

Opinion

Near-Death Experience as a Probe to Explore (Disconnected) Consciousness

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Forty-five years ago, the first evidence of near-death experience (NDE) during comatose state was provided, setting the stage for a new paradigm for studying the neural basis of consciousness in unresponsive states. At present, the state of consciousness associated with NDEs remains an open question. In the common view, consciousness is said to disappear in a coma with the brain shutting down, but this is an oversimplification. We argue that a novel framework distinguishing awareness, wakefulness, and connectedness is needed to comprehend the phenomenon. Classical NDEs correspond to internal awareness experienced in unresponsive conditions, thereby corresponding to an episode of disconnected consciousness. Our proposal suggests new directions for NDE research, and more broadly, consciousness science.

NDE: An Emerging Field of Research

In 1975, the terminology of NDE was first introduced into the English language by Dr Raymond Moody, after having collected over 150 coma survivors' reports [1]. However, accounts and representations of the phenomenon emerged much earlier, dating back as far as 1505 with Hieronymus Bosch's famous painting representing the 'Ascent of the Blessed'. Although no universal definition of the phenomenon currently exists, it is commonly assumed that a NDE is a set of distinguishable mental events – known as features – with self-related, highly emotional, and mystical aspects [2]. Examples of prototypical features are **out-of-body experiences (OBEs; see Glossary)**, experiencing a deep feeling of peacefulness, entering a gateway (e.g., a tunnel) and seeing a bright light [2,3]. These subjective experiences emerge following a broad range of situations, when people are objectively near death or when they simply believe themselves to be [4]. Scientific investigation of NDEs has accelerated over the past decades in part because of the improvement of resuscitation techniques. As a consequence, these non-ordinary states of consciousness have been increasingly reported, with an incidence estimated around 10–23% after recovery from cardiac arrest [5–7] but only in 3% after traumatic brain injury [8]. Prototypical NDEs can also emerge in other situations, such as during meditation [9] or syncope [10], when there is an absence of severe physiological insults to brain functioning. These are referred to as near-death-like experiences (NDEs-like; [4]). At present, we cannot distinguish classical NDEs (i.e., in a life-threatening situation) from NDEs-like solely based on their content, and both score similarly on the Greyson NDE scale (16 items with a cut-off score of 7/32 for a NDE; [4,11]). Not all NDEs are pleasant and these experiences are described as nightmarish in about 14% of cases [12].

While the debate about the authenticity of NDEs is now closed, it remains difficult to draw a comprehensive picture of the exact state of consciousness and the neural correlates associated with these experiences. Based on **experiencers'** reports and the circumstances in which they experienced it, various states have been suggested, such as a state of 'enhanced consciousness' [13,14], that is, experiencing enhanced cognitive functions such as memory and thoughts with

Highlights

Scientific investigation of NDEs has accelerated in part because of the improvement of resuscitation techniques over the past decades, and because these memories have been more openly reported. This has allowed progress in the understanding of NDEs, but there has been little conceptual analysis of the state of consciousness associated with NDEs.

The scientific investigation of NDEs challenges our current concepts about consciousness, and its relationship to brain functioning.

We suggest that a detailed approach distinguishing wakefulness, connectedness, and internal awareness can be used to properly investigate the NDE phenomenon. We think that adopting this theoretical conceptualization will increase methodological and conceptual clarity and will permit connections between NDEs and related phenomena, and encourage a more fine-grained and precise understanding of NDEs.

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clear perceptions and self-identity; apparent unconsciousness [15]; altered state of consciousness [12,16,17]; or non-ordinary state of consciousness [18]. These terminologies point out the complexity of understanding the relationship between NDEs and consciousness.

In this article, we focus on the following fundamental question: what are the possible states of consciousness that might be experienced during a NDE? We examine the phenomenon in light of previous frameworks of consciousness [19,20] and we propose a unified framework, which may facilitate the development of a more nuanced scientific description of NDEs. The goal of this article is also to point out what makes the NDE a distinct entity from other subjective experiences, and to discuss the potential relevance of NDEs to investigate the mechanistic basis of human consciousness in unresponsive states.

