39), syncope (40), intense grief and anxiety (41), Cotard's syndrome (42), and meditative state (43). These NDEs-like appear to be very rich and lead to profound life transformations just like "classical" NDEs. In a case-study published in 2012, a subject reported common NDE features such as witnessing a supernatural light, feelings of peacefulness, profound joy, and a sense of empathic connection with the entire world. Remarkably, these experiences occurred in the absence of any critical cerebral or psychological disorders. It should be noted, however, that this incident occurred during his holiday, which coincided with a difficult period in his life due to an ongoing divorce (34). The subject reported no history of psychiatric disorders, use of psychotropic drugs, nor substance abuse. Although the existing empirical literature comparing NDEs-like with classical NDEs is limited, the few studies available suggest that both are phenomenologically similar (5,10,34,44,45). Indeed, from the reported phenomenology, the context of the experience cannot be inferred (46).

Another possible way to study NDE-like states is through the use of hypnosis (38,47,48). Hypnosis is a technique that alters the state of consciousness, making the individual more receptive to suggestions and stimuli (49). In the field of NDEs, a study was carried out on five volunteers who had experienced pleasant NDEs (38). Hypnosis was used to have the participants vividly recall their NDE memories, as

well as another pleasant autobiographical memory from the same period. The authors succeeded in recreating NDE-like features that closely resemble what the participants experienced several years ago during their NDE, without any adverse effects (38). In the same year, other researchers also successfully used hypnosis pursuing the same goal (47). It thus seems that hypnosis holds promise as a future approach to investigating NDE recall and inducing NDE-like states.

A growing body of evidence has recently focused on the similarity between NDE narratives and narratives experienced when taking psychedelic drugs or dissociative anesthetics. Indeed, some of them, such as ketamine, N,N-Dimethyltryptamine (DMT), lysergic acid diethylamide (LSD), and psilocybin, may induce NDE-like states (44,45). People who take these substances may for example feel a dissociation from their body, altered perceptions of reality, a feeling of unity with the universe, as well as an impression of dying or rebirth experiences. These experiences may lead to spiritual insights and significant personal transformations. Martial and colleagues conducted the first large-scale study aiming to highlight the psychoactive substances most resembling NDEs by assessing the semantic similarity between more than 15,000 narratives linked to the use of 165 different psychoactive substances and 625 NDE narratives using natural language processing (44). The authors found that, in terms of phenomenology, the most comparable substance was the N-methyl-D-aspartate (NMDA) receptor antagonist ketamine, followed by *Salvia Divinorum* (a plant containing a potent and selective κ-receptor agonist) and a range of serotonergic psychedelics, such as the DMT and psilocybin (44). So far, only one placebo-controlled experiment rigorously tested the potential similarity of a psychedelic with NDE in laboratory settings (45). Timmermann and collaborators (45) found a significant overlap between the phenomenology of NDEs and those associated with DMT, with only one prototypical feature that was less reported in DMT than in NDEs: the feeling of coming to a border or point of no return. By finding the substances that induce most resembling phenomenological contents to NDEs and whose underlying mechanisms are relatively well understood, the use of psychedelics in the scientific study of NDEs can offer valuable insights to draw hypotheses for NDEs. This will permit researchers to examine the sensory, emotional, cognitive, and neurobiological aspects of similar phenomenological experiences in a non-life-threatening context. Future empirical studies are needed to understand the contextual and individual factors that influence the nature and intensity of NDE-like.

Negative NDEs

Although NDEs are usually reported as being extremely pleasant, distressing or hellish experiences can also occur. Initial estimations suggested an incidence of 1-2%, but a recent study found a higher percentage of 14% of distressing NDEs in a sample of 123 testimonies (21). This indicates that the frequency of frightening NDEs might be underestimated, possibly due to individuals being reluctant to report them due to the post-traumatic stress component associated with such experiences (50–52). Understanding the frequency of distressing NDEs can therefore be challenging. Bush et al. (50) identified three types of negative NDEs. The first type, called the "inverse experience," shares similar content with pleasant NDEs, such as light or presences. However, in the inverse experience, these elements are perceived as an alien and uncontrollable reality, causing extreme stress. The second type involves experiences of emptiness, where individuals feel abandoned and nonexistent: the "void experiences". The third type represents the prototypical "hellish" encounter, characterized by threatening entities, traditional hell-like imagery, and perceptions of impending judgment and torment. Recently, a larger sample of NDE testimonies provided empirical confirmation of this classification (21). Additionally, this study highlighted that distressing NDE memories exhibited similar ratings for phenomenological memory details and vividness compared to classical NDE experiences (21). Interestingly, the "inverse" and "hellish" narratives appeared to be equally represented, while "void" narratives were the least commonly reported (21).

Despite the obvious importance of detecting distressing NDEs, they are often overlooked in clinical settings. A recent study has shown a higher prevalence of suicide attempts in distressing NDEs compared to classical NDEs, suggesting that the negative context surrounding NDEs can influence the emotional valence of the NDE (21). This also suggests a potential relationship between the negative emotional context of suicides and the nature of the resulting NDEs. According to neuroscientific and psychological approaches of NDEs, the content of the experience, including their emotional valence, may be influenced by "top-down" processes such as an individual's knowledge, beliefs, and expectations and more globally by the NDErs characteristics (21,53,54).

NDE Experiencers' Characteristics

The scientific interest in studying the personal characteristics of NDErs aims to gain a better understanding of the personal traits that may be associated with the reported features of NDEs (55,56). Additionally, it seeks to evaluate the characteristics that can distinguish individuals who report having had an NDE from those who do not (15,57). Studies performed among patients with cardiac arrest have shown that NDEs seem to be reported more frequently before the age of 60 (4,17). This could be attributed to the increased vulnerability of older patients' brains. Indeed, their brain's decreased plasticity potentially affect the encoding, storage, or recall of NDE. The same study highlighted that having had a previous NDE could facilitate the reoccurrence of such experience, as individuals can report multiple NDEs (4). Using the first scale based on arbitrarily weighted items for the rating of NDE accounts, the Ring's Weighted Core Experience Index (9,58), van Lommel et al. (4) observed more intense NDEs in women, but no other studies reported such a difference in gender. This gender observation might be partly explained by the fact that women might be less afraid to report a NDE (1) or that women have been found to score generally higher on anomalous-perception questionnaires than male subjects (59). Other demographic variables such as ethnicity, social class, religiosity, educational level, and factors like prior psychiatric disorders or psychiatric characteristics, suicidal behavior, or family history of suicidal attempts have not been shown to influence the frequency of reported NDEs (4,10,15,16,58,60–62). Most of the NDE literature comes from Western cultures, but according to published data, taking into account religiosity and cultural background, these variables seem to have an influence on the NDEs' content and the features' interpretation (13,63). While Western experiencers might describe the presence perceived in their NDE as guardian angels, Easterners, for example in India, might see them as messengers of the god of death (64,65). Even though the sociocultural background might influence the reported content and interpretation, the overall reports show sufficient common content and meaning to be considered a universal human experience of great interest for modern neuroscience (34,63).

