

To what extent can science explore consciousness after clinical death?

A literature review on near-death experiences (NDEs)

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Abstract

Near-death experiences (NDEs) refer to the accounts of people who have come close to clinical death and who, upon waking, report intense subjective perceptions: leaving the body, heightened sensations, seeing a light, a life review, or meeting deceased loved ones. This literature review examines the extent to which current research can explain these experiences through known natural mechanisms. After defining the phenomenon and presenting two cases frequently cited in the literature, we review the available neuroscientific hypotheses — residual cortical activity, integrated information theory, global neuronal workspace theory, and surges of electroencephalographic activity observed just before death — as well as the more speculative hypothesis of a quantum origin of consciousness (Orchestrated Objective Reduction). We then examine the available data on the psychological outcomes of people who have had an NDE, followed by the lines of technological research likely to advance this field. We conclude that none of the current naturalistic explanations fully accounts for all of the reported observations, in particular cases of apparently verified perception in the absence of brain activity measurable by current tools, and that the question remains an open area of research, requiring larger-scale prospective and controlled protocols.

Keywords: near-death experience; consciousness; neuroscience; electroencephalography; cardiopulmonary resuscitation; Orchestrated Objective Reduction

1. Introduction

The question of what happens to human consciousness at the moment of biological death ranks among humanity's oldest questions, but it has long been considered beyond the reach of the scientific method. Recent advances in cardiopulmonary resuscitation, neuroscience, and brain imaging have, however, made it possible to approach a well-defined phenomenon empirically: the near-death experience (NDE), a state of consciousness reported by patients who have survived cardiac arrest or a critical condition close to clinical death.

This work offers a review of the scientific literature on NDEs. The aim is to assess the extent to which this phenomenon can be explained by known neurophysiological mechanisms, and to identify the elements that still resist a complete naturalistic explanation.

This review is organized into five parts. The first defines the NDE and presents two cases documented in the literature. The second reviews current neuroscientific hypotheses on the origin of these experiences, notably recent research on surges of electroencephalographic activity observed just before death. The third presents the more speculative hypothesis of a quantum origin of consciousness. The fourth summarizes the available data on the psychological outcomes of people who have had an NDE. The fifth presents the lines of technological research that could advance this field in the years to come.

One of the major difficulties of this review was maintaining a nuanced approach by avoiding confirmation bias and systematically examining the counterarguments and methodological limitations of the studies cited — in particular the complexity of some of the concepts addressed (quantum mechanics, biological neuroscience) and the largely retrospective and uncontrolled nature of the available testimonies. Finally, it should be emphasized that the scientific method cannot, by its very nature, definitively confirm or rule out the persistence of some form of consciousness after the cessation of vital functions: the elements presented here should be read as partial scientific indications, not as definitive proof in either direction.

2. Near-death experiences (NDEs)

The scientific literature uses the term “life after death” to refer to the unresolved question of a possible continuation of consciousness beyond biological death. No direct empirical evidence exists to date. One of the only indirect scientific points of access to this question is the study of near-death experiences (NDEs): accounts from people who were clinically dead, or very close to it, before returning to a normal state of consciousness.

2.1. Definition of the near-death experience

There is no single, uniformly accepted definition of the phenomenon. Jeffrey Long, a specialist in radiation oncology and founder of the Near Death Experience Research Foundation (NDERF), proposes breaking the term down into two components: proximity to death, and the subjective experience lived at that moment.^[1]

2.1.1. The “proximity to death” component

In an NDE, a person must first be very close to death. This situation can be caused by many phenomena: cardiac arrest (approximately 9 to 18% of cases), shock resulting from postpartum blood loss or surgical complications, septic or anaphylactic shock, electrocution, coma due to head trauma, intracerebral hemorrhage, suicide attempts, near-drowning, as well as other situations in which death seems imminent.