NDE within the Scope of Consciousness

Classically, NDEs are reported after life-threatening situations like being in a coma or during a cardiac arrest. In such outwardly unresponsive conditions, consciousness is often said to disappear with the brain globally shutting down, but this statement is oversimplified. After decades of scientific research, a distinction has been made between **awareness**, **wakefulness**, **responsiveness**, and **connectedness** [19,20]. In clinical settings, consciousness has been divided into two components: wakefulness and awareness [20,21]. Wakefulness is behaviorally defined by eye opening and is mediated by the brainstem [22]. Awareness refers to a first-person subjective experience (including any thoughts, perception, or emotion) and is primarily assessed with command-following at the patient's bedside [20,21]. Awareness can itself be divided into two further components: **internal awareness** defined by any mental imagery, inner speech, or mind-wandering that is independent of environmental stimulus, and external awareness, that refers to the perception of sensory stimuli [21,23]. This framework was suggested by Laureys [20] to grasp different states of consciousness within the wakefulness boundaries (e.g., minimally conscious state showing limited but clearly discernible evidence of awareness, unresponsive wakefulness syndrome with no awareness; [23,24]). The terms *awareness* and *consciousness* are here used interchangeably.

A more recent framework has been suggested by Sanders and colleagues [19] to study different states in which the individual is not awake but can nevertheless experience some episodes of consciousness. Within this framework, the concept of responsiveness, connectedness, and consciousness are distinguished [19]. Responsiveness corresponds to behavioral interactions with the outside world (excluding reflex behavior). Observing behavioral responsiveness does not necessarily inform the state of consciousness, as demonstrated in anesthesia and disorders of consciousness studies [19,24–30]. The very concept of connectedness allows the distinction between two episodes of consciousness: connected and **disconnected consciousness** [19]. Connected consciousness is defined as the connection to the external world allowing experience of external stimuli [19] and is close to the concept of external awareness used by Laureys [20]. The **isolated forearm technique (IFT)** provides evidence of connected consciousness during general anesthesia [31,32]. In such a setup, the patient may respond to verbal commands with the isolated forearm that remains nonparalyzed [31,32]. By contrast, disconnected consciousness corresponds to a subjective experience without experiencing the external world [19]. In other words, it is the presence of internal awareness while being disconnected from the environment, like when one dreams during rapid eye movement (REM) sleep.

On the strength of these two models [19,20], we here propose a unified framework, in which consciousness is a multifaceted concept that has three major dimensions: wakefulness, connectedness, and internal awareness. As illustrated in [Figure 1](#), this framework brings to light the particularity of NDEs, that is, they are experienced during a clear dissociation between these

Glossary

Awareness: any subjective experience one might have, may it be from external stimuli (e.g., visual, olfactory) or internally oriented (e.g., inner speech). Awareness and consciousness are often interchangeable terms.

Connectedness: the connection to the external world allowing the experience of external stimuli, either in a state of wakefulness or non-wakefulness.

Disconnected consciousness: a state of non-wakefulness in which the awareness of external stimuli/environment is absent but during which there can still be subjective experience (i.e., conscious content).

Ecstatic epilepsy: a specific type of focal epileptic seizure with an aura consisting of a special mental state with a focus on the inner world and often also on the external world which becomes very vivid, and results in pleasurable sensations and bliss.

Experiencer: a person who has experienced an NDE.

Hallucination: a percept-like experience occurring without an appropriate stimulus that has the full force or impact of an actual perception.

Internal awareness: all environmental stimulus-independent thoughts (e.g., mental imagery, inner speech, mind wandering).

