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Review Article

Mysterious "Wave of Death" Could Mark Critical Divide Between Life and Death

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Abstract: Despite modern advances in medical science, the critical divide between life and death remains a mystery. The ability to more accurately determine when death occurs would be of enormous clinical and practical benefit in the care of dying patients. In both animals and humans, a peculiar spike of highly coherent electroencephalographic (EEG) activity during the dying process has been observed by several research groups. Some researchers believe that this spike of activity could be the brain's last burst of normal signaling prior to death and may also provide a neuropsychological explanation for the puzzling phenomenon of near-death experiences (NDEs). This analysis offers an entirely new perspective on end-of-life electrical surges. Based on available clinical and electrophysiological evidence, it contends that the so-called "wave of death" is not initiated by the brain but rather *mediated* by the brain as the departing soul leaves the body at the time of death. Hypothetically, the head of the soul (the mind), upon separating from the dying brain, experiences a burst of enhanced awareness, and the associated magnetic fields drive a corresponding burst of neurological activity until the soul passes outside the physical proximity in which its electromagnetic activity can induce neuronal signals. To my knowledge, this is the first anatomically, psychophysiologically, and electrophysiologically-based explanation that links end-of-life EEG activity to NDEs without discounting the seeming extracorporeal nature of those experiences. If this hypothesis is correct, then end-of-life electrical surges could be highly precise objective markers of the transition from life to death. Beyond the benefits that this would offer to dying patients and their caregivers, it would offer a new form of scientific validation for near-death and end-of-life experiences, which have increasingly become a source of inspiration, wisdom, and hope for the dying, their loved ones, and people all over the world.

Keywords: End-of-Life Electrical Surges, Wave of Death, Determination of Death, Science of Near-Death Experiences, Psychophysiology of NDEs, Mind-Brain Duality, Dying Brain, Life After Life

1. Introduction

Though death in a seriously ill or injured patient may sometimes be inevitable, there are important spiritual, religious, and existential questions that arise when a loved one is in a deeply unconscious state with diminishing hopes of recovery. There may also be disagreement, even among members of the healthcare team, about whether a dying patient on life support has any hope of survival or, in some cases, whether the patient is already dead.

From a medical standpoint, there is still no clear definition of when a person actually dies. The currently accepted definition, which defines death as a lack of responsiveness to nociceptive stimuli, a loss of brainstem reflexes, and a flattening of the electroencephalogram (EEG), is incompatible with the observation that these same biomarkers are intentionally (and reversibly) induced during general anesthesia [1]. Thus, these indicators are not adequately specific to make a reliable determination of death, nor are they able to define the exact moment of death.

In recent years, a flood of new questions about the mysterious divide between life and death has been raised by the growing number of so-called "near-death experiences" (NDEs), in which persons who appear to have died clinically unexpectedly regain consciousness and, in many cases, make a full recovery. In the largest study of its kind, Parnia et al. [2] reviewed the outcomes of more than 2,000 patients who had undergone emergency resuscitation following cardiac arrest. The study, which involved fifteen medical centers in the United States, Europe, and Australia, found that among 330 survivors, 55 recalled having had some form of conscious awareness during the time that they were clinically dead, and nine of these patients had NDEs. Among these, two recalled having been aware of the events that took place in the resuscitation area, one of whom provided information that was later corroborated by hospital staff that were present at the time. The dramatic and unexpected recoveries that many of these patients make, and the consistency of the experiences that they describe irrespective of their cultural or religious background have launched a whole new field of inquiry that has been championed by the International Association for Near-Death Studies (IANDS). Today, IANDS conferences and meetings are being held at medical centers all over the world, and a growing number of scholarly articles, books, and research findings related to NDEs are being published by a growing number of physicians, scientists, and allied health professionals [3-7]. These findings have divided the scientific community into two camps: those who believe that NDEs are mediated by disrupted neural signaling in the dying brain, and those who believe that NDEs may be evidence that life can continue independent of the brain and body.

This analysis will consider both sides of the debate and discuss the significance of an electrophysiological phenomenon that could mark the critical divide between life and death. A better understanding of the dying process and, correspondingly, a more reliable definition of death could, on the one hand, help avoid a premature pronouncement of death and, on the other hand, avoid an unnecessary prolongation of a process that is both labor-intensive and highly stressful for everyone involved.

