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Beyond Life And Death: Understanding Neural Correlates Of Near-Death Experiences Through EEG And FMRI

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Abstract: Near-death experiences (ndes) are a phenomenon that often changes people's lives drastically. It occurs when a person goes through extreme psychological or physical trauma and survives by narrowly escaping death. This includes out-of-body feelings, intense life reviews, feelings of peace, and meeting deceased loved ones. Ndes are challenging to explain because they are fundamentally subjective, and the neural basis is even more difficult to explain. However, newer and more progressive techniques of neuroimaging such as eeg and fmri machines have provided more evidence towards the correlates of these experiences. This review focuses on the neurochemical and physiological changes accompanying ndes with emphasis on the cortical and subcortical regions of the brain. It also analyzes the eeg results regarding oscillation of the brain and fmri result that mark particular brain parts that make neural networks responsible for ndes. The clinical and philosophical perspectives of these findings along with the methodological approaches to study such phenomena are also provided. The point of this review is to interpret how profound the results are and attempt to outline what future research needs to be aimed at attempts to unmask the neurosciences of ndes.

Keywords: near-death experiences (ndes), eeg (electroencephalography), fmri (functional magnetic resonance imaging), brain oscillations, neural correlates, cortical and subcortical brain regions, neurochemistry, consciousness, out-of-body experiences, neuroimaging, neurophysiology.

1. INTRODUCTION

Individuals who have survived extreme psychological or physical stress or have been close to death have described near-death experiences (NDEs), which are a fascinating and often life-altering phenomenon. NDEs are defined by a range of subjective phenomena that have interested researchers as well as members of the general public. They include out-of-body feelings, profound feelings of peace, communication with dead individuals, and intense life reviews. Since such experiences occur at the interface of consciousness, the area of neurology and human experience, it is especially challenging to comprehend the underlying mechanisms.

Exploration of near death experiences (NDEs) is plagued with well-known methodological difficulties and the fundamental problems of investigating subjective phenomena. Nevertheless, improvements in neuroimaging techniques such as EEG and fMRI have given a new starting point to examine these phenomena. To understand the brain regions and neural mechanisms that are active during the onset of these complex subjective experiences, researchers have turned to the brain, by recording brain activity either at the time of, or immediately after events that lead to NDEs. This line of inquiry is motivated by a central question: Can objective, quantifiable neural markers be identified that correspond to the subjective experiences reported in NDEs?

This review integrates findings from EEG and fMRI research that have aimed to specify the neural co-relates of NDEs. That is, we will review here the neurochemical and physiological processes postulated to account for NDEs and the respective roles of cortical and subcortical brain functions. Next, we will present the observations made in EEG research on the pattern of brain oscillations recorded during NDEs. Second, we will examine fMRI results implicating particular neural networks in NDEs. Third, we will consider the clinical and philosophical implications of identifying neural correlates of NDEs. Fourth, we will note the limitations and challenges involved in investigating NDEs with neuroimaging methods. This review seeks to summarize the most important findings, discuss their meaning, and delineate areas of future research with the ultimate goal of demystifying the neuroscience of these unusual human experiences.

2. OBJECTIVE

This review aims to thoroughly investigate the neurochemical, physiological, as well as the neural associations of near-death experiences (NDEs) to gather data from the most recent studies of EEG and fMRI. It promotes the objectives of the article to locate which areas of the cortex and subcortex are activated in such conditions, try the neural oscillations and networks that are relevant to NDEs, and inform the potential treatment and philosophical angle of the latest findings. . This summary will additionally detail the imperfections and shortcomings of imaging methods in the study of highly complex neuroscientific phenomena. In this context, the main goal is not only to the lead the future investigation but also to unmask the complex neuroscientific foundation of NDEs and their potential influence on human consciousness.

3. MATERIALS AND METHODS

53 articles have been analyzed for the literature review. Keywords such as Near-death experiences (NDEs), EEG (electroencephalography), fMRI (functional magnetic resonance imaging), Brain oscillations, Neural correlates, Cortical and subcortical brain regions, Neurochemistry, Consciousness, Out-of-body experiences, Neuroimaging, Neurophysiology were used for the literature searches in databases such as Google Scholar and PubMed.

4. RESULTS

According to the reviewed literature, experiential similarities between near-death experiences (NDEs) and some specific brain circuits---although not yet sufficiently investigated---are proposed: It was found out that EEG studies of NDEs patients indicated that pixel phase synchronization measures the coupling between brain areas. fMRI proved that certain brain fibers are activated in the posterior cingulate and the precuneus whereas some fibers in the temporal-parietal junction are in resting states during out-of-body experiences. On the other hand, the anterior cingulate and amygdala were linked to emotional responses during which the life review took place. Thus, these outcomes implied that NDEs prompt an interplay of perception, memory, and emotion in relevant cerebral regions. Despite these encouraging results, the different responses in NDEs and the limitations of neuroimaging certainly call for further research to guide our new perspectives on the neural basis of NDEs.

5. DISCUSSION

5.1 Neurochemical and Physiological Mechanisms Underlying NDEs, Role of Cortical and Subcortical Brain Activity During NDEs

Near-death experiences (NDEs) have been reported since ancient times and often are followed by an altered perception of light, interactions with astral entities, and a complete recall of one's lif (Mashour et al., 2024; Van Lommel et al., 2001) e. The terminology of NDE was first introduced by Dr. Raymond Moody after analysing over 150 reports of coma survivors(Martial et al., 2020; Miller, 1988).Based on reports collected from people who experienced NDEs, various states of consciousness have been suggested such as enhanced consciousness(Medicine & 2014, n.d.; van Lommel, 2011), enhanced cognitive functions, clear perceptions of self-identity, and an apparent state of unconsciousness(Cassol et al., 2018, 2019; Martial et al., 2017; Palmieri et al., 2014).