In recent years, some articles have also explored the role of personality traits and cognitive profile as potential factors in the occurrence of NDEs. Bicego et al. (55) retrospectively examined whether certain personality traits, dissociative experiences, fantasy proneness (propensity for imagination), and adherence to paranormal beliefs could be associated with the recall of classic NDEs or NDEs-like, as compared to people who never experienced a NDE. The results demonstrated that traits such as openness and fantasy proneness were linked to a greater recall of NDEs (55). Similarly, Martial et al. (56) reported a positive correlation between the intensity of NDEs and engagement in fantasy. Finally, and following the footsteps of Greyson's retrospective study (66), Rousseau et al. (15) conducted the first prospective study demonstrating the influence of dissociation propensity on the occurrence of NDEs. Dissociation is a psychological phenomenon that is characterized by the separation of thoughts, feelings or experiences from the normal stream of consciousness (66). The study found that a higher frequency of dissociative symptoms (e.g., daydreaming) and a greater sense of spiritual and personal well-being were the strongest predictors for recalling NDEs.

NDEs and its consequences

Individuals who experienced NDEs often undergo significant and lasting changes in their beliefs, attitudes, relationships, and behaviors (25). Noyes (67) conducted one of the first studies on the impact of NDEs, involving 205 individuals who had faced life-threatening situations. Regardless of their subjective experiences during these events, approximately two-thirds of the participants reported a subsequent shift in their outlook on life and death. Other studies show that consequences also include a decrease in the fear of death, a heightened sense of invulnerability, a feeling of being special or important, an increased belief in life after death and many individuals also report feeling more connected to others, compassionate, and purposeful following their NDEs (68). In sum, NDEs can potentially lead to a comprehensive reconstruction of personal beliefs and values related to fundamental aspects such as life and death, spirituality, religion, and relationships (68). It is nevertheless worth noting that a few studies did not observe any significant impact on the overall quality of life as a results of NDE (e.g., (15)).

Interesting studies (69,70) also used immersive virtual reality to explore the impact of NDEs and OBEs. Participants embodied virtual avatars and experienced various stages of life, including witnessing the death of companions and their own simulated NDE during six sessions. They also could experience OBEs. These participants showed attitudinal changes like those reported by authentic NDErs, such as increased concern for others and decreased materialistic interests (69). Moreover, in one virtual reality session participants experienced a virtual OBE and showed reduced fear of death (70).

To assess the extent and direction of changes after an NDE, Ring (71) developed the Life Change Inventory (LCI), a questionnaire that measures changes in traits and values using a 5-point Likert scale. Studies using the LCI or its revised version (LCI-R) (72) have consistently found that NDErs report a greater extent of change compared to people who never experienced a NDE (71,73). Moreover, a study found a correlation between changes reported on the LCI and scores on the Greyson NDE scale, suggesting that more intense NDEs may lead to greater changes (74). Despite the existence of assessment tools, people who have had NDEs continue to face challenges in effectively sharing and integrating their NDEs into their daily lives. NDErs may face consequences such as depression, anxiety, sadness, isolation, and strained relationships (68,75,76). Furthermore, since NDEs are often considered to be the most important memory/event in the lives of NDErs, it becomes crucial to cultivate the awareness and support of caregivers (77). This is especially important given the general lack of knowledge about NDEs among the general population and the potential psychological trauma that can result from the struggle to personally integrate such a profound experience (75). Healthcare professionals and therapists need to be aware of these potential effects and consider NDEs when providing care (68). Meaning-making interventions and practitioner awareness of NDEs have shown promise in supporting individuals who have had NDEs, reducing suicidal thoughts, grief, and post-traumatic stress disorder symptoms (78,79). Recognizing the importance of NDEs and providing appropriate support, including improving listening skills among medical practitioners, can help NDErs manage changes, integrate their experiences, and promote a holistic approach to healthcare (80).

Limits and debates in NDE

Although there has been a recent rapid growth in the literature on NDEs(-like) (see Figure 14.4), NDE research is still at the early stage. Until now, the comprehension of NDEs has been constrained notably by our limited understanding of the altered state of consciousness associated with this phenomenon. To clarify this issue, Martial et al. (2) proposed a model based on a distinction between three concepts:

wakefulness (i.e., spontaneous or stimulus-induced eye opening), connectedness (i.e., the connection to the external world allowing the experience of external stimuli), and internal awareness (i.e., all stimulus-independent thoughts) (see Figure 14.5).

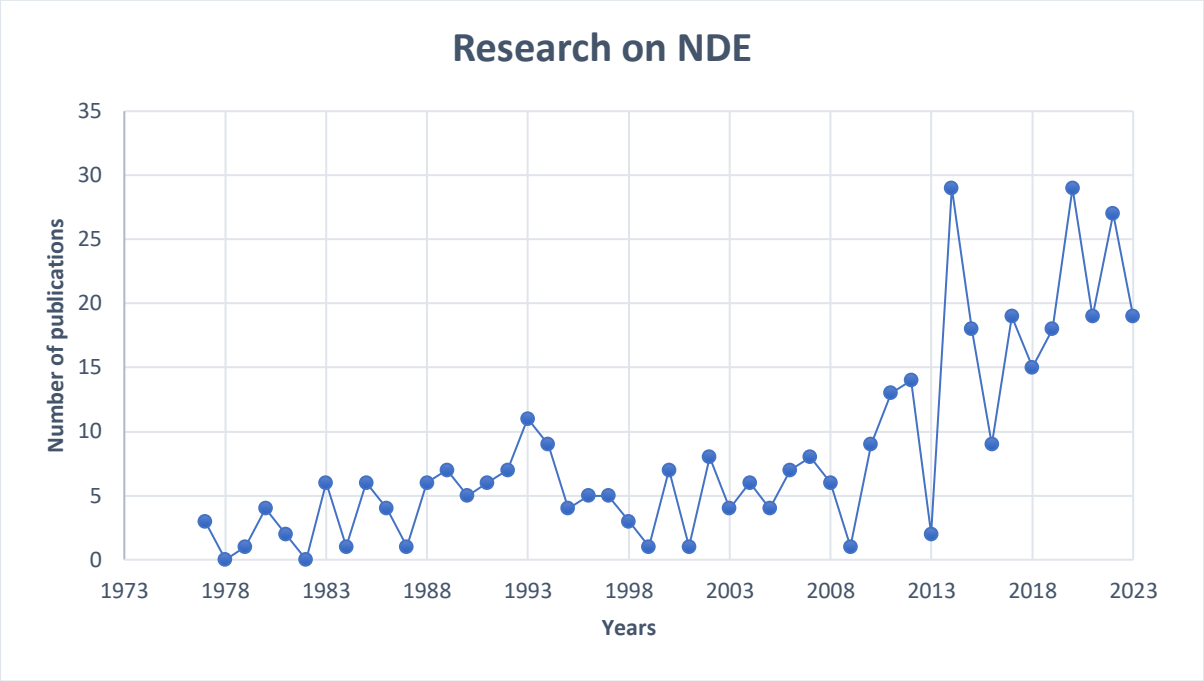

Fig. 14.4
Number of publications per year (for a total of 397 publications): PubMed search in June 2023 with the keywords “near-death experience” OR “near-death experiences”.