2. The “Wave of Death”

A series of recent studies appears to have provided a clue to when a person dies. In both animals and humans, a brief spike in neurological activity has been identified after a near-complete cessation of brainwave activity during the transition from life to death [8-11]. Specifically, the EEG nearly flatlines, then spikes for a brief period (ranging from about 30 seconds to 30 minutes), before giving way to a multi-focal spreading wave of depolarization that initiates a plethora of toxic changes that end in irreversible brain injury [10, 12].

In animals, total ischemia causes the EEG to flatline in just 20-30 seconds [12, 13]. This cerebral silencing, which involves a hyperpolarization of neurons, is known as "non-spreading depression” [12]. During this phase of the response to hypoxia, there is still enough adenosine triphosphate (ATP) to maintain the ionic gradients that allow synchronized neuronal messaging to occur [12]. That raises the question of why the EEG flattens at this time. It has been hypothesized that the shutdown in neural signaling is a systems effort to conserve energy before the ATP pool is depleted [12]. However, a physiological mechanism for such a conservation process is lacking, and a similar flattening of the EEG has, in some cases, been observed in advance of cardiovascular arrest [14]. This raises the possibility that brainwave activity could be driven by something more than just pacemaker cells and weighted synaptic inputs. It reinvokes the long-held idea that there is a life-force or “soul” that animates the body and that when this spiritual element leaves the body, the various systems of the body begin to shut down. Chief among these systems would be the brain as the head of the soul (the mind) [15], along with the rest of the spiritual body, separates from the physical body.

3. A Duality of Mind and Brain

It has long-been thought that the mind and the brain are distinctly different entities. One of history's strongest proponents of the mind-brain duality was the pioneer in mathematics, science, and metaphysics René Descartes. Descartes believed not only that the mind was substantively different than the brain but also that it could function independent of the brain [16]. However, his treatise on dualism was hampered by the mind-body problem: how could the mind and the brain communicate if their natures were different? A possible answer to that historic question is offered by modern advances in chemistry, biology, and physics.

It is self-evident that the mind exerts effort. It takes mental effort to concentrate; it takes mental effort to push one’s self physically; and it takes mental effort to grapple with intrapsychic conflict. Effort involves energy, and energy induces magnetic fields. At the same time, neurological processes induce magnetic fields as neurons depolarize and repolarize. Hence, the mind and the brain are naturally poised to communicate in the same language; namely, electromagnetic energy. In accordance with Faraday’s law [17], mentally-induced magnetic fields could stimulate the production of action potentials [18], and action potentials could induce the production of magnetic fields [19].

That this two-way dialogue between the mind and the brain actually occurs has now been demonstrated experimentally. Recording from single neurons in patients implanted with intracranial electrodes for clinical reasons, Cerf et al. [20] found that willful thoughts and intentions readily stimulated specific neurons when subjects were asked to perform specific mental tasks. Conversely, Penfield [21], in his seminal work on brain mapping, found that stimulating different parts of the human brain with an electrical probe triggered different thoughts and emotions. The idea that the mind is an independent, self-governing entity that works closely with the brain could help explain many phenomena in psychology and psychiatry, including selective attention, learning and memory, creative thought, self-discipline, stress-induced kindling, mental illness [15], dream sleep [22-24], and the onset of coma ahead of any significant depletion of ATP reserves or loss of ionic gradients.

Yet the most compelling evidence that the mind is an entity distinct from the brain is the growing number of NDEs, in which persons who have been on the brink of death due to a severe illness or injury claim to have separated from their bodies and had vivid experiences while clinically dead [5, 6]. Beyond the fact that these experiences, by definition, occur when the patient is judged to be either dead or very nearly dead, the profound nature of them, the consistency of the descriptions across diverse ethnic and religious groups, and the fact that some of them include verifiable information, is compelling evidence that they are something other than products of neurological function.

From the perspective of a mind-brain duality of the cognitive-emotional system, any disruption of neurological function, such as that caused by diminished blood flow or traumatic injury to the brain, would be expected to disrupt communications between the mind and the brain. As a result, both the mind and the brain would be expected to become increasingly quiescent. This idea is supported by the observation that the EEG slowing that is observed in the comatose state is virtually indistinguishable from the slowing that is observed during deep sleep [1]. If, beyond that point, there were enough will to live and enough return of neurological function to support the re-establishment of a normal dialogue between the mind and the brain, the person would be expected to regain consciousness. If not, the person would be expected to either remain comatose or begin to separate from the brain and body.