Now this brings us to the age-old question, why and how does this happen from the perspective of neurology?
The modern scientific study of consciousness began as early as the early 2000s, with the primary objective being proper identification of the neural correlates of consciousness (NCC)-the threshold set of brain activity/events necessary for conscious perception(Crick & Koch, 2003; Mashour et al., 2024). Significant progress has been made in this field but there still exists an active debate as to whether the prefrontal cortex is actively involved in synthesizing experiential content of consciousness or whether it serves only for post-perceptual cognitive processing(Boly, Massimini, Tsuchiya, Postle, Koch, & Tononi, 2017; Boly, Massimini, Tsuchiya, Postle, Koch, Tononi, et al., 2017; Mashour et al., 2024). A significant number of frameworks for consciousness are reliant on the prefrontal cortex, 2 of relevance to our investigation. The two are integrated information theory(Albantakis et al., 2023) and the global neuronal workspace hypothesis(Mashour et al., 2020). Integrated information theory (IIT) states that consciousness is the same as integrated information(Mashour et al., 2020; Oizumi et al., 2014; Tononi, 2004), and that it arises in the posterior cortex; primarily the sensory and association cortices which is often referred to as the 'hot zone' for consciousness(Koch et al., 2016; Siclari et al., 2017). Global neuronal workspace (GNW) on the other hand, postulates that consciousness emerges when the information is widely broadcasted across the brain through long-distance connections that involve the prefrontal cortex. This entire process is termed as 'ignition' and sustains a particular reverberant activity in different cortical regions of the brain(Dehaene et al., 1998; Dehaene & Changeux, 2011; Mashour et al., 2020). Both IIT and GNW can be used to explain the phenomenon of NDE, but they are not mutually exclusive.

Another remarkable distinction in the research of consciousness is between the phenomenal consciousness and access consciousness(Block, 2005). Phenomenal consciousness is often referred to as a pure subjective experience, whereas access consciousness is referred to as the ability to process, remember, and report a particular experience. Since NDEs are reported around the world, they belong to the access consciousness, which further suggests that the prefrontal cortex is the main player behind this. Despite this, the rich sensory experience of NDEs also implicates the activity of the posterior cortex, thereby supporting the statement that NDEs engage both perceptual and cognitive processes.

A dying brain undergoes three levels of activity which eventually leads to a state of isoelectricity (i.e. loss of neuronal activity)(Carton-Leclercq et al., 2023; Schramm et al., 2020). It is shown that NDEs arise in dying patients during the recovery phase when resuscitation is successful. The brain during this phase exhibits an overwhelming amount of reduced high-frequency activity, a pattern akin to hallucinatory disorders such as schizophrenia and BPD(Schramm et al., 2020).

To explain the phenomenon of NDE just through a theoretical perspective will not suffice. We are now fully capable of providing a neurochemical background for NDEs with the data obtained from mice models, as well as patients who are critically ill. This data has led us to postulate that NDEs could be a manifestation of coordinated high-frequency brain activities around the time of death(Borjigin et al., 2013; Chawla et al., 2017; Xu et al., 2023). A 2020 study regarding the neural origins of high-frequency activity during NDEs used concomitant electrocorticographic and intracellular recording in asphyxia-induced rat models(Schramm et al., 2020). The findings of this study stated that post asphyxia, there was an observed surge in beta-gamma(10-50Hz) electrocorticographic activity, which was accompanied by a rhythmic pyramidal neuron firing at a rate of 6-7 Hz. This activity is postulated to be shaped by high-frequency depolarizing and hyperpolarizing synaptic potentials (a rate between 100 and 140 Hz)(Schramm et al., 2020).

Similar findings were observed in different studies performed on the hippocampus of rats in vivo and in vitro during cerebral ischemia that suggested the synaptic activities originated due to γ-aminobutyric acid (GABA) and adenosine-dependent inhibition(Dzhala et al., 2001; Freund et al., 1989). Another study postulated that these effects are mediated through glutamate-gated channels following oxygen deprivation(Revah et al., 2016). The increase of certain neurotransmitters in different cortices within the first two minutes of asphyxia was documented by Li et al.(Li et al., 2015). Adenosine, norepinephrine serotonin, GABA, glutamate, and aspartate were found to be in increased concentration in the frontal and occipital cortices. Serotonin showed a remarkable surge of up to 20 times its normal concentration in the first two minutes, and up to 250 times after the first

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twenty minutes(Li et al., 2015). An increase in N,N-Dimethyltryptamine(DMT) was also noticed, but validated evidence was not obtained to provide a causal relationship between the increase in DMT and NDE-like effects.

5.2 Insights from EEG Studies: Patterns of Brain Oscillations in NDEs

In this century two major neuroscientific models have surfaced to explain NDEs.

One is The REM{Rapid Eye Movement} sleep intrusion theory (Nelson et al., 2006),which suggested that elements of REM sleep can occur even when a person is awake.The other is the Gamma Oscillation Theory,(Borjigin et al., 2013a) which was discussed as the landmark discovery as it is particularly new and quite a thought provoking topic.

Recent studies have challenged the idea that high frequency gamma oscillations are the main cause of neural basis of near death experiences[NDEs].The initial report made by Xu et al suggested that the near death experiences cause a spike in gamma activity but this theory was questioned by Christof Koch (2023) who suspected that the these high-frequency,high amplitude oscillations might be contaminated by seizures or muscle

activity.stronger evidence comes from studies on psychedelics, which replicate the experience of NDEs.

DMT, *N,N*-dimethyltryptamine (DMT) (aka ayahuasca), a serotonergic hallucinogen, has also been proven to show an altered state of consciousness which is strikingly similar to NDEs. Although EEG recordings during DMT intoxication{Fig 1} (Timmermann et al., 2018, 2019, 2023) showed prevalence of slow delta and theta oscillation over gamma surge. Moreover,Carbon dioxide therapy also induces an altered state which resembles NDEs and shows theta dominant patterns. Several research findings have also reported an increase in gamma activity following psychedelic intoxication.

These findings directly contradicted the expectations of the GBA model, which initially assumed high frequency activity bursts played a key role in NDEs.