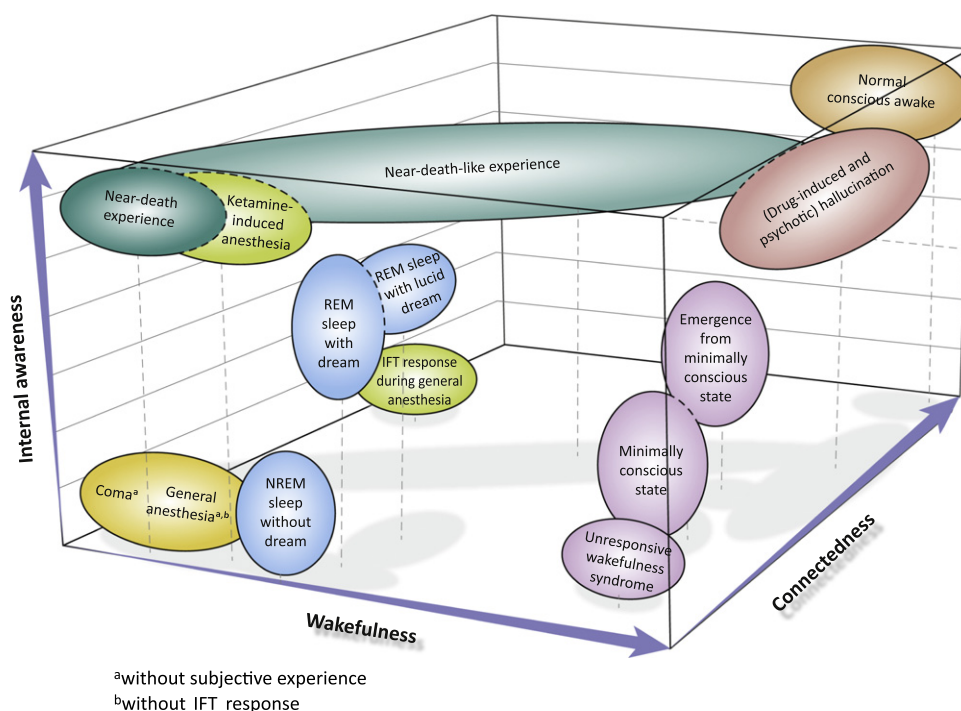
Isolated forearm technique (IFT): a technique consisting of inflating a tourniquet on one arm (above the systolic blood pressure) in an anesthetized person before the administration of the muscle relaxant, allowing a potential movement of the isolated arm in response to a verbal command.

Meta-consciousness: explicit awareness of the contents of consciousness when experiencing it.

Out-of-body experience (OBE): a subjective experience in which the self is perceived outside the body boundary (i.e., disembodiment), with or without the experience of perceiving one's body in an extrapersonal space (from a place outside one's body; i.e., autoscopia).

Responsiveness: spontaneous or goal-directed behavioral interactions with the outside world.

Wakefulness: spontaneous or stimulus-induced eye opening.



Trends in Cognitive Sciences

Figure 1. Illustration of Different States and Conditions Based on Wakefulness, Connectedness, and Internal Awareness. These three major components can be used to study physiologically, pharmacologically, and pathologically altered states of consciousness. The shadows drawn on the bottom flat surface of the figure allow to situate each state with respect to levels of wakefulness and connectedness. In a normal conscious awake state, the three components are at their maximum level [19,23]. In contrast, states such as coma and general anesthesia have these three components at their minimum level [19,23]. All the other states and conditions have at least one of the three components not at its maximum. Classical near-death experiences (NDEs) can be regarded as internal awareness with a disconnection from the environment, offering a unique approach to study disconnected consciousness in humans. Near-death-like experiences (NDEs-like) refer to a more heterogeneous group of states varying primarily in their levels of wakefulness and connectedness, which are typically higher than in classical NDEs. Abbreviations: IFT, isolated forearm technique; NREM, non-rapid eye movement; REM, rapid eye movement.

three dimensions. We may regard a classical NDE as internal awareness with a disconnection from the environment, corresponding to a state of disconnected consciousness. In contrast, NDEs-like are typically experienced during higher levels of wakefulness and connectedness and refer to a more heterogeneous group of states including, for example, syncope [10] with low levels of wakefulness and connectedness, or meditation where the individual is awake with connectedness [9]. This framework permits a more in-depth examination of both classical NDEs and NDEs-like, which are similar in terms of phenomenology [4] but different in terms of wakefulness and connectedness. The present framework can also be used to compare NDEs with other subjective experiences with more similar states of consciousness but different phenomenology, such as dreaming.