Evidence of this comes from the unexpected association between the EEG tracing in the initial hours post-cardiac arrest and the prognosis for survival in resuscitated patients. Lemmi et al. [25] found that regardless of the health of the brain either preceding or following cardiac arrest, the preservation of consciousness (or rapid regaining of it) was a strong predictor of survival, whereas those patients who were unconscious from the onset of cardiac arrest and remained unconscious until the time of their first EEG several hours later never left the hospital. Those patients who expressed an alpha rhythm intermixed with diffuse slowing were found to have intermediate chances of survival. These findings were corroborated by Westhall [26], who has studied the prognostic value of temporally-correlated EEG readings more extensively.

What may lead to a pathological loss of consciousness is a failure of thalamo-cortical function, as thalamo-cortico-thalamic circuit loops are thought to be the primary mediators of the dialogue between the mind and the brain [27]. What would distinguish this form of sleep, known clinically as "coma," from normal sleep is that it would be initiated and perpetuated by a disruption of normal brain function; hence the lack of sleep-wake cycles, dream sleep, or responsiveness to pain in comatose patients. From a mind-brain perspective, the greater the disruption of neurological function and the longer it persists, the smaller the chances that the brain will ever again be able to signal the mind to reawaken as it normally would from sleep. The mere fact that the mind-brain dialogue is being pathologically disrupted would increase the risk that the mind would separate from the brain. This idea is supported by the fact that nearly half of all anesthesia-related deaths occur at therapeutic anesthetic doses [28]. It is also supported by the observation that those patients in the Lemmi study who remained conscious (or only briefly lost consciousness) during their cardiac arrest had a better prognosis than those patients who lost consciousness and subsequently remained unconscious after being resuscitated.

Another important factor would be the attitude of the patient. It has been said that the spiritual body, of which the mind is the head [15] (Figure 1), leaves the physical body when it becomes convinced that there is no longer any hope of survival or, in some cases, when it refuses to go on living. This is something that all human beings seem to know intuitively. For example, if a person were to suddenly lose consciousness due to an acute illness or severe injury, most bystanders would instinctively try to rouse the person back to consciousness. This is not always in vain, as there have been many instances in which such efforts were successful and may have even saved the person's life. From the perspective of a mind-brain duality of the cognitive-emotional system, such interventions as saying the person's name, touching the person's face, and holding the person's hand, send messages to the mind via the somatosensory system [15]. In so-doing, they provide the neurological input that can help reestablish a normal dialogue between the mind and the brain. In the absence of such efforts, the unconscious person might begin to separate from the physical body, awaken to life outside the body (as presumably occurs during an NDE), and, due to a loss of engagement with others or interest in returning to the body, decide to leave the body permanently. Even in the absence of a life-threatening illness or injury, an intense desire to leave the world or flee from a dangerous situation could be enough to cause the mind to dissociate from the brain, thus explaining why dissociative episodes are most commonly precipitated by a highly traumatic or life-threatening event [29]. In rare instances, a person's fear could be so intense that it would hypothetically drive an immediate and permanent separation between the mind and the body; hence the expression "scared to death."

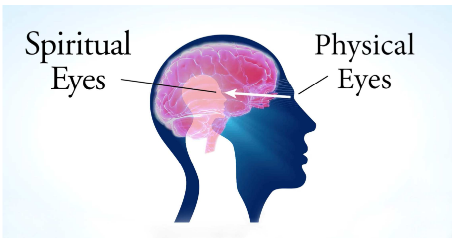

Figure 1. *Schematic illustration of the spiritual body within the physical body. In this example, light is being converted into a neurological signal and transferred from the physical eyes to the spiritual eyes at the mind-brain interface, which is hypothesized to lie deep within the brain [15].*