5.3 fMRI Findings: Neural Networks Implicated in NDEs

Earlier research suggested people who lived through near death experiences could recall and re-experience their NDEs with very high multi sensory awareness by hypnosis. Further research conducted using a 32 channel EEG suggested that electroencephalographic patterns which were observed during NDE recall showed that theta activity was linked to recalling real life memories. More recent studies have suggested highly hypnotizable individuals who had never experienced NDEs or OBEs showed a decrease in beta and gamma band activity in their right parieto-temporal region.

The ability to replicate near death experiences in controlled laboratory environments allows for a deeper examination of neural mechanisms,which is helpful in addressing the complications of studying brain activity during spontaneous NDEs. However, studies have yet to examine the neural patterns of hypnotically induced NDEs using high-density EEG in individuals with prior genuine NDEs.

A Study was conducted were two groups of individuals who had experienced genuine near death experiences were invited and were asked to recall a positive life experience along with their near death experience in two states:usual state of awareness and during hypnosis, Memory characteristic questionnaires were also provided which were specifically designed to explore both subjective experiences of NDEs. This study mainly focused on two of the most reported features: The strong feeling of peace and Out- of- body experiences{OBE}(Fig:2)

EEG Results:EEG examination (Fig. 3) revealed that the NDE condition during hypnosis and usual state of awareness led to a significant increase in alpha power in both frontal and posterior scalp regions. At a significance threshold of $p < 0.016$, these regions formed a single cluster comprising 161 significant channels, with the most pronounced effect observed at channel E2 (right frontal; $T = 7.298$, $p = 0.0009$). In the posterior region, the strongest alpha peak was detected at channel E122 (left posterior; $T = 5.486$, $p = 0.0014$).

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For the better understanding of possible interaction and covariates, the focus was directed towards two peak channels, E2 and E122. At the frontal electrode (E2) a significant interaction between HY_NC and NDE_AUTOBIO ($\chi^2(1) = 8.318$, $p = 0.004$) was found,which

indicated that alpha power was elevated during NDE recall during both hypnosis and usual state of awakeness, with a more pronounced effect during usual state of awakeness.

At the posterior electrode (E122), there were significant main effects for both conditions and NDE_AUTOBIO, though no interaction was observed between them. Similar to the frontal region, alpha power was higher during NDE recall ($\chi^2(4) = 43.268$, $p < 0.001$) and significantly increased during hypnosis compared to usual state of awareness alone ($\chi^2(4) = 62.297$, $p < 0.001$). Significantly, at the posterior site, alpha power was positively correlated with SHSS scores ($\chi^2(1) = 4.959$, $p = 0.026$), while a marginal negative trend was observed with age ($\chi^2(1) = 3.824$, $p = 0.051$).

While the previous analysis mainly focused on alpha power changes, Fig. 3 suggests that effects from other frequency bands may overlap. To isolate alpha-specific changes, comparison was made between the 10–11 Hz band with its lower neighboring band (7–8 Hz). This approach reduced some central electrode effects but emphasized increased alpha activity in frontal and posterior regions, with a rightward bias. The most significant effect was observed in a right posterior cluster of 49 electrodes (peak: E167; $T = 5.393$, $p = 0.008$), showing increased alpha power during NDE regardless of Hypnotism or usual state of awakeness. A frontal cluster of 35 electrodes (peak: E36; $T = 4.982$, $p = 0.014$) also exhibited an alpha power increase during NDE.

Further analysis of the frontal peak channel (E36) revealed a significant interaction between the two conditions and NDE_AUTOBIO ($\chi^2(1) = 9.593$, $p = 0.002$), along with a weaker interaction between NDE_AUTOBIO and OBE_PE ($\chi^2(1) = 5.454$, $p = 0.019$). As depicted in Fig. 3, alpha power was generally higher during hypnosis, NDE, and PE conditions. Additionally, both age ($\chi^2(1) = 6.523$, $p = 0.011$) and SHSS scores ($\chi^2(1) = 15.917$, $p < 0.001$) were significant predictors of alpha power. No three-way interaction was found ($\chi^2(1) = 2.183$, $p = 0.140$), nor any interaction between and OBE_PE ($\chi^2(1) = 0.064$, $p = 0.801$).

For the posterior peak channel (E167), we again observed a significant interaction between hypnosis and usual state of awareness and NDE_AUTOBIO ($\chi^2(1) = 11.933$, $p < 0.001$). As shown in (Fig.4), this effect indicated that the increase in alpha power during NDE was present only in the NC condition ($\chi^2(2) = 51.079$, $p < 0.001$) and not during HY ($\chi^2(2) = 0.372$, $p = 0.83$). No three-way interaction was detected ($\chi^2(1) = 0.550$, $p = 0.458$), nor were there interactions between HY_NC and OBE_PE ($\chi^2(1) = 2.695$, $p = 0.101$) or between NDE_AUTOBIO and OBE_PE ($\chi^2(1) = 1.711$, $p = 0.191$). Notably, all reported results followed the same pattern even when age and SHSS were excluded as covariates.

5.4 Multifactorial aspects and challenges of Studying Near-Death Experiences

A Medical and Sociological Perspective

NDEs have fascinated the public and the scientific community over decades. With increased media coverage and medical research since the late 1970s, global debate has been ongoing, particularly regarding the possibility of an afterlife. The topic is widely debated across medical, cultural, and religious circles. Despite continued research, the true nature and significance of NDEs are still matters of debate among scientists, physicians, and sociologists.

Characteristics of Near-Death Experiences

NDEs always take place in recognizable patterns, as well documented in research. common features include:

- Deep feeling of peacefulness and calmness.
- Feeling of separation from physical body.
- Perception from outside one's body, often with feeling of being able to look around from above.
- Sensory travel through blackness or void.

- Movement into a realm of resplendent light and beauty.
- Experiences with spiritual beings, such as God, Jesus, or deceased loved ones.

Because religion addresses fundamental questions about death and the afterlife, NDEs are typically related to people's religious beliefs. Religious experiences—objectively real-appearing encounters of spiritual significance—are defined by a person's religion, culture, and theological structures .