Whatever the cause, the victim most often suffers oxygen deprivation, which reduces the brain's electrical activity until it ceases altogether, marked by a flat electroencephalogram (EEG). In this state, the sensory organs are non-functional, and cognitive functions (thought, memory, language) are either absent or severely impaired. The person is often declared clinically dead by the medical teams.^[2]

2.1.2. The “experience” component

No two NDEs are strictly identical, but the reported experiences, studied by different research groups, show notable consistency. According to the largest survey conducted by NDERF, covering 1,122 people, the six most frequently reported experiences are:

- Out-of-body experience — 74.9%
- Heightened senses — 74.4%
- Intense and generally positive emotions — 77.7%
- Encounter with a bright light — 64.8%
- Voluntary or involuntary return to the body — 58.5%
- Encounter with deceased family members or friends — 51%

Cardiologist and researcher Pim van Lommel proposes a convergent characterization: NDEs can be defined as the reported memory of a variety of impressions experienced during a special state of consciousness, including an out-of-body experience, pleasant emotions, seeing a tunnel and/or a light, seeing deceased relatives, a life review, or a conscious return into the body.^[3]

During NDEs, there thus seems to be a sense of detachment from the body: people report being able to perceive their surroundings without using their usual physical senses. This phenomenon is often associated with an out-of-body experience (OBE). Those concerned describe being able to observe their surroundings, the operating room, or places outside of it. Notably, some people who are blind from birth report OBEs during their NDE and manage to describe their surroundings with surprising accuracy — a point examined later through a documented case.^[4]

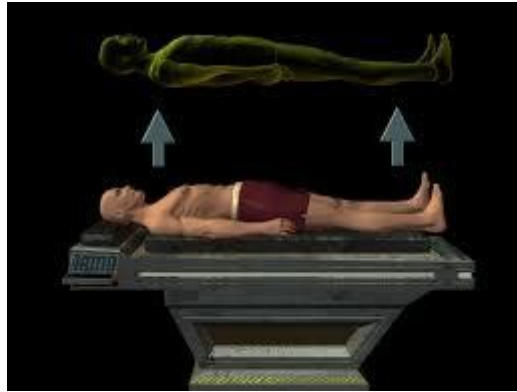


Figure 1 — Schematic representation of an out-of-body experience (adapted from Wikipedia, 2025).

People who have had an NDE also frequently report a complete absence of pain, including patients who were previously in extreme pain: these positive sensations often lastingly change people's relationship to their own existence, as we will see in section 5. Conversely, a minority of testimonies report negative experiences, which are also discussed later.^[3]

2.2. Two cases reported in the literature

There are several thousand NDE testimonies collected by academic institutions (New York Academy of Sciences, Harvard, Baylor, University of California Riverside, University of Virginia, among others), in disciplines ranging from neuroscience to intensive care, by way of psychiatry and psychology. These accounts nonetheless remain retrospective and uncontrolled testimonies: they are reported after the fact, sometimes collected years later, and are therefore subject to the usual biases of autobiographical memory — reconstruction, suggestion, confirmation. A synthesis of 107 NDE cases estimated that approximately 8% of the accounts contained details that were unverifiable or inconsistent with established facts.^[5]

The two cases presented below are frequently cited in the literature on the subject because they appear to be verifiable *a posteriori*. However, they were not the subject of a prospective, controlled protocol (unlike, for example, AWARE-type clinical trials on visual perception during cardiac arrest), and must therefore be interpreted with the methodological caution inherent to any single, retrospective case study.

2.2.1. The case of “Maria”

This case is reported by physician Melvin Morse and his research assistant Kimberly Clark Sharp. Maria, a hospital patient, had an NDE in the course of a cardiac arrest, during her resuscitation. She reported an out-of-body experience during which she is said to have floated above her body and observed the resuscitation team. She also reported having seen a blue sneaker sitting on a window ledge of the building.^[6]

Kimberly Clark Sharp, initially skeptical, went to the location described and found the shoe there, in a position that the patient could not have observed from her room or from any other access point in the hospital. This case is presented in the NDE literature as one of the rare examples in which a reported detail was independently verified; however, it has never been the

subject of a peer-reviewed scientific publication detailing the exact conditions of verification, which limits its evidential value by the standards of empirical research.

2.2.2. *The case of Brad Barrows*

Brad Barrows, blind since birth, had an NDE at the age of eight following a cardiac arrest brought on by severe pneumonia; his heart stopped for at least four minutes before he was resuscitated with chest compressions. He reported rising above his body and watching his roommate leave to get help — a detail later confirmed by the roommate — and then “seeing,” for the first time in his life, the outside of the hospital: an overcast sky, streets cleared of snow but still muddy, and a streetcar passing nearby, details that were verified after his experience.