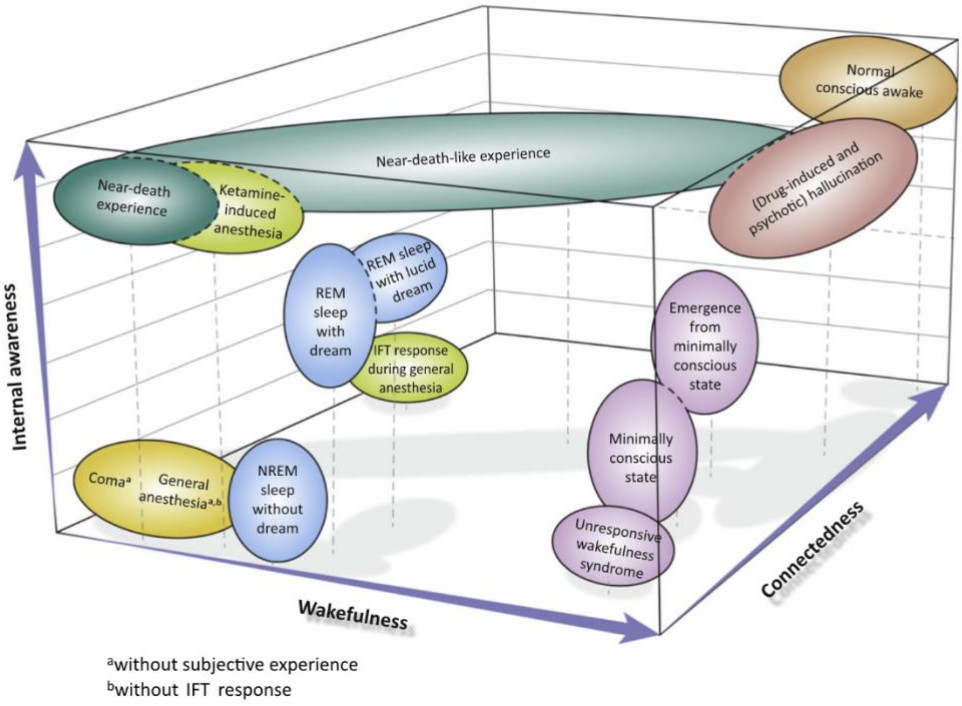

Fig. 14.5 From Martial et al. (2) – Altered states of consciousness model

This figure illustrates a model based on a distinction between three components: wakefulness, connectedness, and internal awareness.

This model highlights the similarities and distinctions between classic NDEs referring to internal awareness and disconnection from the environment, and NDE-like experiences which may correspond to higher levels of arousal and connection. Moreover, this opinion paper thus permits to establish a clear framework for studying NDEs (2). Importantly, Martial et al. (2) also stressed that so far, it is not clear whether NDEs may be associated with connectedness. Indeed, we do not know whether some external and environmental stimuli can be incorporated into the NDE, or whether these memories are the result of memory reconstructions. Despite numerous anecdotal reports of OBEs in which individuals perceive themselves floating above their physical bodies and observing their surroundings from a different perspective, no empirical study has been able to provide conclusive evidence of actual external events occurring during NDEs that would suggest a genuine connection with the environment. Among the most ambitious studies that attempted to do it, Parnia et al. (81) aimed to prospectively examine the accuracy of the reports of NDEs, and more broadly, of the range of subjective mental experiences reported after cardiac arrest in 15 hospitals. They reported that one patient out of the 140 interviewed recalled some elements of the environment experienced (sounds, people, and activities in the room) during cardiopulmonary resuscitation. However, their protocol could not confirm that these elements corresponded to real-life-based events (46).

A second major issue inherently associated to the above-mentioned absence of consensus regarding a framework is the lack of consistency in the different definitions and descriptions of NDEs. Some articles (46,82,83) point to the wide debate and lack of consensus, especially concerning the terminology used. Recently, Parnia and colleagues (82) have proposed a new terminology to characterize NDEs: "*recalled experience of death*". Both Martial and al. (46) and Evrard, Pratte, and Rabeyron (83) have critically analyzed these claims and expressed serious reservations about the authors' statements, highlighting that this new terminology lacks a scientific basis and lacks valid research support to date. Parnia and colleagues' theories imply that humans can have conscious experiences in the absence of a functioning brain (46) such as depicted in transcendental theories in which the self, cognition, and emotions would function independently from the brain, but would retain the possibility of non-sensory perception (84,85). Quantum physics models of nonlocal consciousness have also been used to support the premise of the continuation of mental function when the brain is apparently inactive or impaired or when an individual is "near death" (86,87). However, empirical protocols that have been set up to test for that hypothesis are still failing. Therefore, it seems now more probable that NDEs are the result of specific interactions between psychological and neurological mechanisms precipitated by the context of occurrence (59,88).

Explicative Models for NDEs

Psychological and neurobiological theories have been put forth to account for the global phenomenon and more specifically for its core features.

Psychological Theories

The "awareness of being dead" or very close to dying has been proposed to be an important factor for triggering NDEs. In fact, as suggested by Owens et al. (37), "it would seem that among individuals who were not near-death could be precipitated by their belief that they were". The NDE phenomenology

would reflect the individual's system of beliefs and expectations of dying and about a possible afterlife (37,89,90). According to the "depersonalization and dissociation hypothesis," when facing a life-threatening situation, an individual would disconnect from the external world and engage in internally oriented fantasies as a projective defense mechanism to make the new reality more intelligible and less distressing (66,91). In particular, individuals with "fantasy-proneness personality" would be particularly prone to recall a NDE because they have the propensity to focus their attention on imaginative or selected sensory experiences —and to exclude events from the external environment (56,92). In a similar fashion, a tendency to dissociative states seems to have a correlation with the occurrence of an NDE (15,66). As suggested, dissociation would provide a less distressing 'reality' for people faced with potential danger (91). These psychological theories are very interesting and permits to complete the neurobiological theories reviewed below.

Neurobiological Theories

In the field of NDE, numerous neurobiological theories have emerged and evolved over time, fueled by advances in understanding other fields and pathologies, as well as cutting-edge technology and imaging. Recently, Martial et al. (2) identified three majors potential triggers occurring during a life-threatening event: (A) The physiological stress including changes in the levels of blood gases, such as decreased cerebral oxygen (O2) and elevated carbon dioxide (CO2) levels (2,93,94), (B) the release of endogenous neurotransmitters such as endorphins or epinephrine, potentially favoring also memory encoding (95,96), and (C) cortical dysfunction of the temporal brain regions more specifically in the medial temporal lobes, temporoparietal junction and insular cortex (2,39,97–104) (see Figure 14.6).