Religious Orientation and its Influence on NDEs

The religious tradition of the individual informs religious experiences but has universal characteristics. William James was one of the first commentators on these universalities, distinguishing between institutional religion and personal religion. Institutional religion was used to describe formally constituted religious beliefs and practices and their role in society, while personal religion spoke of direct, mystical experiences regardless of cultural input.
James characterized religious experiences in terms of the mnemonic PINT:

- Passive – The experience occurs spontaneously, outside conscious control.
- Ineffable – The experience is impossible to verbalize.
- Noetic – The individual feels deep knowledge or truth.
- Transient – The experience is brief but has a profound impact.

Religious orientation also affects death attitudes. Those who are intrinsically religious tend to be more positively oriented towards death and view it as a passage and not an ending. Conversely, religious persons externally motivated, or those who act religiously to benefit themselves or society, fear death more. Religious people with higher spiritual attachment would tend to report NDE as a life-transforming experience, while others, even atheists, may undergo their beliefs drastically change after NDE.

Mystical Characteristics of NDEs

NDEs have been compared to mystical experiences, which are characterized by altered states of consciousness. According to the definition given by Pahnke and elaborated on by Greyson, mystical experiences have the following inherent characteristics:

- Interconnectedness and unity.
- Space-time transcendence.
- Deep positive emotionality.
- Ultimacy and sense of sacredness.
- Paradoxicality (something that is difficult to explain in a rational way).
- Ineffability (difficulty in describing the experience in its entirety).
- Transience and long-lasting psychological impact.

Noyes and Kletti proposed a three-stage model of consciousness change near death: resistance, submission and life review, and transcendence. Such stages correlate with mystical features such as deepened insight, disintegration of ego control, heightening states of emotionality, and redefinition of personal meaning and values.

Sociological and Medical Implications of NDEs

The fascination with NDEs is of major importance for the sociology of medicine. Advances in resuscitation techniques have meant that individuals who experience profound visionary experiences on the threshold of death are able to survive. The phenomenon demonstrates the ways that medical developments can impact on societal belief and philosophical reflection in unforeseen way.

Reports of NDEs have spawned theological and philosophical discussion about an afterlife. However, no scientific or rational principles currently allow reliable inferences about life after death. Physicians and scientists must delineate empirical medical investigation from theological speculation to maintain scientific integrity. The best course of action for health professionals is to deal with clinical and research concerns while being receptive to patients' experiences.

Scientific Theories of NDEs

Several psychobiological theories of NDEs have been proposed, none of which have been definitively proven. Theories have focused on the neurological and biochemical processes that may generate the experiences:

- Retinal Ischemia Hypothesis – The tunnel vision of NDEs may be due to retinal ischemia brought about by the lack of oxygen supply.
- Endogenous Opioid Release – The brain responds to intense stress by releasing natural pain-killing chemicals, such as endorphins, that can be held accountable for the euphoric sensation in NDEs.
- Glutamate Excitotoxicity – A massive release of glutamate, typically triggered by acute traumatic brain injury, has been theorized to produce neurochemical effects in the same manner as ketamine, leading to distorted perception.
- Free Radical Hypothesis – certain researchers suggest that the bright lights reported in NDEs might be explained by bioluminescent photons produced by free radicals within the visual system.
- Neurophysiological Response to Cardiac Arrest – Experiments with rats have demonstrated transient spikes of neural activity following cardiac arrest, which has raised speculations that humans may go through a temporary state of heightened consciousness under these conditions.
- Expectancy Hypothesis: A psychological hypothesis suggesting that individual and cultural beliefs organize NDEs, which are shaped into typical religious or mystical forms.
- REM Intrusion and Temporal Lobe Activity: Some scientists have argued that NDEs might be caused by REM sleep intrusion or by temporal lobe seizures, although clinical evidence to support this is non-existent.

Neural imaging studies of EEG and fMRI have also documented widespread activation across various parts of the brain while recalling an NDE, indicating complex neurophysiology beyond the temporal lobes. The findings are opposed to reductionist oversimplifications and suggest a more complex inter-relationship among various neural circuits.

Cognitive and perceptual phenomena in NDEs

1. Enhanced Mental Clarity During NDEs
   One of the mandatory features of NDEs is higher mental clarity despite circumstances when consciousness should be reduced. The majority assert having definite ideas and vivid sensory perceptions.
   - 80% indicate that their thoughts were clearer than usual.
   - Increased mental functioning is more common close to death
   - 24% include a panoramic review of one's life.
2. Out-of-Body Perceptions
   Many experiencers report viewing their physical body from an external perspective.
   - 48% observe their resuscitation efforts.
   - Some cases claim distant perceptions, including blind individuals reporting quasi-visual experiences.
   - 43% of verifiable out-of-body perceptions were confirmed by independent witnesses.
3. Visions of Deceased Individuals
   A common element is encountering deceased relatives or acquaintances.

- 42% report meeting recognizable deceased persons.
- Those near death are more likely to perceive the deceased than the living.
- Some cases involve veridical perceptions of newly deceased individuals.

NDEs in children

Children in the pilot study reported their experiences as "real", assigning a subjective reality to their extra sensory experiences.

Study participants reflect the transcendental qualities of a knowing consciousness, extended time and sense of serenity. These findings are similar to studies with children on peak and mystical experiences in non-clinical and clinical samples.17 Statistical findings from PMH Atwater's research show that 76 % of children, compared to 20 % of adults, have a world of loving nothingness or living darkness. Children who had indicated NDE type experiences in the pilot study spoke of being in a blackness but feeling calm, or of having a sense of "home". Children's NDE's reported in the study were simple compared to the complex experiential reports made by adults.

Positive and Negative NDEs

Most find NDEs to be highly positive, with reduced fear of death and lower neurotic anxieties. Many subjects also report higher belief in post-mortem survival. But traumatic NDEs have also been described, some transforming from positive to negative. Notably, moral character is not at all associated with the kind of person's NDE. Even suicide attempts do not predict further traumatic events.