Another observation that could reflect the importance of attitude in the recovery of consciousness is the speed of return of EEG power during surgically-induced cardiac arrest compared to spontaneous cardiac arrest. When a bolus of short-acting adenosine is used to temporarily stop the heart in patients undergoing thoracic aorta endovascular repair, EEG power is reduced to 57% but returns to normal within 5 minutes of cardiac arrest [30]. This is in contrast to patients who, after unexpectedly experiencing cardiac arrest, typically fail to make such a speedy recovery even if, once resuscitated, their brains are just as adequately reoxygenated and with no greater delay than those who undergo elective endovascular repairs. Of course, it could be argued that such patients are more severely ill than their surgical counterparts. However, in most cases, their illnesses involve the heart, not the brain. Hence, the observed difference in neurological response would be difficult to explain on a purely physiological basis. A more plausible explanation would be that the two groups differ in their degree of hope. In general, one would expect the patient who is undergoing an elective surgical repair in anticipation of making a full recovery to be more hopeful than the patient who is unexpectedly experiencing a life-threatening cardiac arrest. Hope causes one to embrace life and, thus, cling more tightly to the body than a lack thereof. The same reasoning could be applied to patients who are less seriously ill and in coma compared to those who are more seriously ill and in coma; those who are less seriously ill would be expected to be more hopeful and, thus, more likely to reawaken from coma than those who are more seriously ill.

4. Animal Studies

Both a duality of mind and brain and the importance of hope also appear to be supported by animal studies. In an effort to determine whether decapitation is a humane method of euthanasia in awake laboratory animals, van Rijn et al. [8] monitored the EEGs of seven rats before and after decapitation via guillotine. When rats who were fully conscious were decapitated, EEG power in the 13-100 Hz range fell to one-half after just 4 seconds, indicating that, at that point, the animals were too deeply unconscious to perceive pain or other stimuli (Figure 2, graph a). The EEG proceeded to flatline after another 11 seconds. This is hardly enough time for hypoxia to have had such a profound effect on brain function since there would still have been enough ATP to maintain the ionic gradients that are necessary for the production of action potentials and related cellular processes [31]. A more plausible explanation is that once decapitated, the rats lost conscious awareness for a brief time, and then, as they began to separate from their dying bodies, regained consciousness—not corporeal consciousness but incorporeal consciousness; that is, consciousness apart from the brain or body. That the rats had regained awareness though seemingly unconscious is suggested by the surge of synchronized EEG activity that was consistently observed approximately 50 seconds post-decapitation (Figure 2, graph a). Of course, one could argue that this electrical activity could have been purely physiological, but that would fail to explain the high coherence of the activity, which was consistent with normal conscious processing. It would also fail to recognize the significance of the similarity in both the timing and the duration of the same phenomenon that in humans has been linked to vivid conscious experiences; that is, NDEs. Hence, the electrical surge in these animals more likely reflects a reawakening of the mind as it begins to separate from the dying brain. Based on Coulomb's law, which states that the intensity of a magnetic field is inversely proportional to the distance from its source, the mind of a dying rat could, at least for a brief time, remain in close enough proximity to the brain to influence it before passing away from it. Interestingly, a comparable group of rats that had been anesthetized prior to decapitation showed the same decline in EEG power; however, the death wave was significantly delayed, beginning approximately 80 seconds post-decapitation as compared to just 50 seconds post-decapitation in the conscious rats (Figure 2, graph b). The additional 30-second delay in the anesthetized rats could reflect the temporary interference that anesthesia would have had in their ability to recognize that something catastrophic had happened to them, something that was clearly incompatible with life. Hence the delay in their willingness to surrender their lives and separate from their bodies.

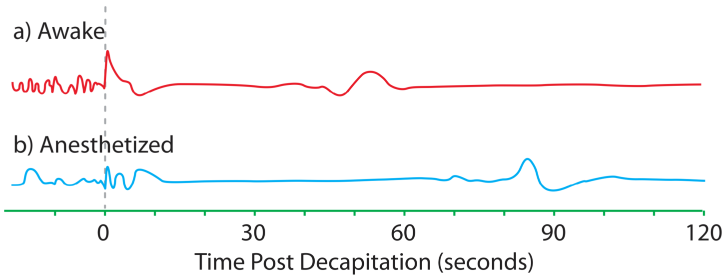

Figure 2. *Electroencephalograms of (a) waking rats pre and post-decapitation; (b) anesthetized rats pre and post-decapitation. Adapted from van Rijn CM, et al. Decapitation in rats: Latency to unconsciousness and the 'wave of death' [8].*