[7]

Like other blind people who have reported an NDE, Brad Barrows describes detailed visual perceptions even though he had never had the ability to see in his waking life. This type of case is particularly discussed in the literature because it poses a specific challenge to the usual neuroscientific explanations based on reconstruction or hallucination from prior visual memories, since the subject never had any such memories.

3. Neuroscientific explanations of consciousness during NDEs

3.1. What is consciousness?

Consciousness is generally defined as awareness of the outside world, of one's own body, and of oneself. It can be broken down into three distinct dimensions: the level of consciousness (wakefulness), that is, a person's state of arousal (awake, comatose, anesthetized); the content of consciousness (internal awareness), that is, what a person subjectively experiences — sensations, memories, emotions; and connectivity, that is, a person's ability to interact with their environment and respond to external stimuli.^[8]

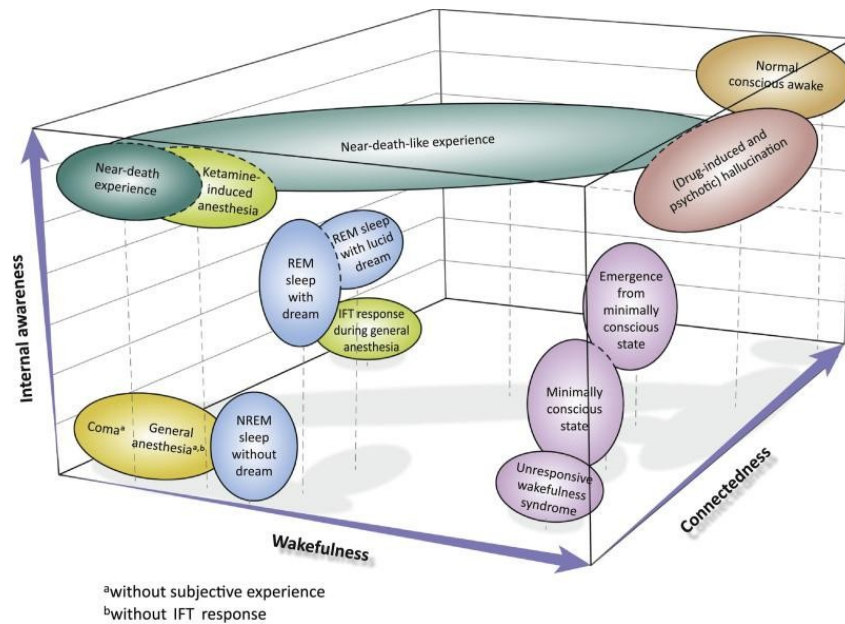


Figure 2 — Representation of the different states of consciousness as a function of wakefulness, connectivity, and internal conscious content (adapted from Martial et al., 2020).

In this representation, a fully conscious person is located in the upper right, with all three dimensions fully functioning. A person in a coma or under general anesthesia is located in the lower left, with all three dimensions greatly reduced. A person having an NDE, on the other hand, would be located in the upper left: their measurable level of consciousness and connectivity are very low, even though they report intense subjective experiences a posteriori.

3.2. The explanatory gap and NDEs

In the philosophy of mind and in neuroscience, the explanatory gap refers to the difficulty of explaining how neural activity gives rise to subjective experience — for example, how neural processes produce the qualitative sensation associated with listening to music. This gap becomes particularly salient in the case of NDEs, since the brain is then often in a hypofunctional state, due to oxygen deprivation, the effect of anesthetics, or other factors, while those giving these accounts report subjectively very vivid experiences. A severely hypoactive brain should not, in theory, be able to produce such a rich conscious state — it is this apparent contradiction that the following neuroscientific hypotheses attempt to resolve.

3.3. Neuroscientific hypotheses

3.3.1. Residual neural activity and memory processing

Several lines of evidence suggest that the state of consciousness of people in critical condition may be underestimated, and that residual neurological activity could explain some of the perceptions reported during NDEs.