Undoubtedly, the NDE literature has suffered from a lack of a structured framework for analyzing the phenomenon, and especially for studying the (seemingly paradoxical) dissociation between the richness of the subjective experience and the trigger event, that probably occurs during a short moment of brain dysfunction. In such a context, the resulting rich memory is also not easy to explain (see section on NDE memory). Due to this lack of framework modeling this dissociation, a considerable number of publications have been devoted to discussing the fact that NDEs are in support of the nonlocal consciousness theories (e.g., [33–35]) in which consciousness may not

always coincide with the functioning of the brain. However, convincing empirical evidence of this hypothesis is currently lacking. The literature has also suffered from a dearth of empirical evidence regarding the NDE event itself because of its unpredictable aspect, which makes its scientific investigation extremely difficult. Nonetheless, experimental methods have been developed to go beyond limitations inherent in NDE research (see section on neural correlates).

So far, it is uncertain whether experiencers have an explicit awareness of the contents of consciousness when experiencing the NDEs (i.e., **meta-consciousness**). It is also unclear whether some external or real-life-based stimuli may still trigger or be incorporated in the NDE itself, and hence indicating connectedness (Table 1). Although many anecdotes have been reported [36,37], no empirical study has confirmed that NDEs include some real external events. Among the most rigorous studies, Parnia and colleagues [38] stated that one of their experiencers reported afterwards some elements from the environment experienced during cardiopulmonary resuscitation, which were subsequently corroborated by the medical records. However, their protocol did not allow to exclude that the reported memories were based on retrospective imaginative (re)constructions built up from memories, prior knowledge, and/or expectations about the world. Based on current empirical research, it is difficult to draw any conclusions regarding the accuracy of such descriptions. We need more refined methodologies to objectively examine the validity of specific reports associated with actual (real-life-based) events in NDEs.

NDE in Comparison with Other Episodes of Disconnected Consciousness

Classical NDEs are distinguished from other subjective experiences by their richness of content of consciousness while being in a state of (absence or) low levels of wakefulness and connectedness. Unlike NDEs, when individuals hallucinate (i.e., due to psychotic disorders or drug use excluding general anesthesia), they are awake, (totally or largely) responsive, and (at least widely) connected to the environment ([39]; Figure 1). By contrast, ketamine-induced anesthesia is similar to NDEs in the level of wakefulness and connectedness ([40]; Box 1). While NDEs have the particularity to contain specific and recurrent prototypical features (e.g., seeing a bright light; [3]), the content experienced during drug-induced or psychotic **hallucinations** vary considerably. The hallucinatory themes reported by people who have consumed recreational ketamine or

Table 1. Wakefulness, Connectedness, Internal Awareness, and Meta-consciousness in Different States

States/components	Wakefulness	Connectedness	Internal awareness	Meta-consciousness
Classical NDE	—	TBD	+	TBD
NDE-like	Possible ^a	Possible ^a	+	Possible ^a
NREM sleep without dream	—	—	—	—
REM sleep with dream	—	—	+	—
REM sleep with lucid dream	—	TBD	+	+
Drug-induced hallucination (excluding general anesthesia)	+	Possible	+	Possible
Ecstatic epilepsy	+	Possible	+	+
General anesthesia	—	Possible using IFT	Possible ^b	—
Coma	—	—	Possible if NDE	—

Abbreviation: TBD, to be determined.

^aNDEs-like refer to a very heterogeneous group of states/experiences.

^bDepending on the type of anesthetic agent and dose.

Box 1. Ketamine-Induced General Anesthesia as the Closest Model to Study Classical NDEs

The association between ketamine-induced experiences and NDEs have been frequently discussed in terms of anecdotal evidence (e.g., [99–101]). Using natural language processing tools to quantify the phenomenological similarity of NDE reports and reports of drug-induced hallucinations, we recently provided indirect empirical evidence that endogenous N-methyl-D-aspartate (NMDA) antagonists may be released when experiencing a NDE [40]. Ketamine, an NMDA glutamate receptor antagonist, can produce a dissociative state with disconnected consciousness. Despite being behaviorally unresponsive, people with ketamine-induced general anesthesia provide intense subjective reports upon awakening [102]. Complex patterns of cortical activity similar to awake conscious states can also be observed in ketamine-induced unresponsiveness states after which reports of disconnected consciousness have been recalled [27,29]. The medical use of anesthetic ketamine has been limited due to several disadvantages and its psychoactive effects [102], however, ketamine could be used as a reversible and safe experimental model to study classical NDEs.