In a similar study, Borjigin et al. [9] performed continuous EEG monitoring in two groups of rats, one undergoing experimentally-induced cardiac arrest in a waking state, and the other, in an anesthetized state. As in the van Rijn study, the investigators identified a transient surge of EEG activity just prior to death. More specifically, these were global, highly coherent, synchronous gamma oscillations that exhibited tight phase-coupling to both theta and alpha-band frequencies in conjunction with an eightfold increase in anterior–posterior-directed connectivity (normally associated with conscious processing) and a fivefold increase in bottom-up information flow (normally associated with sensory processing) [9, 32]. This high-frequency neurological activity exceeded the levels found during the conscious waking state, demonstrating to the authors that the brain can generate neural correlates of consciousness (and even heightened awareness) during the transition from life to death. The so-called "wave of death" was also observed when carbon dioxide inhalation was used as an alternative form of death, thus demonstrating that the surge of brainwave activity was not uniquely related to the specific cause of death [9]. However, in these experiments, no group differences were observed in the timing of the wave of death. This is not surprising because cardiac arrest, which in animals would presumably cause a loss of consciousness before there were any clear recognition of trauma or disability, would not be as indicative of impending death as decapitation.

5. Human Studies

In an effort to monitor changes in the level of consciousness during the dying process in humans, Chawla and Seneff [10] used an integer-based system to precisely track blood pressure in relation to level of alertness, the latter being measured by muscle and frontal activity, in a series of seven patients who were neurologically intact before a decision was made, based on severity of illness, to withdraw life support. In each case, a loss of blood pressure (as measured by an indwelling arterial line) was followed by the expected loss of muscle tone and EEG activity. However, this was followed by a transient surge in EEG activity that, as observed in the rodent studies, approached levels normally associated with conscious awareness. In each case, the spike was of short duration (30-180 seconds) and was followed by a decline in activity to a level associated with burst suppression. The investigators were able to confirm that this activity was not due to artifact and that, on the contrary, it was a high-frequency wave form that could realistically explain the vivid, highly-coherent mental experiences reported by NDErs. The authors reported that they had observed these EEG spikes, which were generally of higher frequency than those observed in animals, in more than 20 other patients immediately prior to the pronouncement of death. They also pointed out, however, that they had observed these spikes in only about half of the patients who had expired in the intensive care unit [10]. This last observation would be difficult to explain if the wave of death were merely a normal correlate of neurological deterioration.

In another report, Auyong et al. [11] had been using the same integer-based system to monitor cognitive function during the process of organ donation after cardiac death in a patient who was irreversibly brain-damaged but not technically brain-dead. On physical examination, the patient exhibited flaccid paralysis and was unresponsive to stimuli. The patient's bispectral index (BIS) scores ranged from 1 to 20 until a few minutes after life support was discontinued, at which point the BIS (in the absence of any electromyographic interference on the monitor) rapidly rose to 92 (Figure 3, time-point 3). The BIS values continued to range between 85 and 95 for approximately 23 minutes, and then abruptly fell to less than 4. This apparent movement to a lighter plane of anesthesia would be difficult to explain on a purely physiological basis not only because the patient was irreversibly brain-damaged but also because the collapse of cerebral circulation following the discontinuation of life support would have further impaired brain function. Yet the brain expressed a burst of synchronized, coherent, bi-frontal oscillations, signals that are the electrophysiological correlate of normal conscious processing. The same phenomenon, which had a duration of 3-4 minutes, was observed in two other patients, both of whom were free of hypnotic or anesthetic drugs and in which cases there were no significant changes in monitoring artifact.