The “posterior cortical hot zone” hypothesis proposes that certain neural activity persists in the posterior regions of the brain, with the frontal regions playing a less central role than

previously thought in producing subjective experience. According to integrated information theory (IIT), consciousness would not be reducible to raw neural activity but would correspond to a degree of integrated information within a system — a hypothesis that nevertheless remains controversial and has been little tested empirically. Global neuronal workspace theory (GNWT), for its part, proposes that consciousness emerges from an extensive neural network, connected by long-range projections of which the prefrontal cortex is thought to be a point of origin; this mechanism could also play a role in the reorganization and storage of memories after an NDE.^[9]

Evidence also indicates that the memory of a person in critical condition may be influenced by external stimuli perceived during the resuscitation phase: a person who is still unconscious, but with residual neural activity, could incorporate elements of medical conversations into the reconstructed memory of their experience. Explanations based on hallucinogenic substances (such as ketamine) or on hypoxia alone are, for their part, generally ruled out by researchers in the field: the experiences reported under ketamine or during isolated hypoxia differ markedly, in their content and structure, from classic NDE accounts.^[10]

3.3.2. Surges of EEG activity before death

One of the most discussed lines of research in this field concerns electroencephalographic surges (measured by bispectral index, using a SedLine device) observed just before death. An EEG detects, through surface electrodes, the electrical signals associated with brain activity; an increase in this activity can potentially indicate an intensification of consciousness, perception, or affect.^[11]

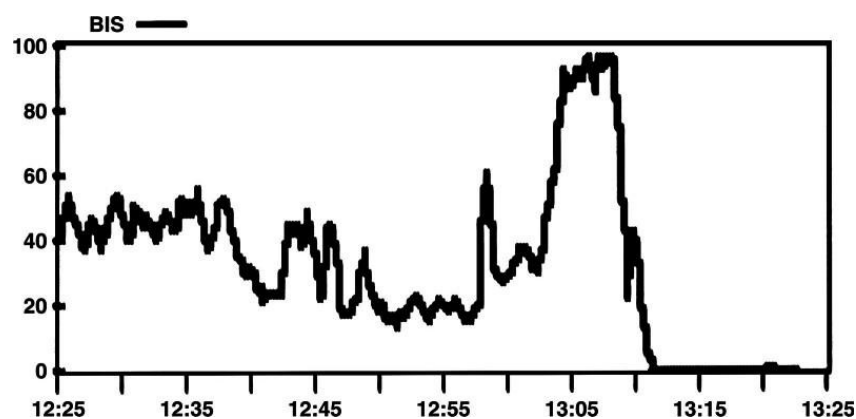


Figure 3 — Surge of electroencephalographic activity observed just before death in a critically ill patient (Mashour, Lee, Pal & Li, 2024).

In a study of critically ill patients with no prior neurological damage, an electroencephalographic surge was detected just before death in 7 people. The trace shows a gradual decline in brain activity, followed by a sudden peak consistent with a heightened state of consciousness — despite the preceding hypoxia — and then a final decline corresponding to death.^[11]

A follow-up study of 35 patients, however, strongly qualifies this result: 7 of the 35 patients were brain-dead and showed no surge; of the remaining 28, only 46.4% exhibited this

phenomenon. This study shows that these surges are neither universal nor observable in brain-dead patients, and that a certain level of residual brain function seems necessary for them to occur. Furthermore, current surface EEGs cannot distinguish with certainty between organized neural activity linked to consciousness and nonspecific activity linked to post-hypoxic neural degradation, nor between a waking state and epileptic-type activity; nor does the electrode configuration, often limited to the frontal regions, capture all of the brain events associated with consciousness. These methodological reservations limit the scope of these results, which nonetheless remain one of the most promising avenues for a partial neurophysiological explanation of NDEs.

3.3.3. Follow-up study in rodents

To get around the methodological limitations inherent in human studies, Borjigin and colleagues conducted an equivalent experiment in rats, using intracranial EEG — a method implanted directly on the surface of the brain and therefore much more precise than surface EEG. After inducing cardiac arrest by intracardiac injection of potassium chloride, the researchers identified four distinct stages of brain activity; the third stage showed a marked surge in gamma and theta oscillations.^[11]