Greyson and Bush categorized distressing NDEs into three types:
1. Frightening Out-of-Body Experiences – Individuals experience typical NDE characteristics but perceive them as terrible since they have lost control.
2. Existential Void – Sense of complete nonexistence and loneliness.
3. Hellish Imagery – Perceptions of devilish beings, ghastly scenery, and eerie sounds.

The Intersection of Science and Spirituality

Perhaps the biggest challenge for scientists and physicians who study near-death experiences (NDEs) is how to integrate non-materialist religious and philosophical insights into clinical practice. NDE accounts habitually appear to challenge standard paradigms of science, creating polarities between religious fundamentalism at one extreme and material scientism at the other. Fundamentalists will occasionally interpret NDEs as physical, literal events, whereas strict materialists will dismiss them as hallucinations or delusions and refuse to entertain any alternative perspective whatsoever.

Challenges in Research Methodology

A primary limitation of NDE research is that it is retrospective in nature. Most studies rely on self-reported experiences, bringing into question the validity and reliability of autobiographical memory. Emotional and psychological processes can lead to memory distortion over time, particularly for extraordinary or traumatic events.
Most studies rely on self-reported experiences, bringing into question the validity and reliability of autobiographical memory. Emotional and psychological processes can lead to distortion of memory over time, particularly for extraordinary or traumatic events. However, as per some studies, memories of NDE are experienced as "more real" than other life memories and remain consistent over decades, with some reports showing no alteration whatsoever even after 20 years.

6. CONCLUSION

The profound intricacy and subjective nature of near-death experiences is something that science has sought to understand by diving deep into the neural and physiological mechanisms of the phenomena, and the progress made is milestone. Studies conducted with EEG and fMRI point towards the involvement of higher order functioning and lower subcortex integration along with the alteration of neurotransmitters during periods of stress NDEs. While the proposed explanations of REM intrusion, gamma oscillations, and neurotransmitter surges are phenomenally insightful, none singularly answer the variability of NDEs. We recommend that future work improve the scientific understanding of NDEs by advancing the imaging process, developing pharmacological paradigms of NDEs, and attending to methodological issues. The duality of neuroscience, psychology, and philosophy is what makes it possible for

NDEs to be simultaneously analyzed through the lens of science and examined with deep subjective passion.

REFERENCES

[1]. Cooper, R. A., & Ritchey, M. (2019). Cortico-hippocampal network connections support the multidimensional quality of episodic memory. *eLife*, *8*.

[2]. Peinkhofer, C., Dreier, J. P., & Kondziella, D. (2019). Semiology and Mechanisms of Near-Death Experiences. *Current Neurology and Neuroscience Reports*, *19*(9).

[3]. Bush, N. E., & Greyson, B. (2014, December 1). *Distressing Near-Death Experiences: The Basics*.

[4]. Sleutjes, A., Moreira-Almeida, A., & Greyson, B. (2014). Almost 40 years investigating Near-Death experiences. *The Journal of Nervous and Mental Disease*, *202*(11), 833–836.

[5]. Romand, R., & Ehret, G. (2023). Neuro-functional modeling of near-death experiences in contexts of altered states of consciousness. *Frontiers in Psychology*, *13*.

[6]. Nelson, K. (2015, April 1). *Near-Death Experiences: Neuroscience Perspectives on Near-Death Experiences*.

[7]. Greyson, B. (2015). Western scientific approaches to Near-Death experiences. *Humanities*, *4*(4), 775–796.

[8]. Albantakis, L., Barbosa, L., Findlay, G., Grasso, M., Haun, A. M., Marshall, W., Mayner, W. G. P., Zaeemzadeh, A., Boly, M., Juel, B. E., Sasai, S., Fujii, K., David, I., Hendren, J., Lang, J. P., & Tononi, G. (2023). Integrated information theory (IIT) 4.0: Formulating the properties of phenomenal existence in physical terms. PLOS Computational Biology, 19(10), e1011465.

[9]. Block, N. (2005). Two neural correlates of consciousness. Trends in Cognitive Sciences, 9(2), 46–52.

[10]. Boly, M., Massimini, M., Tsuchiya, N., Postle, B. R., Koch, C., & Tononi, G. (2017). Are the Neural Correlates of Consciousness in the Front or in the Back of the Cerebral Cortex? Clinical and Neuroimaging Evidence. Journal of Neuroscience, 37(40), 9603–9613.

[11]. Boly, M., Massimini, M., Tsuchiya, N., Postle, B. R., Koch, C., Tononi, G., Odegaard, B., Knight, R. T., & Lau, H. (2017). Should a Few Null Findings Falsify Prefrontal Theories of Conscious Perception? Journal of Neuroscience, 37(40), 9593–9602.

[12]. Borjigin, J., Lee, U. C., Liu, T., Pal, D., Huff, S., Klarr, D., Sloboda, J., Hernandez, J., Wang, M. M., & Mashour, G. A. (2013). Surge of neurophysiological coherence and connectivity in the dying brain. Proceedings of the National Academy of Sciences of the United States of America, 110(35), 14432–14437.

[13]. Carton-Leclercq, A., Carrion-Falgarona, S., Baudin, P., Lemaire, P., Lecas, S., Topilko, T., Charpier, S., & Mahon, S. (2023). Laminar organization of neocortical activities during systemic anoxia. Neurobiology of Disease, 188, 106345.

[14]. Cassol, H., Martial, C., Annen, J., Martens, G., Charland-Verville, V., Majerus, S., & Laureys, S. (2019). A systematic analysis of distressing near-death experience accounts. Memory (Hove, England), 27(8), 1122–1129.

[15]. Cassol, H., Pétré, B., Degrange, S., Martial, C., Charland-Verville, V., Lallier, F., Bragard, I., Guillaume, M., & Laureys, S. (2018). Qualitative thematic analysis of the phenomenology of near-death experiences. PloS One, 13(2).