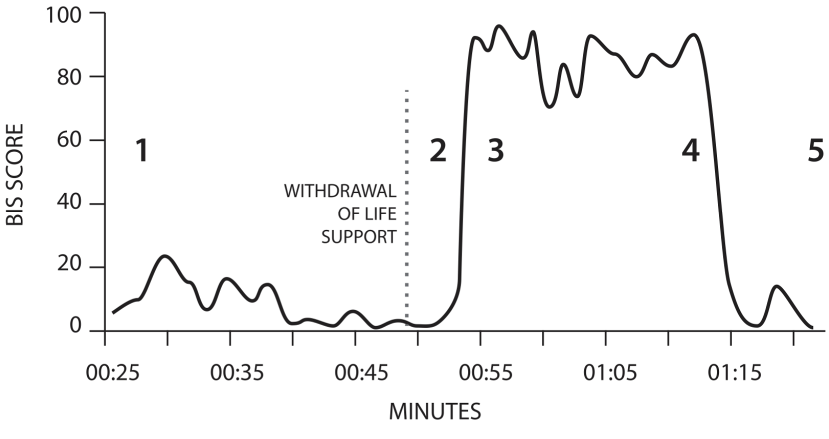

__Figure 3.__ Conceptual reconstruction of real-time EEG data from an irreversibly brain-damaged (but not brain-dead) comatose patient pre and post-removal of life support in preparation for organ donation surgery. Prior to the removal of life support, BIS scores ranged between 1 and 20 (time-points 1-2 on the graph). Within 5 minutes of withdrawing life support, the BIS value abruptly rose from 1 to 92 (time-point 3) without evidence of EMG interference on the BIS monitor. Heart rate and oxygen saturation remained high for the first 8 minutes after withdrawal of support. 25 minutes after withdrawal of support, the BIS value abruptly fell to less than 4 (time-point 4) and, simultaneously, heart rate decreased from 108 bpm to 0, and blood pressure dropped from greater than 100 mm Hg to less than 40 mm Hg. The patient was pronounced dead 32 minutes after the withdrawal of support (time-point 5). Adapted from Auyong DB, et al. Processed Electroencephalogram During Donation After Cardiac Death [11].

What may have happened in these cases is that the mind regained consciousness—not corporeal consciousness but incorporeal consciousness—either by spontaneously disengaging from the malfunctioning brain or by being drawn away from it by some outside influence. Hypothetically, the mind is magnetically attracted to the brain (and by extension, the rest of the body) by a combination of three factors: 1) sensory input via the brain; 2) motor function via the brain; and 3) the experience of pleasure via the brain. As these modes of attraction diminish in magnitude, the magnetic attraction between the mind and the brain would likewise diminish, thus increasing the chances that the mind would disengage from the brain. As the mind disengaged from the brain, the spiritual body would separate from the physical body and experience life divested of the physical body. This newfound freedom from the limitations of the body could explain why NDErs universally describe a heightened sense of awareness and marked enhancement of sensory perception during the NDE.

In the Auyong study, a loss of sensory input from the malfunctioning brain would have caused a loss of corporeal consciousness, and a return of sensory input, which would more aptly be called extrasensory input, as the mind disengaged from the brain would have caused a return of consciousness—not corporeal consciousness but incorporeal consciousness. Likewise, divested of the physical body's sensory limitations, this return of consciousness would have been experienced as a burst of awareness. During the disengagement process the mind, as previously discussed, would presumably have been able to influence the brain until the associated magnetic fields had, along with the mind, passed outside the sphere of influence in accordance with Coulomb's law.

6. Direct Effect vs. Indirect Effect

The foregoing analysis raises the question of whether the wave of death is driven entirely by the mind's effect on the brain, or whether some component of the wave is driven by a direct effect of mental activity on the EEG electrodes. What makes this question challenging is that mental activity and neurological activity are hypothetically occurring simultaneously during the wave of death. There are, however, a few observations that suggest that the wave is powered exclusively via mental stimulation of the brain. First, it is self-evident that neurological activity is more powerful than mental activity. For example, everything that one thinks, sees, and hears is much "louder" than what one perceives intuitively. Intuition is thought to be unconscious; hence, it is believed to involve purely mental processes [33]. This implies that neurological activity is more robust than mental activity, thus making neurological activity the more likely driver of end-of-life electrical surges. Second, the electrodes that were used to monitor the brainwave activity in both the animal and human studies were affixed to the scalp. Consequently, they are presumed to be recording the activity of cortical neurons [34]. The similarity of the end-of-life electrical surges to normal scalp EEG recordings strongly suggests that they too were driven by the activity of cortical neurons. Third, common psychiatric disorders, such as clinical depression, bipolar disorder, and panic disorder, which are thought to be the consequence of neuronal hyperexcitability [35], tend to overpower the mind. This again suggests that neurologically-induced magnetic fields are stronger than mentally-induced magnetic fields. Fourth, all of the laboratory animals that were monitored in the aforementioned studies displayed end-of-life electrical surges, whereas only about half of the humans did [10]. However, unlike the humans, all of the laboratory animals were healthy prior to expiring, thus increasing the likelihood that their brains would have been responsive to their minds during the dying process. This again suggests that the electrical surges that were observed in all of these studies were driven primarily, if not entirely, by the mind vis-à-vis the brain rather than by the mind directly.