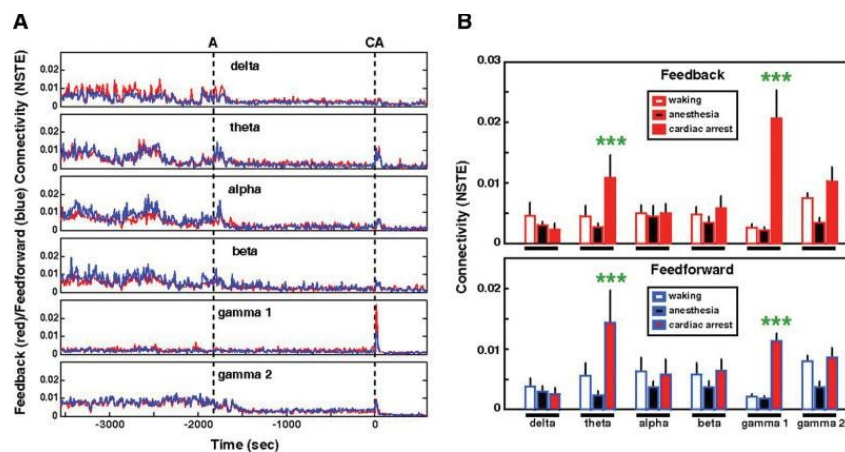


Figure 4 — Surge of gamma and theta oscillations observed in rats after induced cardiac arrest (Borjigin et al., cited in Mashour et al., 2024).

Notably, directed functional connectivity between brain regions, measured by symbolic transfer entropy, also increased during this phase — which indicates organized activity rather than mere electrical noise. This study opens a promising avenue for understanding the potential neurological substrate of consciousness in near-death states, but its extrapolation to humans remains to be confirmed, and it does not, on its own, explain how subjects such as Maria or Brad Barrows could have perceived information that was in principle inaccessible to their senses.

In summary, the hypotheses of integrated information theory and global neuronal workspace theory propose mechanisms by which neural activity could persist after the clinical cessation of vital functions, and memory could play a role in the retrospective construction of the testimonies. The surges of EEG activity documented in both humans and animals constitute a substantial neurophysiological avenue, albeit not universal and still poorly understood. None

of these avenues, however, fully accounts for the cases of apparently verified perception in the absence of any possible sensory activity.

4. The quantum consciousness hypothesis (Orch-OR)

Physicist Roger Penrose and anesthesiologist Stuart Hameroff proposed a model combining quantum physics and neuroscience, Orchestrated Objective Reduction (Orch-OR). Penrose argues that classical physics is insufficient to explain consciousness, since neural activity governed by non-random processes cannot, in his view, account for its complexity; drawing on Gödel's incompleteness theorem, he puts forward the idea that consciousness may not be entirely computable, and proposes a mechanism of objective reduction (OR) based on the collapse of the quantum wave function.^[12]

Hameroff adds a biological component to this hypothesis: microtubules, structures present in the cytoskeleton of neurons, could sustain quantum coherence and function as natural quantum processors. According to the Orch-OR model, consciousness would emerge at the moment this quantum coherence in the microtubules collapses under the effect of gravity, this collapse being “orchestrated” by biological mechanisms in the brain.^[13]

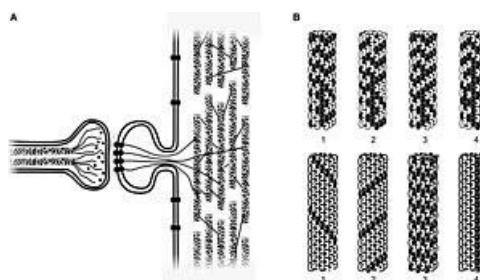


Figure 5 — Schematic representation of a neuronal microtubule (Wikipedia, 2025).

A speculative implication of this hypothesis follows from the so-called quantum no-hiding theorem, according to which quantum information cannot be destroyed, only transformed or transferred. If consciousness did indeed arise from a quantum process of this kind, the information associated with it would not necessarily disappear at the moment of biological death — it could, according to this hypothesis, dissipate into the environment or be transferred. This consequence remains, to date, entirely speculative and lacks any direct empirical support.^[14]

This theory remains highly controversial. The major problem lies in the lack of empirical evidence demonstrating that microtubules can actually sustain quantum coherence in the warm, wet environment of the brain: most known quantum coherence effects collapse rapidly in this type of environment, which makes the persistence of coherent quantum activity in the brain unlikely in light of current knowledge in physics. Most neuroscientists consider classical cell biology sufficient to account for consciousness, without recourse to an additional quantum mechanism.^[15]

In the current state of knowledge, the Orch-OR hypothesis remains an interesting but unvalidated theoretical avenue. Further empirical work, particularly in quantum biology, would be needed before its relevance to the question of post-mortem consciousness could be seriously assessed.