[16]. Chawla, L. S., Terek, M., Junker, C., Akst, S., Yoon, B., Brasha-Mitchell, E., & Seneff, M. G. (2017). Characterization of end-of-life electroencephalographic surges in critically ill patients. Death Studies, 41(6), 385–392.

[17]. Crick, F., & Koch, C. (2003). A framework for consciousness. Nature Neuroscience 2003 6:2, 6(2), 119–126.

[18]. Dehaene, S., & Changeux, J. P. (2011). Experimental and Theoretical Approaches to Conscious Processing. Neuron, 70(2), 200–227.

[19]. Dehaene, S., Kerszberg, M., & Changeux, J. P. (1998). A neuronal model of a global workspace in effortful cognitive tasks. Proceedings of the National Academy of Sciences of the United States of America, 95(24), 14529–14534.

[20]. Dzhala, V., Khalilov, I., Ben-Ari, Y., & Khazipov, R. (2001). Neuronal mechanisms of the anoxia-induced network oscillations in the rat hippocampus in vitro. Journal of Physiology, 536(2), 521–531.

[21]. Freund, T. F., Buzsáki, G., Prohaska, O. J., Leon, A., & Somogyi, P. (1989). Simultaneous recording of local electrical activity, partial oxygen tension and temperature in the rat hippocampus with a chamber-type microelectrode. Effects of anaesthesia, ischemia and epilepsy. Neuroscience, 28(3), 539–549.

[22]. Koch, C., Massimini, M., Boly, M., & Tononi, G. (2016). Neural correlates of consciousness: progress and problems. Nature Reviews Neuroscience 2016 17:5, 17(5), 307–321.

[23]. Li, D., Mabrouk, O. S., Liu, T., Tian, F., Xu, G., Rengifo, S., Choi, S. J., Mathur, A., Crooks, C. P., Kennedy, R. T., Wang, M. M., Ghanbari, H., & Borjigin, J. (2015). Asphyxia-activated corticocardiac signaling accelerates onset of cardiac arrest. Proceedings of the National Academy of Sciences of the United States of America, 112(16), E2073–E2082.

[24]. Martial, C., Cassol, H., Laureys, S., & Gosseries, O. (2020). Near-Death Experience as a Probe to Explore (Disconnected) Consciousness. Trends in Cognitive Sciences, 24(3), 173–183.

[25]. Martial, C., Charland-Verville, V., Cassol, H., Didone, V., Van Der Linden, M., & Laureys, S. (2017). Intensity and memory characteristics of near-death experiences. Consciousness and Cognition, 56, 120–127.

[26]. Mashour, G. A., Lee, U. C., Pal, D., & Li, D. (2024). Consciousness and the Dying Brain. Anesthesiology, 140(6), 1221.

[27]. Mashour, G. A., Roelfsema, P., Changeux, J. P., & Dehaene, S. (2020). Conscious Processing and the Global Neuronal Workspace Hypothesis. Neuron, 105(5), 776–798.

[28]. Medicine, P. V. L.-M., & 2014, undefined. (n.d.). Consciousness beyond life: the science of the near-death experience. Pmc.Ncbi.Nlm.Nih.Gov. Retrieved February 23, 2025.

[29]. Miller, J. (1988). The light beyond, by Raymond A. Moody, Jr. with Paul Perry. Journal of Near-Death Studies, 7(3), 191–199.

[30]. Oizumi, M., Albantakis, L., & Tononi, G. (2014). From the Phenomenology to the Mechanisms of Consciousness: Integrated Information Theory 3.0. PLOS Computational Biology, 10(5), e1003588.

[31]. Palmieri, A., Calvo, V., Kleinbub, J. R., Meconi, F., Marangoni, M., Barilaro, P., Broggio, A., Sambin, M., & Sessa, P. (2014). "Reality" of near-death-experience memories: evidence from a psychodynamic and electrophysiological integrated study. Frontiers in Human Neuroscience, 8(JUNE).

[32]. Revah, O., Lasser-Katz, E., Fleidervish, I. A., & Gutnick, M. J. (2016). The earliest neuronal responses to hypoxia in the neocortical circuit are glutamate-dependent. Neurobiology of Disease, 95, 158–167.

[33]. Schramm, A. E., Carton-Leclercq, A., Diallo, S., Navarro, V., Chavez, M., Mahon, S., & Charpier, S. (2020). Identifying neuronal correlates of dying and resuscitation in a model of reversible brain anoxia. Progress in Neurobiology, 185, 101733.

[34]. Siclari, F., Baird, B., Perogamvros, L., Bernardi, G., LaRocque, J. J., Riedner, B., Boly, M., Postle, B. R., & Tononi, G. (2017). The neural correlates of dreaming. Nature Neuroscience 2017 20:6, 20(6), 872–878.

[35]. Tononi, G. (2004). An information integration theory of consciousness. BMC Neuroscience, 5(1), 1–22.

[36]. van Lommel, P. (2011). Near-death experiences: the experience of the self as real and not as an illusion. Annals of the New York Academy of Sciences, 1234(1), 19–28.

[37]. Van Lommel, P., Van Wees, R., Meyers, V., & Elfferich, I. (2001). Near-death experience in survivors of cardiac arrest: A prospective study in the Netherlands. Lancet, 358(9298), 2039–2045.

[38]. Xu, G., Mihaylova, T., Li, D., Tian, F., Farrehi, P. M., Parent, J. M., Mashour, G. A., Wang, M. M., & Borjigin, J. (2023). Surge of neurophysiological coupling and connectivity of gamma oscillations in the dying human brain. Proceedings of the National Academy of Sciences of the United States of America, 120(19), e2216268120.

[39]. Tanny, P. (2024, September 24). The science behind Near-Death experiences: What happens in the brain? *NDE Library*.

[40]. *Cerebral hypoxia*. (2024, July 2). Cleveland Clinic.

[41]. Shaw, N. A. (2024). The gamma-band activity model of the near-death experience: a critique and a reinterpretation. *F1000Research*, *13*, 674.