N,N-dimethyltryptamine (DMT) may nevertheless show some overlap with NDE features, such as semantic concepts related to self-consciousness [40,41]. Thus, although being specific phenomena on their own, some subjective experiences such as drug-induced hallucinations may be close to NDEs in terms of phenomenology – as defined by the Greyson NDE scale [11].

When comparing the phenomenology of classical NDEs and dreams, it becomes apparent that the content and the associated sense of reality seem to be different. Indeed, the NDE prototypical features are not found in classical dreams [42]. Nevertheless, no direct comparison between both contents has been carried out yet. Furthermore, although NDEs are associated with a critical situation or, at least, a very confused period, most of the experiencers report a clear sensorium and an intense sense of reality (i.e., similar phenomenological sense of certainty that accompanies the everyday perception; [6,43]). This may seem counterintuitive, but this real perceptual bias may be explained by a mix of cognitive (e.g., the logical coherence of narratives) and neurophysiological mechanisms taking place during or after the event. However, this needs to be investigated more fully. Finally, dreamers remain arousable at all times, which is not the case of the NDE experiencers who are in critical unarousable situations like in a coma.

As stated above, a phenomenology similar to NDE can emerge in situations where there is no threat to life [4], but nonetheless resulting in an altered integration of somatosensory inputs [44]. This is evidenced by reports of subjective experiences resembling NDEs-like or OBEs recalled after sensory deprivation [45]. In that context, the individual experiences a reduction or a total absence of strong sensory input, followed by the emergence of an internally generated content [44,46]. Similarly, in classical NDEs, people may feel disconnected from the external world and focus their attention on internally generated experience when facing a life-threatening situation [46,47]. This capacity can be considered as a psychological protection mechanism so as to cope with acute stress or trauma experiences [47,48]. Certain psychological mechanisms and personality traits correlate with the emergence and the richness of NDEs (Box 2). Continuously, we use information gathered through our senses (bottom-up processing) and we also

Box 2. Cognitive Characteristics of NDE Experiencers

Retrospective studies showed that most people experiencing NDEs do not present deficits in global cognitive functioning (e.g., [5]). Nevertheless, experiencers may present some characteristics with regard to cognition and personality traits. Greyson and Liester [103] observed that 80% of experiencers report occasional auditory hallucinations after having experienced a NDE, and these experiencers are the ones with more elaborated NDEs (i.e., scoring higher on the Greyson NDE scale [11]). In addition, those with NDEs more easily experience common and non-pathological dissociation states, such as daydreaming or becoming so absorbed in a task that the individual is unaware of what is happening in the room [104]. They are also more prone to fantasy [50]. These findings suggest that NDE experiencers are particularly sensitive to their internal states and that they possess a special propensity to pick up certain perceptual elements that other individuals do not see or hear. Nonetheless, these results come from retrospective and correlational design studies, and their conclusion are thus rather limited. Future prospective research may unveil the psychological mechanisms influencing the recall of a NDE.

construct meaning about our environment (and our interactions with it) by using information we have already stored in memory (top-down processing) [49,50]. The NDE phenomenology may reflect individuals' attempts to make sense of the ambiguous perceptive features in critical circumstances [44,50–52]. NDEs have also been conceived as a type of depersonalization (i.e., a sense of the self as unreal or lacking agency) inducing an altered sensation in one's sense of identity [53]. This detachment would offer experiencers a more intelligible and less distressing reality [54]. More recently, some sensory physiologists have suggested that the brain constantly attempts to maximize the evidence for its model of the world by comparing prior beliefs with sensory inputs and by using the prediction errors to review its model [55].

