

Near-Death Experience: Out-of-Body and Out-of-Brain?

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During the last decades, several clinical cases have been reported where patients described profound subjective experiences when near-death, a phenomenon called “near-death experience” (NDE). Recurring features in the accounts involving bright lights and tunnels have sometimes been interpreted as evidence of a new life after death; however the origin of such experiences is largely unknown, and both biological and psychological interpretations have been suggested. The study of NDEs represents one of the most important topics of cognitive neuroscience. In the present paper the current state of knowledge has been reviewed, with particular regard to the main features of NDE, scientific explanations and the theoretical debate surrounding this phenomenon.

Keywords: near-death experience, death studies, body-mind problem, psychology and religion, consciousness

“I’m not afraid of death. It’s just that I don’t want to be there when it happens”

—Woody Allen

Definition and Incidence of Near-Death Experiences

The question of whether there is any life after death represents one of the most important philosophical topics. The dying process and the subjective experience of dying is a question of which very little is currently known. Indeed scientific investigation seems to have neglected this important theoretical area for a long time and considered it an entirely theological question. Nonetheless, the comprehension of the mechanisms underlying the end of life may enhance our knowledge of consciousness and its relation to brain functions as well. Furthermore, a scientific approach may permit us to understand whether some surprising mental phenomena may be at least partially explained by physiological aspects.

Recent studies in cardiac arrest patients have begun to shed some light on human experience near death. Cardiac arrest probably represents the most appropriate condition in which to study the dying process since, regardless of its cause, it seems to represent the final stage before death. During a cardiac arrest, the clinical criteria of death are always reached for a variable length of time from a few seconds to even 10 minutes or more (van Lommel, van Wees, Meyers, & Elfferich, 2001). The result of a cardiac arrest is essentially a sudden circulatory arrest, with blood flow and oxygen uptake in the brain plunging swiftly to near-zero levels, and electroencephalogram (EEG) signs of cerebral ischemia. In short, full arrest leads rapidly to the major clinical signs of death, making cardiac arrest patients one of the best models to study the mental processes associated with death.

In 1975 Raymond Moody published a book where the experiences of more than 100 people who had been close to death have

been reported (Moody, 1975). Recurring features in their accounts included seeing a tunnel, a bright light, deceased relatives, a mystical being, entering a new domain, reaching a point of no return, a review of their lives as well as “out-of-body experiences” in which people described a feeling of separation from their bodies and the capacity to watch themselves from a point above (see Table 1 for a list of elements commonly reported in literature). These recurring features are traditionally called “near-death experiences” (NDEs).

NDEs have received high attention not only by neuroscientists (Blackmore, 1996; Greyson, 2010b), but also by scholars of religion, since the belief in life after death is shared among different religions. In a recent review, Dell’Olio (2009) summarized four features necessary to support the fact that NDEs can be read as “veridical”. In his philosophical dissertation the author said that, in order to be considered veridical, 1) the experience must occur in “optimal conditions” for the experience in question: indeed the proximity of subjects to actual death may be considered the ideal conditions for any subjective experience of death; 2) the experience must be repeatable so that other people, in the same position, would experience a similar process, and NDE has been repeated by many patients in the same condition, namely “clinical death”; 3) there must be widespread agreement among those patients who have experienced the same thing. Reports of NDEs are generally similar to each other; 4) there is a sense of phenomenological certainty to the experience. NDEs often share the same phenomenological sense of certainty that accompanies our everyday perception.

Currently the definition of NDE is not fully exhaustive in literature. A “near-death experience” generally refers to an altered state of consciousness commonly occurring during an episode of unconsciousness, as a result of a life-threatening condition (Greyson & Stevenson, 1980). It is worth noting that “near” would not mean something like “almost” dead, it should be read more as a temporary experience of the early stages of death. In particular, Dell’Olio (2009) has recently proposed an analogous example that might help to understand the importance of studying NDEs: the relation between near-paralysis (temporary paralysis) and paralysis. The experience of temporary paralysis is likely to draw con-

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Table 1
Recurring Features Reported in Literature to Describe NDE