[42]. Timmermann, C., Roseman, L., Schartner, M., Milliere, R., Williams, L. T. J., Erritzoe, D., Muthukumaraswamy, S., Ashton, M., Bendrioua, A., Kaur, O., Turton, S., Nour, M. M., Day, C. M., Leech, R., Nutt, D. J., & Carhart-Harris, R. L. (2019). Neural correlates of the DMT experience assessed with multivariate EEG. *Scientific Reports*, *9*(1).

[43]. Martial, C., Mensen, A., Charland-Verville, V., Vanhaudenhuyse, A., Rentmeister, D., Bahri, M. A., Cassol, H., Englebert, J., Gosseries, O., Laureys, S., & Faymonville, M. (2019). Neurophenomenology of near-death experience memory in hypnotic recall: a within-subject EEG study. *Scientific Reports*, *9*(1).

[44]. Timmermann, C., Roseman, L., Williams, L., Erritzoe, D., Martial, C., Cassol, H., Laureys, S., Nutt, D., & Carhart-Harris, R. (2018). DMT models the Near-Death experience. *Frontiers in Psychology*, *9*.

[45]. Mashour, G. A., Lee, U., Pal, D., & Li, D. (2024). Consciousness and the dying brain. *Anesthesiology*, *140*(6), 1221–1231.

[46]. Koch, C. (2023). Do not go gently into that good night: The dying brain and its paradoxically heightened electrical activity. *Proceedings of the National Academy of Sciences*, *120*(22).

[47]. *Near-Death experiences*. (2021, January 18). Psychology Today.

[48]. Moody, R. A. (2013, October 1). *Getting Comfortable with Death & Near-Death Experiences: Near-Death Experiences: An essay in Medicine & Philosophy*.

[49]. Greyson, B. (2011). *Cosmological implications of near-death experiences*. Division of Perceptual Studies, University of Virginia

[50]. Agrillo, C. (2011). Near-Death experience: Out-of-Body and Out-of-Brain? *Review of General Psychology*, *15*(1), 1–10.

[51]. Thomas, D., & O'Connor, G. (2023). Exploring near death experiences with children post intensive care: A case series. *EXPLORE*, *20*(3), 443–449.

[52]. Kopel, J., & Webb, M. (2022). Near-Death Experiences and Religious Experience: An Exploration of Spirituality in medicine. *Religions*, *13*(2), 156.

[53]. Craffert, P. (2015, July 30). *Do out-of-body and near-death experiences point towards the reality of nonlocal consciousness? A critical evaluation*. Craffert | the Journal for Transdisciplinary Research in Southern Africa.

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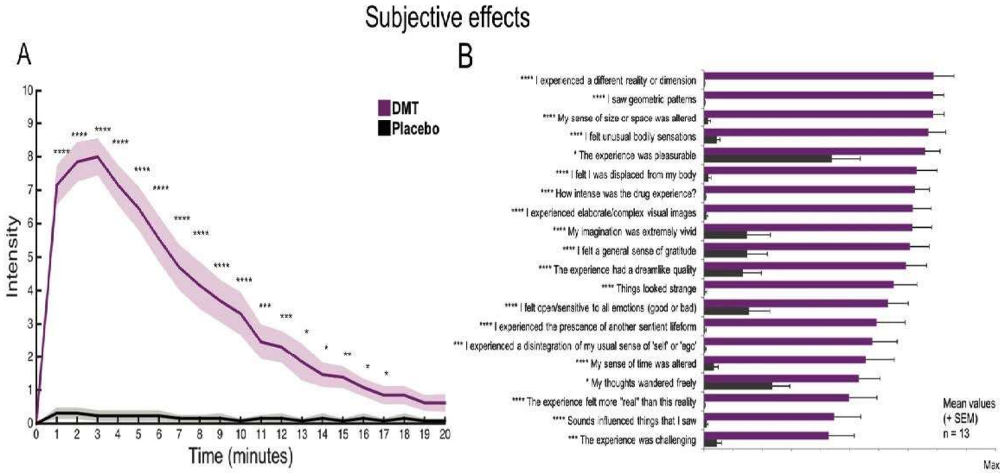
Vol. 49 No. 2 March 2025, pp. 532-545

8. APPENDIX

8.1 Appendix A : Structured graph showing the intensity of the experience changes over 20 minutes after DMT injection.

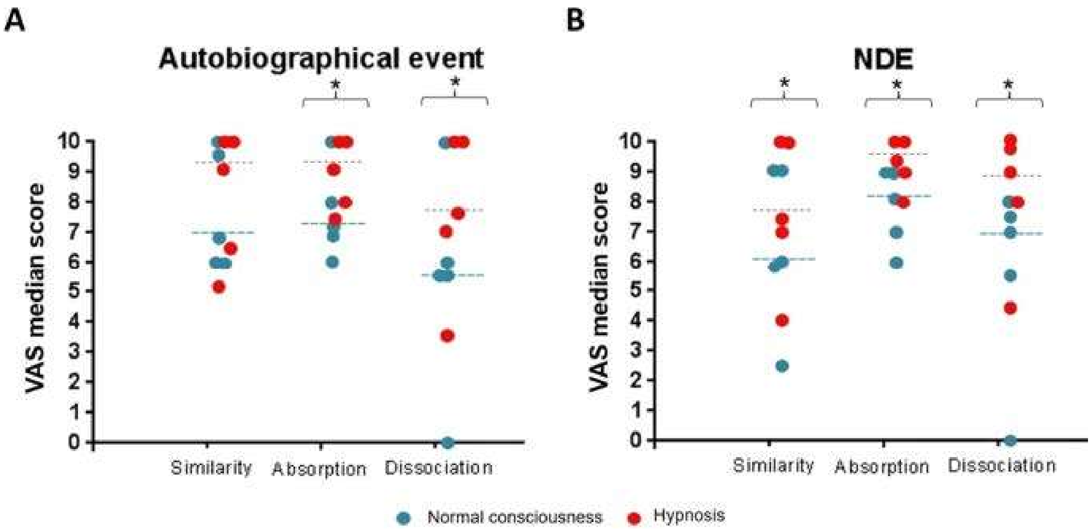
Figure 1:



Description: The graph in Figure 1 shows how the intensity of the experience changes over 20 minutes after DMT injection.