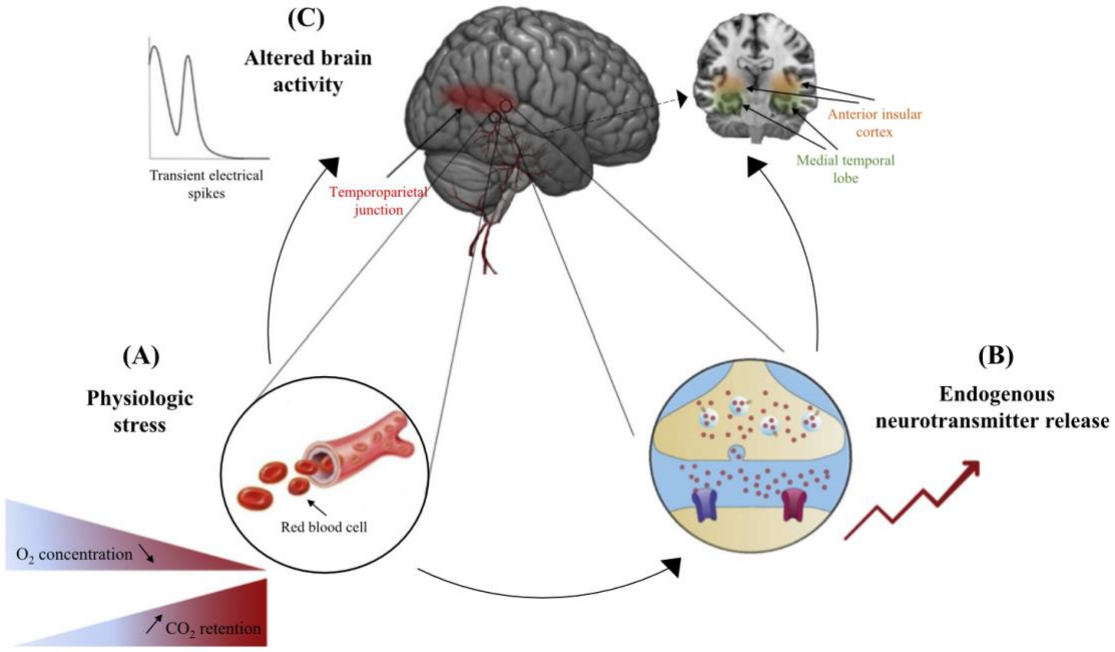

Fig. 14.6 From Martial et al. (2) – Neurobiological model

Based on scarce empirical NDEs and NDE-like literature, this figure depicts the potential (non-exclusive) implications of several causative agents.

(A) First, one of the long-standing hypothesis claims that altered blood gas levels, such as those observed following ischemia and hypoxia, may contribute to the manifestation of NDE(-like) features (93,105). The mechanisms involved have been proposed to occur as a cascade of events, beginning by a neuronal disinhibition in early visual cortex spreading to other cortical areas (88,107–109). Blackmore (1996) proposed that the tunnel vision and the perception of bright lights could be linked to the loss of bilateral peripheral visual field and retinal ischemia (53). Based on previous neuroimaging data, it seems clinically plausible that resuscitated patients with NDEs may suffer from transient ischemic and/or hypoxic lesions or interferences with bilateral occipital cortex and the optic radiation (36,109,110). However, these speculations must be regarded with caution; as to date, no neurological, neuropsychological, and neuroimaging data exist to corroborate these hypotheses empirically. As stated by Blackmore (1993), the brain's altered oxygen levels are probably one of several related mechanisms that lead to NDEs as it does not account for NDEs occurring in the absence of damage attributable to this mechanism (106).

(B) Secondly, it has also been suggested that NDEs would potentially be associated to the release of specific endogenous neurotransmitters (44,45). Indeed, by studying drugs, some studies have shown similarity between NDEs and drug phenomenology, as exposed above. In 1997, Jansen et al. (111) proposed the ketamine model for the study of NDEs. Indeed, the recreational ketamine experience have highlighted many similar features with NDEs: peace and tranquility, the conviction that one is dead, trips through dark tunnels into light, OBEs, seeing spirits, telepathic communion with God, and mystical states (112,113). This dissociative anesthetic and recreational drug has a blockade action on the glutamate NMDA receptors (114). Likewise, conditions which can precipitate NDEs (e.g., decreased brain oxygen, blood flow, blood sugar) could increase the levels of glutamate release in the context of excitotoxic brain damage, stimulating the release of a ketamine-like neurotoxin (115,116). This hypothesis was also recently supported by Martial and colleagues' (44) study which highlighted the high similarity of the phenomenological content between ketamine and NDEs, thereby permitting to assume that neurophysiological mechanisms behind these experiences may be (at least partly) similar. Other studies also emphasize the role of disrupted serotonergic activity (117,118) and the potential massive release of endorphins (96) in a condition of impeding death (119).

(C) Thirdly, we also find research based on empirical results that establish links between the behavioral and neuronal manifestations of NDEs. The brain is assumed to be hypoactive during cardiac arrest. However, studies have shown that acute hypoxia or abrupt cessation of heart activity in healthy animals triggers significant levels of gamma activity, including a global increase in functional and directional connections in gamma oscillations (118,120). These results have led to the highly mediatized and criticized hypothesis that unexpected conscious processing measured in rats after a cardiac arrest could serve as an explicative model for the rich experiences associated with NDEs reported in the same context. In addition, several human studies have shown an increase in high-frequency oscillations that is now identified as supposed marker of consciousness (121,122). These studies confirmed earlier findings from animal models, including an increase in gamma power and gamma coupling with slower oscillations (118,120,122–125). Taken together, these findings suggest an intricate interaction between low and high frequency bands following the gradual cessation of cerebral activity and continuing into the period when cerebral blood flow has stopped (123–125). Very recently, a study from Xu et al. (122) went even further by investigating the dying human brain of four patients and found a high-frequency activation of the temporo-parietal-occipital junction.

In parallel, Lempert et al. (40) while studying motor phenomena of vasovagal syncope incidentally observed that the faints were accompanied by memories. Sixty percent of the fainters reported vivid NDE-like features (e.g., feeling of peace, OBE, entering another world, life reviews). Syncope episodes were induced via the combination of hyperventilation and Valsalva maneuver (i.e., a forced expiration

against the closed larynx) in healthy young adults (40,93). Harmless syncopes have since been proposed to be a good model to study NDEs (126). Another theory has postulated that the transient impaired cerebral oxygen levels caused by a syncope (and more dramatically as in the context of a cardiac arrest) lead to a disruption of the physiological balance between conscious and unconscious states causing the ascending arousal system to blend rapid eye movement (REM) sleep attributed partly to the action of the locus coeruleus–noradrenergic system (126,127). The REM state, characterized by vivid dreaming, can manifest as visual hallucinations even during wakefulness. Additionally, it can intrude during sleep paralysis or cataplexy, where it may take the form of auditory experiences or atonia. Consequently, these instances of REM intrusion can intensify an individual's feeling of being deceased and convey the perception of death to others (127). In line with that hypothesis, a cohort of NDErs have been found to be more sensitive to REM sleep intrusions and sleep paralysis associated with hypnagogic and hypnopompic experiences (127). Recently another study based on an online survey corroborated these results and showed that REM sleep intrusion was the only factor that significantly correlated with NDE compared to other factors such as the place of residence, the employment status or the perceived danger (128).