No.	Recurring features	References
1	Awareness of being dead	van Lommel et al., 2001; Morse et al., 1986; Dell'Olio, 2009
2	Increase of mood with feelings of euphoria, happiness and well-being	van Lommel et al., 2001; Greyson, 2010b; Dell'Olio, 2009; Blackmore, 1996
3	Out-of-body-experience	Morse et al., 1986; van Lommel et al., 2001; Greyson, 2010b; Kelly, 2001; Dell'Olio, 2009
4	Entering a tunnel-like	Morse et al., 1986; van Lommel et al., 2001; Kelly, 2001; Blackmore, 1993; Dell'Olio, 2009; Kellehear, 1993
5	Perception of a light	Greyson, 2010b; van Lommel et al., 2001; Kelly, 2001; Ring & Cooper, 1997; Dell'Olio, 2009
6	Perception of a heavenly or hellish landscape	Greyson & Bush, 1992; Atwater, 1994; van Lommel et al., 2001
7	Encounter with deceased relatives, religious figures or beings of light	Kelly, 2001; Greyson & Stevenson, 1980; Greyson, 2010b; Betty, 2006
8	Experience of a life review	Stevenson & Cook, 1995; Greyson, 2010b; van Lommel et al., 2001; Kellehear, 1993
9	Different temporal perception	Greyson & Stevenson, 1980; Greyson, 1998; Dell'Olio, 2009
10	Perception of sounds or music	Greyson & Stevenson, 1980; Ring & Franklin, 1981; Greyson & Bush, 1996

clusions about permanent paralysis on the basis of it; similarly NDEs may help us to understand at least the first stages of a dying brain/mind.

It is unfortunate that the definite moment of biological death cannot be exactly determined. A number of researchers for instance tend to assume that a flat EEG reading can be considered as a proof of total brain inactivity, but this is not fully correct. Unless surgically implanted into the brain, EEG principally measures surface cortical activity, hence a flat EEG tends to be more indicative of neocortical inactivity but not full-brain inactivity (Braithwaite, 2008; French, 2001; Bardy, 2002). By definition, patients having no cardiac output, no respiration, and fixed dilated pupils are classified as clinically dead. However, it is neither easy to determine the border between biological life and death, nor to understand when an NDE exactly occurs.

Currently the most used scale used to evaluate NDEs has been developed by Greigson (1983b). It consists of 16 items and was found to have high internal consistency, split-half reliability, and test-retest reliability (see Table 2).

Most people who have experienced NDEs have described them as very pleasant. However, there have also been some reports of unpleasant experiences similar to nightmares (Greyson & Bush, 1992; Atwater, 1994). Positive experiences that then changed course to become negatively toned ones have been reported too (Irwin & Bramwell, 1988). Although people have sometimes wondered whether "good" people have pleasurable experiences and "bad" people have distressing ones, research has shown no correlation between apparent life deeds and type of NDE (Rommer, 2000). For instance, we might expect those attempting suicide to have more hellish experiences but in fact they do not (Ring & Franklin, 1981; Greyson & Stevenson, 1980). Distressing NDEs occur about equally to people of both genders and of all ages, educational and socioeconomic levels, sexual orientations, spiritual beliefs, religious affiliations, and life experiences (Bush, 2002).

Greyson and Bush (1996) classified several reports of unpleasant NDEs into three main categories: 1) the most common type includes similar features to the pleasurable type (i.e., out-of-body experience, movement through a tunnel or a light), but then people

experience the features as frightening, probably due to feeling out of control of what was happening; 2) the second type included an acute awareness of nonexistence or being completely alone in an absolutely empty space; 3) the last type is less common and includes hellish imagery such as an ugly or foreboding landscape, demonic beings, annoying noises, and frightening animals.

Extensive changes in personality are often found to occur after an NDE. For people having a positive experience a decrease in the fear of death has been reported (Greyson, 1983a) and a decrease of neurotic anxieties (Noyes & Kletti, 1977). Religious beliefs also tend to be modified, with people being more confident that there is life after death (Gabbard, Twemlow, & Jones, 1981). On the contrary, for people having a frightening NDE it has been reported to intensify fearfulness of death (Bush, 2002).