7. Discussion

The observance of unexpected end-of-life electrical surges in both animals and humans offers new insights into the mysterious divide between life and death. It suggests the possibility that life ends when the mind, together with the rest of the spiritual body, separates from the physical body. Such an idea is certainly not new, as it reiterates a philosophical and religious belief that has been held for thousands of years. It also adds to the already heated debate about how to interpret NDEs. Some clinicians and researchers argue that NDEs can be explained by the wave of death. Others say that NDEs are not necessarily related to this activity, pointing out that some NDErs have had verifiable out-of-body experiences that were not necessarily linked to a specific time period post-cardiac arrest [7].

This analysis mitigates both sides of the argument with a new synthesis. It posits that the mind is an entity distinct from the brain yet partially dependent on it until it disengages from the brain at the time of death. This view allows for an anatomically and psychophysiologically-specific understanding of the seemingly conflictual data on end-of-life EEG activity. From the perspective of a mind-brain duality of the cognitive-emotional system, the mind drives neurological activity, and neurological activity drives mental activity. When this dialogue is interrupted, either by a willful decision of the individual, as in normal sleep, or by a failure of the brain to properly interact with the mind, as in various disease states, such as seizure disorders, chemical intoxication, injury, or end-stage neurodegeneration, the mind falls asleep. Given that seizure activity induces abnormally strong magnetic fields, whereas other forms of dysfunction generally have the opposite effect, it is conceivable that the mind, like the photoreceptors in the eye, is insensitive to electromagnetic activity that is either above or below a certain threshold. The loss of intelligible stimulation that would occur either above or below that threshold could conceivably explain the loss of consciousness or "sleep" that occurs under these divergent conditions.

In NDEs the mind seemingly awakens from this sleep. This is suggested by the close temporal relationship between the NDE, which by definition begins during the transition from life to death, and the spike in synchronized brainwave activity that suddenly arises out of a flat EEG at around the same time. Yet despite this mental awakening, the body remains clinically dead. This, taken together with reports that suggest that the duration of verifiable NDEs sometimes exceeds the duration of end-of-life electrical surges [7], implies that the mind must be separating from the brain and physically moving away from it during an NDE. This idea is corroborated by the accounts of nearly all NDErs, who say that they perceived themselves moving away from their bodies and viewing themselves from a distance, such as from the ceiling or a corner of the room. It is also corroborated by a description that is almost universal among NDERs; namely, that they felt detached from their bodies and a lightness of being that was unlike anything they had ever before experienced. Also common among NDErs is the perception of a heightened awareness, enhanced intuition, and an expansion of the senses despite the fact that their brainwave activity was markedly diminished or even flatline leading up to and likely including much of the NDE. Many of these reports have been corroborated by factual information that the NDErs could not possibly have acquired through their physical senses [3-6]. They have also been corroborated by the temporary acquisition of abilities that they did not have either before or after the NDE, such as blind persons being able to see and deaf persons being able to hear (Vicki Noratuk NDE https://youtu.be/7JkHJaMbbiw., accessed 4/12/19, Kevin Williams NDE http://www.near-death.com/science/evidence/people-born-blind-can-see-during-nde.html., accessed 5/16/18). The only conceivable explanation for these phenomena is that the perceptual element of a human being, which is presumably a component of the spiritual body [15], temporarily separates from the physical body and experiences a glimpse of life outside the confines of the physical body. Hypothetically, the mental and emotional activity that is associated with this experience could, if the mind were still in close enough proximity to the brain, drive a resurgence of brainwave activity just as the mind does when it reawakens from natural sleep. Although most NDErs say that they perceived themselves moving away from their bodies during the NDE, the initial phase of the experience, especially if it were unusually intense and emotionally charged, could still position the mind in close enough proximity to the brain to allow its activity to influence neurological activity [15]. This would also be consistent with the observation that the spike in brainwave activity that has been observed immediately antecedent to death is highly synchronized but brief. Note, however, that this phenomenon, if short enough in duration, would not necessarily prevent the mind from returning to the body and regaining corporeal consciousness.