Studies with neurological patients have led to more hypotheses and findings about the neural correlates of NDE core features. For instance, a study based on an online survey carried out on a large global sample highlights the intriguing relationship between NDEs and migraine aura, with the results showing that migraine aura is a significant predictor of NDEs (129). It has been also shown that the stimulation of the right temporoparietal junction area, including the anterior part of the angular gyrus and the posterior temporal gyrus, can produce OBEs caused by a deficient multisensory integration at the temporoparietal junction area (99–102). Furthermore, there are additional connections worth exploring. Indeed, focal electrical stimulation protocols administered to patients with epilepsy, migraine, or tinnitus have been found to induce repeated OBEs that involve a visuospatial perspective positioned outside the physical body and illusory transformations of the patient’s limbs (59,100). Using a positron emission tomography scan, these authors also showed that the OBE was related to increased activity in the right superior temporal and precuneal cortices (100). The OBE illusions may be the result of a complex illusory replication of one’s body based on ambiguous input from proprioceptive, tactile, visual, and vestibular information and their integration at the disrupted right temporoparietal junction area (102,130). To some extent, these body illusions have also been reported in healthy individuals during microgravity conditions (inversion illusion during space mission or the low gravity phase of parabolic flights) (131), in the context of sleep paralysis (132) and virtual reality (133). In the continuity of these findings, the left temporoparietal junction may be a potential neural correlate of NDE features for the "feeling of a presence" that NDErs may experience. Indeed, a case study on an epileptic patient clarified a strange presence feeling that was felt following stimulation of the left temporo-parietal junction. This happened during the patient's continuing presurgical assessment for the management of epilepsy (99). Concomitantly, Peinkhofer and colleagues (134) suggested an evolutionary hypothesis of the origin of NDE. To face life-threatening events, Homo sapiens as well as animals used thanatosis or "death-feigning". It is a biological and anti-predator/defense strategy that is activated when fight or flight is no longer possible (134–136) and still found today in many animals (134). According to the authors’ hypothesis, this behavior would be the evolutionary origin of NDEs. But today, with the absence of natural enemies, it is less likely that NDEs serve a biological purpose, and rather strive to give meaning to the information that is perceived and experienced. The more sophisticated human brain is now capable of using language and strives to give meaning to the information it receives to maintain interpretative coherence. As a result, a new subjective reality can be created, resulting in a NDE with rich details that can be reported and shared with others (134).

CONCLUSION

Despite worldwide media attention and the profound questions NDEs raise about death and consciousness, they still lack a consensus or complete scientific explanation. The lack of empirical research on the phenomenon, coupled with the challenges of studying such intense subjective experiences that occur close to death, has contributed to the limited scientific understanding of NDE. Contemporary research, supported by numerous studies offering compelling evidence and plausible hypotheses, has shifted the focus from transcendental theories to psychological and neurobiological perspectives. Advances in technology and ongoing research are beginning to shed light on the complex interplay between the various factors involved in the occurrence of NDEs. NDEs appear to be multifaceted in nature, influenced by a combination of psychological, neurobiological, situational, and cultural factors. Further research into NDEs will be necessary in an attempt to explain this fascinating as well as the issues at stake and the consequences.

Acknowledgments

This research was supported by the University and University Hospital of Liège, the Belgian National Funds for Scientific Research (FRS-FNRS), the BIAL Foundation, the European Union's Horizon 2020 Framework Programme for Research and Innovation under the Specific Grant Agreement No. 945539 (Human Brain Project SGA3), the FNRS PDR project (T.0134.21), the ERA-Net FLAG-ERA JTC2021 project ModelDXConsciousness (Human Brain Project Partnering Project), the fund Generet, the King Baudouin Foundation, the Télévie Foundation, the European Space Agency (ESA) and the Belgian Federal Science Policy Office (BELSPO) in the framework of the PRODEX Programme, the Public Utility Foundation 'Université Européenne du Travail', "Fondazione Europea di Ricerca Biomedica", the Mind Science Foundation, the European Commission, the Fondation Leon Fredericq, the Mind-Care foundation, the DOCMA project (EU-H2020-MSCA–RISE–778234), the National Natural Science Foundation of China (Joint Research Project 81471100) and the European Foundation of Biomedical Research FERB Onlus.

References

1. Moody R. Life after life. New York: Bantam Press; 1975.

2. Martial C, Cassol H, Laureys S, Gosseries O. Near-Death Experience as a Probe to Explore (Disconnected) Consciousness. Trends Cogn Sci. 2020 Mar;24(3):173–83.

3. Cardeña E, Lynn SJ, Krippner S, editors. Varieties of anomalous experience: examining the scientific evidence. Second edition. Washington, DC: American Psychological Association; 2014. 452 p.

4. van Lommel P, van Wees R, Meyers V, Elfferich I. Near-death experience in survivors of cardiac arrest: a prospective study in the Netherlands. The Lancet. 2001 Dec;358(9298):2039–45.

5. Charland-Verville V, Jourdan JP, Thonnard M, Ledoux D, Donneau AF, Quertemont E, et al. Near-death experiences in non-life-threatening events and coma of different etiologies. Front Hum Neurosci. 2014;8.

6. Dent P. The Republic. London; 1937.

7. Bosch H. Between heaven and hell. 1450.

8. Heim A. Jahrbuch des Schweizer Alpenclub / 27 Notizen über den Tod durch Absturz. [Verlag der Expedition des Jahrbuchs des S.A.C.]; 1892.

9. Greyson B. The Near-Death Experience Scale: Construction, Reliability, and Validity. J Nerv Ment Dis. 1983 Jun;171(6):369–75.

10. Martial C, Simon J, Puttaert N, Gosseries O, Charland-Verville V, Nyssen AS, et al. The Near-Death Experience Content (NDE-C) scale: Development and psychometric validation. Conscious Cogn. 2020 Nov;86:103049.

11. Engmann B. Near-Death Experiences: Heavenly Insight or Human Illusion?. Cham: Springer International Publishing; 2014.

12. Gallup G, Proctor W. Adventures in immortality: a look beyond the threshold of death. New York: McGraw-Hill; 1982.

13. Mahendra P, Padmasekara G, Belanti J. Prevalence of near-death experiences in Australia. Journal of Near-Death Studies. 24(2). 2005;109–16.

14. Knoblauch H, Schmied I, Schnettler B. Different kinds of near-death experiences: a report on a survey of near-death experiences in Germany. J -Death Stud. 2001;20(1):15–29.

15. Rousseau AF, Dams L, Massart Q, Choquer L, Cassol H, Laureys S, et al. Incidence of near-death experiences in patients surviving a prolonged critical illness and their long-term impact: a prospective observational study. Crit Care. 2023 Feb 27;27(1):76.

16. Schwaninger J, Eisenberg PR, Schechtman KB, Weiss AN. A Prospective Analysis of Near-Death Experiences in Cardiac Arrest Patients. J -Death Stud. 2002;20(4):215–32.

17. Greyson B. Incidence and correlates of near-death experiences in a cardiac care unit. Gen Hosp Psychiatry. 2003 Jul;25(4):269–76.

18. N SS, P AL, B SL, R R, V SK. A Study of Near-Death Experience in Patients With Chronic Kidney Disease. Omega. 2023 May 26;302228231179352.

19. Hou Y, Huang Q, Prakash R, Chaudhury S. Infrequent near death experiences in severe brain injury survivors - A quantitative and qualitative study. Ann Indian Acad Neurol. 2013;16(1):75.

20. Lange R, Greyson B, Houran J. A Rasch scaling validation of a 'core' near-death experience. Br J Psychol. 2004 May;95(2):161–77.