Searching for the Neural Correlates of NDEs through Different Experimental Methods

Many scientific studies have shown that consciousness and behavioral responsiveness may decouple, and this has also been observed with brain imaging techniques in some specific conditions, such as pharmacologically induced states or brain injury [27,29,30,56,57]. Despite important progress in revealing neural correlates associated with consciousness, neurophysiological mechanisms of NDE are not understood [58]. Like any other disconnected conscious state, NDEs are challenging for research because they rely on the subjective nature of experience. Indeed, researchers are necessarily relying on indirect measures of experiences (e.g., personal accounts collected afterward). Subjective experiences reproduced in laboratory experiments that closely resemble classical NDEs can nevertheless be induced by different methods (e.g., using psychedelic substances, immersive virtual reality, hypnosis, or syncope through hyperventilation, orthostasis, and Valsalva maneuver; [41,59–61]). To a certain measure, reproducing NDEs-like in laboratory settings permits to go beyond previous limitations inherent in NDE research (e.g., lack of real-time brain monitoring, passage of time between the experience and the interview), and to test the current neurobiological hypotheses by objectively mapping brain changes. All these experimental manipulations testify that NDEs-like are fruitful in its applications to consciousness literature.

Altered activity in the medial temporal area and the temporoparietal junction has been studied as a possible mechanism underlying NDEs-like [62–65]. Both direct cortical stimulation [66–68] and altered functioning (e.g., due to damage or seizures; [69]) of these brain regions might produce NDE-like features. Studies have further demonstrated the critical involvement of the anterior insular cortex in **ecstatic epilepsy**, which is a specific type of focal epileptic seizure with an aura resulting in NDEs-like [70,71]. It should however be noted that these NDE-like subjective experiences may be a mere reflection of classical NDEs and caution should be exercised. In parallel, the potential implication of disturbed levels of blood gases, including transient decreased cerebral oxygen levels and hypercapnia, has also been suggested to explain the emergence of NDEs [10,59]. In a prospective study, Klemenc-Ketis and colleagues [72] have corroborated this hypothesis by showing higher concentrations of carbon dioxide in NDE experiencers upon their admission to the intensive care units after out-of-hospital cardiac arrest. The authors also found that the Greyson NDE scale total score (reflecting the richness of the NDE phenomenology [11]) was positively correlated with partial pressures of carbon dioxide and with serum levels of potassium [72]. Yet, some authors pointed out that it is still hard to explain how such a clear memory is reported after those critical circumstances where inherent difficulties in memory retrieval are highly probable [73,74].

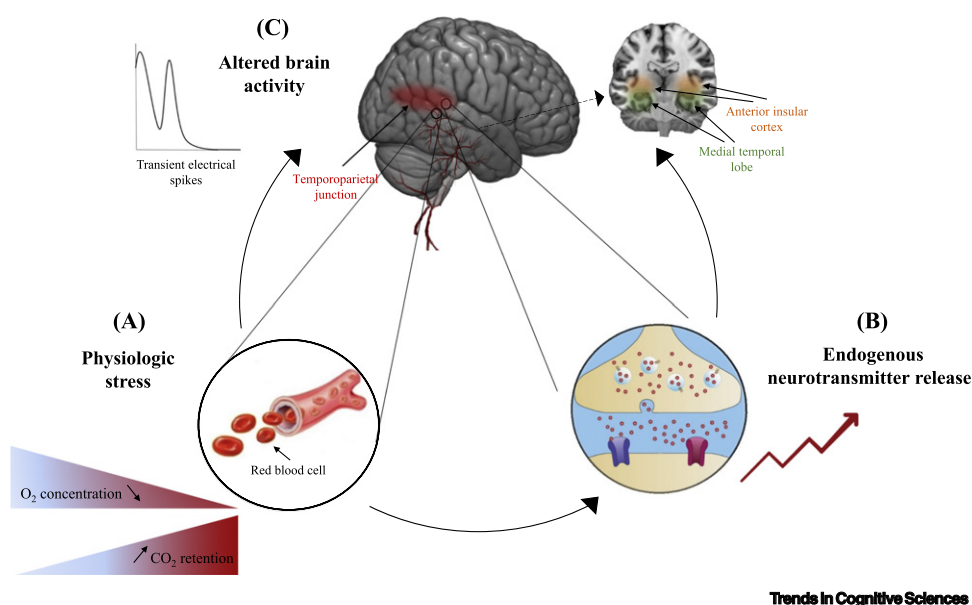
Crucially, Chawla and colleagues [75,76] identified transient electrical spikes in critically ill patients immediately before cardiac arrest. In addition, an electrophysiological study showed a transient