The exact incidence of the phenomenon is not known yet. NDEs are likely to occur with increasing frequency because of improved survival rates resulting from modern resuscitation techniques. Differences in estimates of frequency among cultures may result from varying definitions and from inadequate methods. Recent studies indicate that NDEs are reported by 10–18% of cardiac arrest survivors (van Lommel et al., 2001) and a random investigation of more than 2,000 Germans showed 4.3% of 22-year-olds have described such experiences (Schmied, Knoblauch, & Schnettler, 1999). NDEs are not confined to adults and have also been reported in children, who have been commonly considered too young to have any real concept of death or an afterlife (Morse, Castillo, Venecia, Milstein, & Tyler, 1986). It is interesting that the elements of NDEs reported in patients aged 3 through 16 years are very similar to those described in adults, with memories of being out of the physical body, entering darkness, being in a tunnel, and finally returning to the body. It is even more surprising that different studies have provided evidence that women may have statistically deeper experiences than men (van Lommel et al., 2001; Ring, 1980; Greyson, 2000), even though no firm explanation is possible at this stage.

Other facts speak in favor of a still higher incidence of NDEs. Schroeter-Kunhardt (1993) reviewed some reasons underlying the potential underestimation of the phenomenon. The main points may be summarized as follow: 1) in European hospitals very few

Table 2
Near-Death Experience Scale (Greigson, 1983b). A Score of 7+ Is Considered an NDE

No.	Questions
1	Did time seem to speed up or slow down? 0 = No 1 = Time seemed to go faster or slower than usual 2 = Everything seemed to be happening at once; or time stopped or lost all meaning
2	Were your thoughts speeded up? 0 = No 1 = Faster than usual 2 = Incredibly fast
3	Did scenes from your past come back to you? 0 = No 1 = I remembered many past events 2 = My past flashed before me, out of my control
4	Did you suddenly seem to understand everything? 0 = No 1 = Everything about myself or others 2 = Everything about the universe
5	Did you have a feeling of peace or pleasantness? 0 = No 1 = Relief or calmness 2 = Incredible peace or pleasantness
6	Did you have a feeling of joy? 0 = No 1 = Happiness 2 = Incredible joy
7	Did you feel a sense of harmony or unity with the universe? 0 = No 1 = I felt no longer in conflict with nature 2 = I felt united or one with the world
8	Did you see, or feel surrounded by, a brilliant light? 0 = No 1 = An unusually bright light 2 = A light clearly of mystical or other-worldly origin
9	Were your senses more vivid than usual? 0 = No 1 = More vivid than usual 2 = Incredibly more vivid
10	Did you seem to be aware of things going on elsewhere, as if by ESP? 0 = No 1 = Yes, but the facts have not been checked out 2 = Yes, and the facts have been checked out
11	Did scenes from the future come to you? 0 = No 1 = Scenes from my personal future 2 = Scenes from the world's future
12	Did you feel separated from your body? 0 = No 1 = I lost awareness of my body 2 = I clearly left my body and existed outside it
13	Did you seem to enter some other, unearthly world? 0 = No 1 = Some unfamiliar and strange place 2 = A clearly mystical or unearthly realm
14	Did you seem to encounter a mystical being or presence, or hear an unidentifiable voice? 0 = No 1 = I heard a voice I could not identify 2 = I encountered a definite being, or a voice clearly of mystical or unearthly origin
15	Did you see deceased or religious spirits? 0 = No 1 = I sensed their presence 2 = I actually saw them

(table continues)

Table 2 (continued)

No.	Questions
16	Did you come to a border or point of no return? 0 = No 1 = I came to a definite conscious decision to "return" to life 2 = I came to a barrier that I was not permitted to cross; or was "sent back" against my will

physicians systematically inquire about NDEs; 2) many patients may keep their experiences secret, even from their family members; certain persons may also think that they have had hallucinations or may be embarrassed about the occurrence of an NDE; for others, particularly unpleasant NDEs may be suppressed; 3) some patients remember their experience only under hypnosis or months or years later, when they come into contact with an appropriate association, for instance another NDE account; 4) temporolimbic epilepsy sometimes seems to activate NDE-elements and is also accompanied by an amnesia of variant depth (Durwen & Linke, 1987): since the temporolimbic region seems to be correlated to NDEs (Britton & Bootzin, 2004), an amnesia might be expected; 5) most NDEs are of short duration and their remembrance should therefore be expected to be poor; 6) many people with life-threatening diseases are also under the influence of anesthetics or psychotropic drugs: it is possible that such medicaments can interfere with perception during an NDE or block it.