21. Cassol H, Martial C, Annen J, Martens G, Charland-Verville V, Majerus S, et al. A systematic analysis of distressing near-death experience accounts. Memory. 2019 Sep 14;27(8):1122–9.

22. Thonnard M, Charland-Verville V, Brédart S, Dehon H, Ledoux D, Laureys S, et al. Characteristics of Near-Death Experiences Memories as Compared to Real and Imagined Events Memories. Valdes-Sosa PA, editor. PLoS ONE. 2013 Mar 27;8(3).

23. Cassol H, Bonin EAC, Bastin C, Puttaert N, Charland-Verville V, Laureys S, et al. Near-Death Experience Memories Include More Episodic Components Than Flashbulb Memories. Front Psychol. 2020 May 13;11:888.

24. Moore LE, Greyson B. Characteristics of memories for near-death experiences. Conscious Cogn. 2017 May;51:116–24.

25. Greyson B. Persistence of Attitude Changes After Near-Death Experiences: Do They Fade Over Time? J Nerv Ment Dis. 2022 Sep;210(9):692–6.

26. Martial C, Charland-Verville V, Cassol H, Didone V, Van Der Linden M, Laureys S. Intensity and memory characteristics of near-death experiences. Conscious Cogn. 2017 Nov;56:120–7.

27. Lai CF, Kao TW, Wu MS, Chiang SS, Chang CH, Lu CS, et al. Impact of Near-Death Experiences on Dialysis Patients: A Multicenter Collaborative Study. Am J Kidney Dis. 2007 Jul;50(1):124-132.

28. Hashemi A, Oroojan AA, Rassouli M, Ashrafizadeh H. Explanation of near-death experiences: a systematic analysis of case reports and qualitative research. Front Psychol. 2023;14:1048929.

29. Parnia S, Waller DG, Yeates R, Fenwick P. A qualitative and quantitative study of the incidence, features and aetiology of near death experiences in cardiac arrest survivors. Resuscitation. 2001 Feb;48(2):149–56.

30. Zhi-ying F, Jian-xun L. Near-death experiences among survivors of the 1976 Tangshan earthquake. J -Death Stud. 1992;11(1):39–48.

31. Charland-Verville V, Ribeiro De Paula D, Martial C, Cassol H, Antonopoulos G, Chronik BA, et al. Characterization of near death experiences using text mining analyses: A preliminary study. Amancio DR, editor. PLOS ONE. 2020 Jan 30;15(1).

32. Cassol H, Pétré B, Degrange S, Martial C, Charland-Verville V, Lallier F, et al. Qualitative thematic analysis of the phenomenology of near-death experiences. Yi H, editor. PLOS ONE. 2018 Feb 14;13(2):e0193001.

33. Martial C, Fontaine G, Gosseries O, Carhart-Harris R, Timmermann C, Laureys S, et al. Losing the Self in Near-Death Experiences: The Experience of Ego-Dissolution. Brain Sci. 2021 Jul 14;11(7):929.

32. Facco E, Agrillo C. Near-Death-Like Experiences without Life-Threatening Conditions or Brain Disorders: A Hypothesis from a Case Report. Front Psychol. 2012;3.

35. Gabbard GO, Twemlow SW, Jones FC. Do "Near Death Experiences" Occur Only Near Death?: J Nerv Ment Dis. 1981 Jun;169(6):374–7.

34. Gabbard GO, Twemlow SW. Do "near-death experiences" occur only near death ? -revisited. J -Death Stud. 1991;10(1):41–7.

37. Owens J, Cook EW, Stevenson I. Features of "near-death experience" in relation to whether or not patients were near death. The Lancet. 1990 Nov;336(8724):1175–7.

38. Martial C, Mensen A, Charland-Verville V, Vanhaudenhuyse A, Rentmeister D, Bahri MA, et al. Neurophenomenology of near-death experience memory in hypnotic recall: a within-subject EEG study. Sci Rep. 2019 Oct 1;9(1):14047.

39. Hoepner R, Labudda K, May TW, Schoendienst M, Woermann FG, Bien CG, et al. Ictal autoscopic phenomena and near death experiences: a study of five patients with ictal autoscopies. J Neurol. 2013 Mar;260(3):742–9.

40. Lempert T, Bauer M, Schmidt D. Syncope and near-death experience. The Lancet. 1994 Sep;344(8925):829–30.

41. Kelly EW. Near-death experiences with reports of meeting deceased people. Death Stud. 2001 Apr;25(3):229–49.

42. McKay R, Cipolotti L. Attributional style in a case of Cotard delusion. Conscious Cogn. 2007 Jun;16(2):349–59.

43. Beauregard M, Courtemanche J, Paquette V. Brain activity in near-death experiencers during a meditative state. Resuscitation. 2009 Sep;80(9):1006–10.

44. Martial C, Cassol H, Charland-Verville V, Pallavicini C, Sanz C, Zamberlan F, et al. Neurochemical models of near-death experiences: A large-scale study based on the semantic similarity of written reports. Conscious Cogn. 2019 Mar;69:52–69.

45. Timmermann C, Roseman L, Williams L, Erritzoe D, Martial C, Cassol H, et al. DMT Models the Near-Death Experience. Front Psychol. 2018 Aug 15;9:1424.

46. Martial C, Gosseries O, Cassol H, Kondziella D. Studying death and near-death experiences requires neuroscientific expertise. Ann N Y Acad Sci. 2022 Nov;1517(1):11–4.

47. Facco E, Casiglia E, Al Khafaji BE, Finatti F, Duma GM, Mento G, et al. THE NEUROPHENOMENOLOGY OF OUT-OF-BODY EXPERIENCES INDUCED BY HYPNOTIC SUGGESTIONS. Int J Clin Exp Hypn. 2019 Jan 2;67(1):39–68.

48. Pederzoli L, De Stefano E, Tressoldi P. Hypno-death-experiences: Death experiences during hypnotic life regressions. Death Stud. 2021 Apr 21;45(4):322–6.

49. Oakley DA, Halligan PW. Hypnotic suggestion: opportunities for cognitive neuroscience. Nat Rev Neurosci. 2013 Aug;14(8):565–76.

50. Bush NE. Afterward: making meaning after a frightening near-death experience. J -Death Stud. 2002;21(2):99–133.

51. Greyson B, Evans Bush N. Distressing Near-Death Experiences. Psychiatry. 1992 Feb;55(1):95–110.

52. Peinkhofer C, Dreier JP, Kondziella D. Semiology and Mechanisms of Near-Death Experiences. Curr Neurol Neurosci Rep. 2019 Jul 27;19(9):62.

53. Blackmore SJ. Near-Death Experiences. J R Soc Med. 1996 Feb;89(2):73–6.

54. King RA. The Near-Death Experience and Suicidal Ideation. Omega. 2023 Mar 10;302228231162175.

55. Bicego A, Cassol H, Simon J, Fritz P, Abagnale S, Vanhaudenhuyse A, et al. Personality traits and pattern of beliefs of near-death(-like) experiencers. Front Hum Neurosci. 2023 Apr 28;17:1124739.

56. Martial C, Cassol H, Charland-Verville V, Merckelbach H, Laureys S. Fantasy Proneness Correlates With the Intensity of Near-Death Experience. Front Psychiatry. 2018 Jun 7;9:190.