and global surge of synchronized gamma oscillations, exhibiting increased interregional connectivity, during cardiac arrests in rats [77]. These last studies lead to the hypothesis that NDEs could be caused by transient organized brain activity and neurophysiologic states at near death. However, there is a need for clear empirical evidence. Beside these hypotheses, some authors have suggested the possibility that NDEs may be associated with the release of endogenous neurotransmitters [40,41], particularly highlighting dysregulated serotonergic activity [78] and massive liberation of endorphins [79]. In fact, it is highly likely that several factors trigger a NDE, with each of the above-mentioned neurophysiological mechanisms being just one of them (Figure 2).

To conclude, a clear neurophysiological model that includes all aspects of NDEs is currently lacking. The study of NDEs-like reproduced in laboratory experiments may be used as a model and inform on classical NDEs, but caution is warranted in interpreting these results. Indeed, whether the neurophysiological mechanisms of laboratory-reproduced NDEs-like also occur in people who experience a classical NDE – and if so, how exactly – is appealing but will remain an unresolved issue.

NDE and Its Rich and Vivid Memory

It is now widely accepted that declarative memory is not crucial for consciousness. Many authors have shown the coexistence of profound deficits in long-term memory formation and conscious states (e.g., patients with advanced Alzheimer's disease; [80]), or the possibility to be conscious and responsive but under the influence of alcohol causing lapses of declarative memory for



Trends in Cognitive Sciences

Figure 2. Illustration of Neurophysiological Mechanisms That May Be Involved in the Emergence of Near-Death Experiences (NDEs) and Near-Death-like Experiences (NDEs-like). This figure illustrates the potential (non-mutually exclusive) implications of different causal agents, based on scarce empirical NDEs and NDEs-like literature. (A) Physiologic stress including disturbed levels of blood gases, such as transient decreased cerebral oxygen (O₂) levels and elevated carbon dioxide (CO₂) levels [10,59,72]. (B) Naturally occurring release of endogenous neurotransmitters including endogenous N-methyl-D-aspartate (NMDA) antagonists and endorphins [40,41,78,79] may occur as a secondary change. Both (A) and (B) may contribute to (C) dysfunctions of the (right and left) medial temporal lobe, the temporoparietal junction [62–69], and the anterior insular cortex [70,71]. A NDE may result from these neurophysiological mechanisms, or their interactions, but the exact causal relationship remains difficult to determine.

example. Similarly, some episodes of connected consciousness such as assessed by the IFT appear to rarely be followed by explicit recall postoperatively [32]. By contrast, episodes of disconnected consciousness inherently rely on memory. Classical NDEs are thought to occur in near death states where brain processes are severely diminished; however, NDEs are subsequently described in great detail and firmly anchored in experiencers' memory [81]. Importantly, current research shows that the NDE memory can hardly be considered as typically invented because it contains a high amount of qualitative phenomenological characteristics such as contextual and sensorial details (e.g., remembering what one felt or thought during the event; [15,17,81,82]). It is this subjective experience when remembering that gives one the impression that a memory belongs to one's own past [83–85] – and is not invented. Using electroencephalography, Palmieri and colleagues [15] further showed the presence of theta activity associated with the recall of NDE memories, as being suggestive of episodic memories of real experienced events. Although memory theories have difficulties explaining NDEs and their resulting rich memory [17], an answer can be provided by theories demonstrating the importance of the medial temporal lobe for memory encoding and retrieval [86,87]. Emotionally arousing stimuli might exert their beneficial effect of emotion on declarative memory by enhancing activity in medial temporal structures [88,89], which seem to be involved in the emergence of NDEs-like. Moreover, extrapolating from Cahill and Alkire's [90] study, one can hypothesize that encoding and consolidation of the NDE memory could be related to the release of specific neurotransmitters such as epinephrine [91].