5. Psychological outcomes after an NDE

5.1. Positive and negative experiences

The subjective experience of an NDE varies considerably from one person to another. Most people associate their experience with positive feelings — peace, love, intense happiness — and report a lasting psychological transformation: a change in their relationship to death, their relationship to suicide, or their spiritual practices, as well as, often, encounters with deceased loved ones perceived as positive.

Conversely, a minority of people, estimated at between 10 and 20% of cases, report an experience felt to be extremely distressing or frightening. These negative experiences can be classified into two categories: so-called “inverted” NDEs, which begin pleasantly (light, tunnel, leaving the body) before becoming distressing, often in connection with a sense of loss of control; and so-called “void” NDEs, characterized by a feeling of being trapped in nothingness, associated with distress — although some people report, conversely, finding a form of peace there.

5.2. Attitudinal changes reported after an NDE

A study conducted by Cherie Sutherland (University of New South Wales) with 50 people who had experienced an NDE more than two years earlier documents marked attitudinal changes. The proportion of people describing themselves as non-religious in the sense of institutional practice rose from 46% to 84%, while indicators of personal spirituality (meditation, the quest for spiritual values, belief in reincarnation, belief in a continuation after death) increased sharply within the same sample.^[16]

Table 2
Religious or spiritual experiences, activities, and beliefs.

<i>Experience, activity or belief</i>	<i>Percent General Population</i>	<i>Percent Sample Before NDE</i>	<i>Percent Sample After NDE</i>	<i>NDEr Sample Size</i>	<i>p*</i>
value organized religion	56	36	20	50	.02
attend church	34	38	22	50	.02
pray	56	47	76	49	<.0001
meditate	no data	12	60	50	<<.0001
quest spiritual values	no data	18	88	50	<<.0001
guidance	44	33	88	48	<<.0001
reincarnation	32	43	80	40	<<.0001
life after death	59	50	100	40	<<.0001
fear death	no data	80	0	41	<<.0001

*probability of no change since NDE, based on chi-squared test

Figure 6 — Changes in spiritual experiences, practices, and beliefs before and after an NDE, $n = 41-50$ (Sutherland, 1990).

Attendance at institutional places of worship decreased in this sample, with some respondents indicating that they continued to attend for family or traditional reasons rather than religious ones. Attitudes toward suicide also changed markedly in the same sample: whereas 12% of respondents had previously attempted suicide and 30% had considered it before their NDE, none of the respondents was still contemplating suicide after their experience.

Table 3
Attitudes toward suicide

<i>Attitude toward one's own suicide or toward another person committing suicide</i>	<i>Percent Sample ($n = 50$) Before NDE</i>	<i>Percent Sample ($n = 50$) After NDE</i>
tried it	12	0
thought of it	30	0
could do it if life purpose achieved	0	2
self-righteous	2	0
feel compassion, sadness	2	0
no thoughts about it	9	5
wouldn't judge	7	14
no point in it	0	9
wrong to do it	21	14
wouldn't do it	16	37

Figure 7 — Changes in attitudes toward suicide before and after an NDE, $n = 50$ (Sutherland, 1990).

These data should be interpreted with caution: the sample is small ($n = 50$) and self-selected, and the “before NDE” measure also relies on retrospective recall, potentially reconstructed in light of the experience since. They nonetheless indicate, fairly consistently across the literature in the field, that an NDE is frequently accompanied by a lasting change in one’s existential relationship to death and a marked reduction in the associated anxiety — a finding that,

independently of its metaphysical interpretation, is of clinical and psychological interest in its own right, particularly in the context of palliative care and suicide prevention.

6. Technological perspectives and research directions

Recent advances in brain imaging, quantum biology, and artificial intelligence open up several avenues likely to advance, in the years to come, the scientific understanding of NDEs and of consciousness in general.