57. Holden JM, Greyson B, James D, editors. The handbook of near-death experiences: thirty years of investigation. Santa Barbara, Calif: Praeger Publishers; 2009. 316 p.

58. Ring K. Life at death: a scientific investigation of the near-death experience. New York: Coward, McCann & Geoghegan; 1980. 310 p.

59. Blanke O, Mohr C, Michel CM, Pascual-Leone A, Brugger P, Seeck M, et al. Linking Out-of-Body Experience and Self Processing to Mental Own-Body Imagery at the Temporoparietal Junction. J Neurosci. 2005 Jan 19;25(3):550–7.

60. Greyson B. Near-Death Experiences in a Psychiatric Outpatient Clinic Population. Psychiatr Serv. 2003 Dec;54(12):1649–51.

58. Greyson B. NEAR-DEATH EXPERIENCES AND SPIRITUALITY. Zygon. 2006 Jun;41(2):393–414.

62. Wilson SC, Barber TX. The fantasy-prone personality: Implications for understanding imagery, hypnosis, and parapsychological phenomena. PSI Res. 1982;1:94–116.

63. Belanti J, Perera M, Jagadheesan K. Phenomenology of Near-death Experiences: A Cross-cultural Perspective. Transcult Psychiatry. 2008 Mar;45(1):121–33.

64. Kellehear A. Census of non-Western near-death experiences to 2005: Observations and critical reflections. In: The handbook of near-death experiences: Thirty years of investigation. Santa Barbara, CA, US: Praeger/ABC-CLIO; 2009. p. 135–58.

65. Pasricha S, Stevenson I. Near-Death Experiences in India: A Preliminary Report. J Nerv Ment Dis. 1986 Mar;174(3):165–70.

66. Greyson B. Dissociation in people who have near-death experiences: out of their bodies or out of their minds? The Lancet. 2000 Feb;355(9202):460–3.

67. Noyes R. Attitude Change Following Near-Death Experiences. Psychiatry. 1980 Aug;43(3):234–42.

68. Bianco S, Sambin M, Palmieri A. Meaning making after a near-death experience: The relevance of intrapsychic and interpersonal dynamics. Death Stud. 2017 Oct 21;41(9):562–73.

69. Barberia I, Oliva R, Bourdin P, Slater M. Virtual mortality and near-death experience after a prolonged exposure in a shared virtual reality may lead to positive life-attitude changes. Valdes-Sosa PA, editor. PLOS ONE. 2018 Nov 5;13(11).

70. Bourdin P, Barberia I, Oliva R, Slater M. A Virtual Out-of-Body Experience Reduces Fear of Death. Buckingham G, editor. PLOS ONE. 2017 Jan 9;12(1).

71. Ring K. Heading toward omega: in search of the meaning of the near-death experience. 1st ed. New York: W. Morrow; 1984. 348 p.

72. Greyson B, Ring K. The Life Changes Inventory—Revised. J -Death Stud. 2004;23:41–54.

73. Sutherland C. Transformed by the light: life after near-death experiences. Sydney: Bantam Books; 1992.

74. Groth-Marnat G, Summers R. Altered beliefs, attitudes, and behaviors following near-death experiences. J Humanist Psychol. 1998;38:110–25.

75. Bush NE. Healthcare After a Near-Death Experience. Narrat Inq Bioeth. 2020;10(1):22–4.

76. Whealton E. A Glimpse of Heaven: The Mental Healthcare Practitioner's Role in Supporting the Near-Death Experience. Narrat Inq Bioeth. 2020;10(1):19–22.

77. Cassol H, D'Argembeau A, Charland-Verville V, Laureys S, Martial C. Memories of near-death experiences: are they self-defining? Neurosci Conscious. 2019;2019(1):niz002.

78. Kopel J. Near-death experiences in medicine. Proc Bayl Univ Med Cent. 2019 Jan;32(1):163–4.

79. DuBois JM. Reanimated: Navigating Life After a Near-Death Experience. Narrat Inq Bioeth. 2020;10(1):1–4.

80. Cant R, Cooper S, Chung C, O'Connor M. The divided self: near death experiences of resuscitated patients--a review of literature. Int Emerg Nurs. 2012 Apr;20(2):88–93.

81. Parnia S, Spearpoint K, de Vos G, Fenwick P, Goldberg D, Yang J, et al. AWARE—AWAreness during REsuscitation—A prospective study. Resuscitation. 2014 Dec;85(12):1799–805.

82. Parnia S, Post SG, Lee MT, Lyubomirsky S, Aufderheide TP, Deakin CD, et al. Guidelines and standards for the study of death and recalled experiences of death--a multidisciplinary consensus statement and proposed future directions. Ann N Y Acad Sci. 2022 May;1511(1):5–21.

83. Evrard R, Pratte E, Rabeyron T. Sawing the branch of near-death experience research: A critical analysis of Parnia et al.'s paper. Ann N Y Acad Sci. 2022 Sep;1515(1):5–9.

84. van Lommel P. About the continuity of our consciousness. Adv Exp Med Biol. 2004;550:115–32.

85. Parnia S. Do reports of consciousness during cardiac arrest hold the key to discovering the nature of consciousness? Med Hypotheses. 2007;69(4):933–7.

86. Greyson B. Implications of Near-Death Experiences for a Postmaterialist Psychology. Psychol Relig Spiritual. 2010 Feb 1;2:37–45.

87. Schwartz JM, Stapp HP, Beauregard M. Quantum physics in neuroscience and psychology: a neurophysical model of mind–brain interaction. Philos Trans R Soc B Biol Sci. 2005 Jun 29;360(1458):1309–27.

88. Vanhaudenhuyse A, Thonnard M, Laureys S. Towards a Neuro-scientific Explanation of Near-death Experiences? In: Yearbook of Intensive Care and Emergency Medicine 2009. 2009. p. 961–8.

89. Blackmore SJ, Troscianko TS. The physiology of the tunnel. J -Death Stud. 1989 Sep 1;8(1):15–28.

90. L. Appleby. Near death experience. BMJ. 1989 Apr 15;298(6679):976–7.

91. Noyes R, Slymen DJ. The Subjective Response to Life-Threatening Danger. OMEGA - J Death Dying. 1979 Dec;9(4):313–21.

92. Ring K, Rosing CJ. The omega project: An empirical study of the NDE-prone personality. J -Death Stud. 1990;8(4):211–39.

93. Lempert T, Bauer M, Schmidt D. Syncope: A videometric analysis of 56 episodes of transient cerebral hypoxia. Ann Neurol. 1994 Aug;36(2):233–7.

94. Klemenc-Ketis Z, Kersnik J, Grmec S. The effect of carbon dioxide on near-death experiences in out-of-hospital cardiac arrest survivors: a prospective observational study. Crit Care. 2010;14(2):R56.

95. Cahill L, Alkire MT. Epinephrine enhancement of human memory consolidation: Interaction with arousal at encoding. Neurobiol Learn Mem. 2003 Mar;79(2):194–8.

96. Sotelo J, Perez R, Cuevara P, Fernandez A. Changes in brain, plasma and cerebrospinal fluid contents of β-endorphin in dogs at the moment of death. Neurol Res. 1995 Jun;17(3):223–5.