Unlike dreams, memory trace does not fade for classical NDE memories [17,81]. The NDE memory withstands and even seems to persist over a long period of time [92], just like important self-defining memories [93]. One study has addressed the question of the long-term evolution of NDE memory and showed that accounts of NDEs were not modified over a period of two decades [92]. Nonetheless, the NDE memory was assessed with the Greyson NDE scale, which includes only closed questions [11] and does not evaluate the qualitative memory characteristics and cognitive processes involved in its recall. To date, no study has yet formally investigated the reliability of testimonies or free narratives over time. Importantly, it is necessary to distinguish between memory accuracy and subjective certainty. It has been postulated that some NDEs may be comparable to false memories and that report or non-report of NDEs after cardiac arrest may reflect individual differences in memories [94]. Using a word recall test, we showed that experiencers are more likely than non-experiencers to illusory recollect details associated with the generation of a false memory, thereby suggesting that the richness of details of these memories may result from specific psychological mechanisms [95]. Indeed, despite experiencers usually harboring no doubts about the accuracy of their NDE memory [81], it is reasonable to assume that the subsequent narrative of this particular experience is highly likely to be influenced by the natural memory process of construction, as all lived experiences. Constantly, the content of human memory is matched with emotions, events previously experienced, and current events which influence it. The content may also be influenced by one's own expectations, fantasies, and unconscious thoughts, each of which is influenced by culture. In support of this reconstructive view, experiencers' religiosity and cultural background have also been suggested to influence the NDE content and features' interpretation [96,97]. Memory reactivation frequency (internally or externally; e.g., sharing it with other people) and metacognitive experiences that accompany retrieval may also influence the memory accuracy [17,98]. Notably, some authors have demonstrated that the ease with which items are retrieved from long-term memory may contribute to one's sense of confidence independently of accuracy [98]. Additionally, two studies found that the frequency of NDE recalls is higher in cardiac arrest survivors younger than 60 years old, suggesting a greater vulnerability to forget the event at an advanced age [5,7].

Concluding Remarks and Future Directions

At present, we have a limited understanding of the NDE phenomenon. An important issue is that scientists use different descriptions that likely lead to distinct conclusions concerning the phenomenon and its causes. Advances in classical NDE understanding require that the concepts of wakefulness, connectedness, and internal awareness are adequately untangled. These subjective experiences typically originate from an outwardly unresponsive condition, corresponding to a state of disconnected consciousness. Therein lies the belief that a NDE can be considered as a probe to study (disconnected) consciousness. We think that adopting the present unified framework based on recent models of consciousness [19,20] will increase methodological and conceptual clarity between NDEs and related phenomena such as NDEs-like experienced spontaneously in everyday life or intentionally produced in laboratory experiments. This conceptual framework will also permit to compare them with other states which are experienced in similar states of consciousness but show different phenomenology. This will ultimately encourage a more precise understanding of NDEs.

Future studies should address more precisely the neurophysiological basis of these fascinating and life-changing experiences. Like any other episodes of disconnected consciousness, classical NDEs are challenging for research. Nevertheless, a few studies have succeeded in inducing NDEs-like in controlled laboratory settings [41,59–61], setting the stage for a new paradigm for studying the neural basis of disconnected consciousness. No matter what the hypotheses regarding these experiences, all scientists agree that it is a controversial topic and the debate is far from over. Because this raises numerous important neuroscience (see Outstanding Questions) and philosophical questions, the study of NDEs holds great promise to ultimately better understand consciousness itself.

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Outstanding Questions

To what extent is proximity to death (real or subjectively felt) involved in the appearance of NDE phenomenology?

To what extent are some external or real-life-based stimuli incorporated in the NDE phenomenology itself?

What are the neurophysiological mechanisms underlying NDE? How can we explain NDE scientifically with current neurophysiological models?

How is such a clear memory trace of NDE created in situations where brain processes are thought to work under diminished capacities? How might current theories of memory account for these experiences? Do current theories of memory need to invoke additional factors to fully account for NDE memory created in critical situations?

How can we explain the variability of incidences of NDE recall found in the different etiological categories (cardiac arrest vs traumatic brain injury)?

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