Based on this analysis, one could indeed say that NDEs are related to the surge of EEG activity that has been observed around the time of death. However, I argue that it is not the surge that drives the NDE but the NDE that drives the surge. What may be happening is that the liberated mind is reawakening to life outside the physical body and driving a surge of neurological activity until it moves a critical distance away from the brain. The validity of this hypothesis is further supported by the observation that, as would be expected by the exhilaration of the experience, the surge of EEG activity that occurs around the time of death often exceeds that of normal corporal consciousness. That the mind can power the brain while simultaneously passing away from it is corroborated by the sudden demonstration of inexplicable cognitive abilities as a person transitions from this life to the afterlife, such as the ability of obtunded patients to suddenly become lucid and begin to recollect fine details of past experiences, or the ability of demented patients to suddenly begin to recognize loved ones in the room [5, 6].

Although deathbed observations corroborate the idea that end-of-life electrical surges are driven by the independent function of the mind as it begins to separate from the brain, most resuscitated patients do not recall having had an NDE. The most likely explanation for this is that their minds did not detach from their brains enough to awaken to the afterlife and have an NDE. In contrast, every laboratory rat that died in the Rijn [8] and Borjigin [9] studies would have left their physical bodies, thus explaining why every one of them expressed a death wave. These observations suggest that perhaps death should be redefined as a separation of the mind or, more accurately, the spiritual body or “soul” from the physical body.

Curiously, however, not every patient who dies expresses an identifiable wave of EEG activity immediately antecedent to the time that they are pronounced dead. According to Chawla and Seneff [10], about half of the patients who had EEG monitoring as they expired in the intensive care unit failed to display an end-of-life electrical surge. One possible explanation is that such patients could have left their bodies just prior to, or in the process of, lapsing into a coma and before any EEG monitoring had begun. Another possibility is that the same neurological abnormalities that had led to a comatose state could have prevented the mind from effectively reactivating the brain when it began to separate from it. The same would apply to patients who experienced a further deterioration of brain function after lapsing into a coma. Yet another possibility is that some patients, having been pronounced clinically dead, had their EEG monitoring equipment removed before their souls actually left their bodies. What adds weight to this last possibility is that most patients who regain consciousness after being pronounced clinically dead do not report having had an NDE. These patients presumably remained asleep (and in their physical bodies) until the moment that they regained consciousness; hence the lack of an NDE.

This theoretical formulation raises important questions about the criteria that are used to make a determination of death. While death has traditionally been thought of as a global shut-down of biological processes, the indicators that are used to make a determination of death are the same as those that are used to ensure that a patient under general anesthesia is adequately anesthetized. Clinical and electrophysiological indicators such as a loss of responsiveness to nociceptive stimuli, a loss of brainstem reflexes, and a pronounced slowing of the EEG occur in both the anesthetized and near-death states [1]. This again suggests that the transition from life to death involves something more than just a shut-down of bodily functions. That something is also reversible, an observation that, together with the other observations that have been discussed, points to the idea that death involves a separation of the energetic essence of a human being from the physical essence—the soul from the body.

8. Conclusion

The growing number of NDEs that are being reported around the world together with the discovery of brief but highly coherent EEG activity arising out of a flatline EEG around the time of clinical death raises important questions about the relationship between the mind and brain. Contrary to the widely-held scientific belief that the mind is purely a manifestation of complex brain function, it corroborates the long-held philosophical and religious belief that the mind is an entity distinct from the brain and that, from an anatomical perspective, death is the moment at which the spiritual essence of a person separates from the physical essence. What the clinical and electrophysiological evidence suggests is that the mind, while asleep in the corporeal state, begins to separate from the brain and, in the process, suddenly awakens and drives a surge of neurological activity that corresponds to what it sees, thinks, and feels until it passes outside the physical proximity in which its cognitive-emotional processes are able to induce the corresponding electrical activity in the brain. To my knowledge, this is the first anatomically, psychophysiologically, and electrophysiologically-based explanation that links end-of-life EEG activity to near-death experiences without discounting the perceived extracorporeal nature of those experiences. What is perhaps most reassuring is that any patient who meets established criteria for clinical death is either deeply asleep within the body or has passed away from the body, both of which minimize the chances of experiencing any physical pain or discomfort. Notwithstanding, the growing number of patients who, thanks in-part to modern advances in life support, are returning from the other side argues strongly for the need to delay a determination of death for at least twenty minutes beyond the time that the patient meets clinical criteria for death. This would allow for the possibility that, until the time that the anoxic damage to the brain has become irreversible, the person who has left the body could still return to it and regain corporeal consciousness.

Conflicts of Interest

The author declares that he has no competing interests.

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