97. Blanke O, Metzinger T. Full-body illusions and minimal phenomenal selfhood. Trends Cogn Sci. 2009 Jan;13(1):7–13.

98. Britton WB, Bootzin RR. Near-death experiences and the temporal lobe. Psychol Sci. 2004 Apr;15(4):254–8.

99. Arzy S, Seeck M, Ortigue S, Spinelli L, Blanke O. Induction of an illusory shadow person. Nature. 2006 Sep 21;443(7109):287.

100. De Ridder D, Van Laere K, Dupont P, Menovsky T, Van de Heyning P. Visualizing out-of-body experience in the brain. N Engl J Med. 2007 Nov 1;357(18):1829–33.

101. Blanke O, Ortigue S, Landis T, Seeck M. Stimulating illusory own-body perceptions. Nature. 2002 Sep 19;419(6904):269–70.

102. Blanke O, Landis T, Spinelli L, Seeck M. Out-of-body experience and autoscopy of neurological origin. Brain J Neurol. 2004 Feb;127(Pt 2):243–58.

103. Bartolomei F, Lagarde S, Scavarda D, Carron R, Bénar CG, Picard F. The role of the dorsal anterior insula in ecstatic sensation revealed by direct electrical brain stimulation. Brain Stimulat. 2019;12(5):1121–6.

104. Picard F, Friston K. Predictions, perception, and a sense of self. Neurology. 2014 Sep 16;83(12):1112–8.

105. Saavedra-Aguilar J, Gómez-Jeria JS. A Neurobiological Model for Near-Death Experiences. J -Death Stud. 1989 Jun 1;7:205–22.

106. Blackmore SJ. Dying to live: near-death experiences. Buffalo, N.Y: Prometheus Books; 1993. 291 p.

107. Rodin EA. The reality of death experiences. A personal perspective. J Nerv Ment Dis. 1980 May;168(5):259–63.

108. Woerlee GM. Mortal minds: the biology of near-death experiences. Amherst, NY: Prometheus Books; 2005. 282 p.

109. Ammermann H, Kassubek J, Lotze M, Gut E, Kaps M, Schmidt J, et al. MRI brain lesion patterns in patients in anoxia-induced vegetative state. J Neurol Sci. 2007 Sep 15;260(1–2):65–70.

110. Els T, Kassubek J, Kubalek R, Klisch J. Diffusion-weighted MRI during early global cerebral hypoxia: a predictor for clinical outcome? Acta Neurol Scand. 2004 Dec;110(6):361–7.

111. Jansen KLR. The ketamine model of the near-death experience: a central role for the N-methyl-D-aspartate receptor. J -Death Stud. 1997;16(1):5–26.

112. Collier BB. Ketamine and the conscious mind. Anaesthesia. 1972 Apr;27(2):120–34.

113. Coyle JT, Basu A, Benneyworth M, Balu D, Konopaske G. Glutamatergic synaptic dysregulation in schizophrenia: therapeutic implications. Handb Exp Pharmacol. 2012;(213):267–95.

114. Curran HV, Morgan C. Cognitive, dissociative and psychotogenic effects of ketamine in recreational users on the night of drug use and 3 days later. Addict Abingdon Engl. 2000 Apr;95(4):575–90.

115. Jansen K. Near death experience and the NMDA receptor. BMJ. 1989 Jun 24;298(6689):1708.

116. Jansen K. Using ketamine to induce the near-death experience: mechanism of action and therapeutic potential. In: Yearbook for Ethnomedicine and the Study of Consciousness. 1996. p. 51–81.

117. Morse ML, Venecia D, Milstein J. Near-death experiences: A neurophysiologic explanatory model. J -Death Stud. 1989 Sep 1;8(1):45–53.

118. Li D, Mabrouk OS, Liu T, Tian F, Xu G, Rengifo S, et al. Asphyxia-activated corticocardiac signaling accelerates onset of cardiac arrest. Proc Natl Acad Sci U S A. 2015 Apr 21;112(16).

119. Endorphins at the approach of death. Lancet Lond Engl. 1981 Feb 14;1(8216):390.

120. Borjigin J, Lee U, Liu T, Pal D, Huff S, Klarr D, et al. Surge of neurophysiological coherence and connectivity in the dying brain. Proc Natl Acad Sci. 2013 Aug 27;110(35):14432–7.

121. Koch C, Massimini M, Boly M, Tononi G. Neural correlates of consciousness: progress and problems. Nat Rev Neurosci. 2016 May;17(5):307–21.

122. Xu G, Mihaylova T, Li D, Tian F, Farrehi PM, Parent JM, et al. Surge of neurophysiological coupling and connectivity of gamma oscillations in the dying human brain. Proc Natl Acad Sci. 2023 May 9;120(19).

123. Chawla LS, Akst S, Junker C, Jacobs B, Seneff MG. Surges of electroencephalogram activity at the time of death: a case series. J Palliat Med. 2009 Dec;12(12):1095–100.

124. Chawla LS, Terek M, Junker C, Akst S, Yoon B, Brasha-Mitchell E, et al. Characterization of end-of-life electroencephalographic surges in critically ill patients. Death Stud. 2017 Jul;41(6):385–92.

125. Vicente R, Rizzuto M, Sarica C, Yamamoto K, Sadr M, Khajuria T, et al. Enhanced Interplay of Neuronal Coherence and Coupling in the Dying Human Brain. Front Aging Neurosci. 2022;14:813531.

126. Nelson KR. Near-death experience: arising from the borderlands of consciousness in crisis. Ann N Y Acad Sci. 2014 Nov;1330:111–9.

127. Nelson KR, Mattingly M, Lee SA, Schmitt FA. Does the arousal system contribute to near death experience? Neurology. 2006 Apr 11;66(7):1003–9.

128. Kondziella D, Dreier JP, Olsen MH. Prevalence of near-death experiences in people with and without REM sleep intrusion. PeerJ. 2019;7.

129. Kondziella D, Olsen MH, Lemale CL, Dreier JP. Migraine aura, a predictor of near-death experiences in a crowdsourced study. PeerJ. 2019;7.

130. Romand R, Ehret G. Neuro-functional modeling of near-death experiences in contexts of altered states of consciousness. Front Psychol. 2022;13:846159.

131. Lackner JR. Sense of body position in parabolic flight. Ann N Y Acad Sci. 1992 May 22;656:329–39.

132. Cheyne JA, Girard TA. The body unbound: vestibular-motor hallucinations and out-of-body experiences. Cortex J Devoted Study Nerv Syst Behav. 2009 Feb;45(2):201–15.

133. Maselli A, Slater M. Sliding perspectives: dissociating ownership from self-location during full body illusions in virtual reality. Front Hum Neurosci. 2014;8:693.

134. Peinkhofer C, Martial C, Cassol H, Laureys S, Kondziella D. The evolutionary origin of near-death experiences: a systematic investigation. Brain Commun. 2021 Jul;3(3):fcab132.

135. Skelhorn J. Avoiding death by feigning death. Curr Biol CB. 2018 Oct 8;28(19):R1135–6.

136. Kondziella D. The Neurology of Death and the Dying Brain: A Pictorial Essay. Front Neurol. 2020;11:736.