6.1. Brain imaging and connectome mapping

Magnetic resonance imaging (MRI) and high-resolution EEG techniques now make it possible to observe neural activity with increasing precision. Progress in mapping the human connectome — the full set of neural connections in the brain — opens up prospects for better understanding brain activity during and after an episode of clinical death, and could eventually help determine whether certain aspects of consciousness arise solely from measurable cortical activity or still elude current tools.^[17]

6.2. Quantum biology and models of consciousness

A strand of research in quantum biology is studying the possibility that quantum coherence effects persist in certain biological systems (for example, in photosynthesis), in warm, wet environments, which until recently was considered impossible. If such results were to be confirmed and extended to neural tissue, they would strengthen the physical plausibility — without, however, demonstrating it — of the Orch-OR hypothesis presented in section 4. Further work focusing specifically on neuronal microtubules would be needed to settle this question.

6.3. Artificial intelligence and modeling of consciousness

Artificial intelligence plays a growing role in the study of consciousness, through attempts at computational modeling of human cognitive processes. These systems are not, as things stand, considered conscious, but their development could enrich our understanding of brain activity. “Brain uploading”-type projects, which aim to represent computationally all of the neural connections of a human brain, as well as advances in quantum computing applied to neural simulation, could eventually make it possible to test certain hypotheses about the computational — or non-computational — nature of consciousness.

6.4. Brain-computer interfaces and virtual reality

Brain-computer interfaces, already used to restore thought-driven motor control in paralyzed patients, could in the future help detect and analyze cognitive phenomena that are still poorly characterized. In addition, virtual reality experiments are exploring the possibility of simulating certain altered states of consciousness, with the aim of better understanding the

phenomenological structure of near-death experiences without resorting to a context of real, life-threatening danger.^[18]

7. Discussion and limitations

The avenues presented in this review rest on very uneven levels of empirical robustness. The descriptive data on the structure and frequency of NDEs (section 2) are based on large-sample surveys (NDERF) and are relatively well replicated. The individual cases (Maria, Brad Barrows), on the other hand, remain unique, retrospective, and uncontrolled testimonies whose evidential value is limited by the standards of empirical research, even when a reported detail appears to have been verified after the fact.

The neuroscientific hypotheses (section 3) rely on increasingly solid experimental data, in particular the studies on surges of EEG activity in humans and animals, but they remain partial: they explain neither the relative universality of NDE content across different populations and cultures, nor the cases of apparently verified perception in subjects with no possible sensory access to the reported information. The quantum consciousness hypothesis (section 4) remains, at this stage, largely speculative and has no direct empirical support in humans.

A cross-cutting limitation of this field of research is the near-impossibility, for obvious ethical reasons, of conducting controlled prospective studies under conditions of actual clinical death: research must make do with samples of survivors, who are necessarily unrepresentative of all people who have come close to death, and with observation protocols that are necessarily limited in time and in the measurement modalities available. AWARE-type studies, which attempt to place verifiable visual targets in resuscitation rooms, represent to date the most rigorous methodological approach available for empirically testing claims of verifiable perception during cardiac arrest, but their numbers of positive cases remain, for now, very small.

8. Conclusion

This review has examined the extent to which current science can explain near-death experiences. The available neuroscientific data — residual cortical activity, integrated information theory, global neuronal workspace theory, surges of electroencephalographic activity just before death — provide partial explanatory avenues, converging on the idea that organized brain activity can persist longer than previously thought in states close to clinical death.

These explanations nonetheless remain incomplete in the face of certain elements reported in the literature, in particular cases of apparently verified perception in the absence of any possible sensory activity, such as that of people blind from birth describing coherent visual scenes. The hypothesis of a quantum origin of consciousness (Orch-OR) offers an alternative

theoretical framework, but in the current state of knowledge in physics and biology, it remains largely speculative and lacks direct empirical validation.

Furthermore, the available data on the psychological outcomes of people who have had an NDE indicate attitudinal changes that are relatively consistent from one study to another — a marked reduction in anxiety about death, changing attitudes toward suicide — which are of clinical interest in their own right, independently of any interpretation of the ultimate nature of the phenomenon.

Ultimately, current science can neither confirm nor rule out a possible continuation of consciousness beyond biological death. It does, however, make it possible to document part of the phenomenon empirically, to rule out certain overly simple explanations (isolated hypoxia, the effects of hallucinogenic substances), and to identify precisely the gray areas that remain. Larger-scale prospective and controlled protocols, combining continuous EEG monitoring, brain imaging, and independent verification of reported perceptions, would be needed to significantly advance this field of research.

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