8.2 Appendix B: Visual Analogic Scales (VAS) scores of participants.

Figure 2: Graph showing participants' Visual Analogic Scales (VAS) scores.



Description: Shows the participants' Visual Analogic Scales (VAS) scores (and median, dashed lines) relating to level of similarity, absorption, and dissociation in usual state of awareness (blue) and hypnotic state (red)

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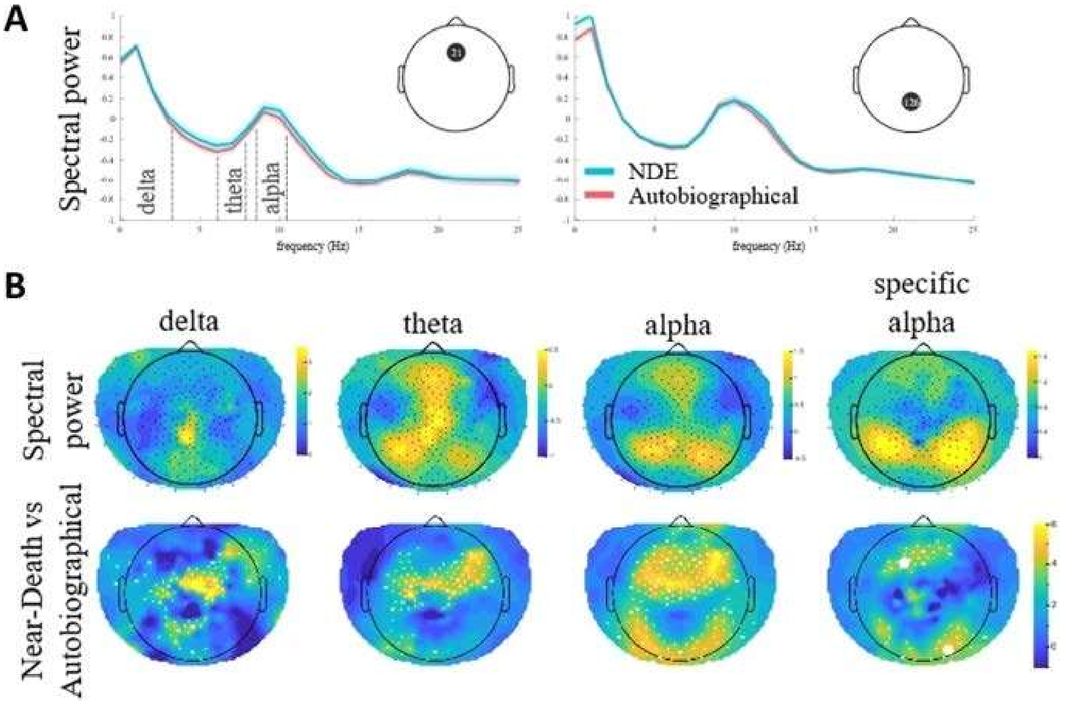
8.3 Appendix C: Neural Oscillations in Near-Death and Autobiographical Memories.

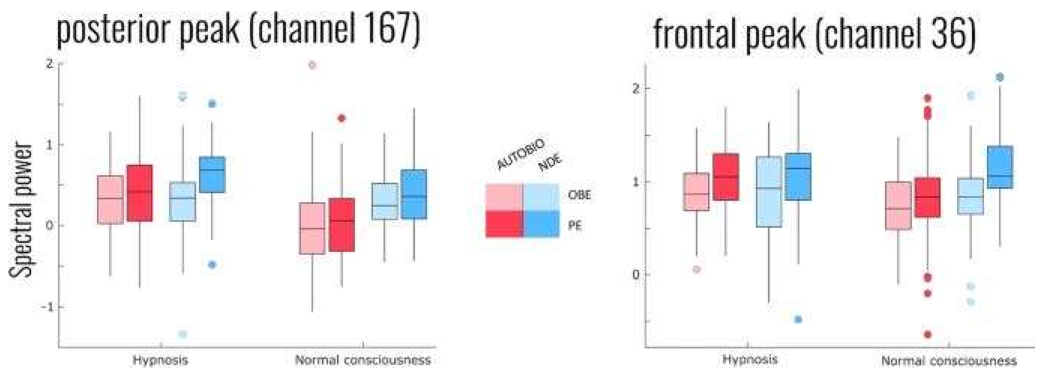
Figure 3: Spectral power differences reveal distinct neural activity in near-death and autobiographical memories.



Description: (A) The figure shows the power at a central frontal channel (left) and a central posterior channel (right), across all frequencies between 0 and 25 Hz. There are clear peaks at both channels at the low, delta frequencies, and around the alpha frequency which are then further examined. (B) The top panel shows the spectral power across all channels at selected frequency bands: delta (0.5–3.5 Hz), theta (7–8 Hz) and alpha (10–11 Hz) and “specific” alpha (alpha - theta band).

8.4 Appendix D: Spectral Power Shifts in Hypnosis vs. Consciousness.

Figure 4: Frontal and posterior spectral peaks vary across states of conciousness and hypnosis.



Description: Shows spectral power of alpha activity for two selected channels with peak significant differences between near-death experience (NDE) and recollection of another autobiographical event (AUTOBIO) which is mentioned in the bottom of fig 4. The left graph also shows the right-of-midline posterior channel also split by hypnosis (HY) and state of usual awareness as well as recall of out-of-body experience (OBE)/kinaesthetic sensation (KS)which is marked in light colour or peacefulness (PE) marked with darker colour.

9. DISCLOSURE

Acknowledgment

We thank the authors for their contribution to this project.

Ethical approval

Ethical approval was not required for this study

Declaration of patient consent

Patient's consent was not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.