Recently, it has been speculated that accounts of NDEs may have been exaggerated over the years. In order to test this hypothesis, Greyson (2007) asked 72 patients to complete a questionnaire at least 20 years after the first account of an NDE. Results have contradicted the idea of any exaggeration over the years, showing that accounts were reliable, in particular reports of their positive effect. It is interesting that memories of NDEs appear to be more stable than memories of other traumatic events.

NDEs have been reported throughout time in essentially all cultures. It has been suggested that the content of NDEs and the effects on people would be similar among all cultures. This would imply the existence of an unified pattern of experience regardless of education or religion (Belanti, Perera, & Jagadheesan, 2008). Blackmore (1993) for example, reported similar experiences in India compared to those reported by Moody (1975), including tunnels, dark spaces and bright lights. More recently NDE accounts collected before and after 1975 have been compared (Athappilly, Greyson, & Stevenson, 2006). Research considered 24 accounts collected before 1975 and 24 more recent accounts, matched on relevant demographics. In an interesting finding, NDE accounts collected after 1975 differed only in one of 15 features described in Moody's book (increased frequency of tunnel phenomena), thus suggesting that NDEs would not be affected by cultural variations.

Nonetheless, the universality of the pattern has been criticized by other cross-cultural studies describing partial differences in the content of the experience, and the relative interpretation of the experience itself may reflect religious beliefs. For instance Knoblauch, Schimied, and Schnettler (2001) reported a survey on NDEs in Europe: patterns of German NDEs did not correspond to earlier findings and differed with respect to cultural variables, with particular regard to religious interpretations. Satwant and Stevenson (1986) previously described 16 cases of NDEs in India and the

reports differed from the larger sample of American cases made by Moody.

Similar conclusions have been drawn also by Belanti and colleagues (2008). The authors compared NDEs in a cross-cultural context finding similarities between particular cultures, which differed from typical western European or American experiences. It has been suggested that the differences reported may derive from the effects of people's beliefs (education and religion) on what happened after death. A culture-dependence in the emergence of some specific features, such as "life review" and "tunnel sensation", has also been reported with these experiences being mainly confined to societies where historic religions are dominant (Kellehear, 1993).

It is clear that the exact role of society/education needs to be determined and cross-cultural studies are needed in the near future to deepen this aspect. It is likely that Christians might see Jesus in the light while Hindus might see the messengers of Yamraj coming to take them away (Blackmore, 1996). However, it is worth noting the fact that culture affects the specific features of experience does not provide any explanation per se on why people reported such experiences with a dying brain. The interaction between culture, language, and thought is complex and an increasing number of studies have currently shown that culture can even shape the way we perceive the world (Davidoff, Davis, & Roberson, 1999; Roberson & Hanley, 2007; Fuhrman & Boroditsky, 2010), therefore it sounds reasonable to assume that NDEs may be partially shaped by culture. Culture influences some of the recurring features; what is unclear is to what extent culture can shape NDEs and why the general pattern is similar throughout time in different cultures.

Two theoretical frameworks are reported in literature. The first is traditionally called "biological/psychological" interpretation, while the second is commonly referred to as "survivalist" interpretation (Braithwaite, 2008). However, in the present review I will label them respectively as "in-brain" and "out-of-brain" theories, since survivalist interpretations per se do not exclude the role of biological or psychological components and similar analyses of the psychobiological aspects underlying NDEs have also been conducted by survivalists (van Lommel et al., 2001). The key point, to me, is not whether "something" can survive or not after biological death (as far as we know nobody can say anything for sure about this, regardless of the theoretical position), but whether the NDE is a process that can be fully explained within the brain. Readers can easily understand how deeply NDE is related to a very historical debate on philosophy of mind, namely the "body-mind" problem. Even though some scientists do not directly refer to this ancient debate in their empirical studies, the two perspectives reflect monism and dualist positions. 'In-brain' theorists indirectly support "monism"—no fundamental division between mind and

body (specifically the brain) —while “out-of-brain” theorists tend to support the opposite “dualist” argument.

In or Out-Brain?

In-Brain Theories

According to several scientists NDE can be explained by physiological changes in the brain, such as neurons dying as a result of cerebral anoxia. Hence, NDE would be explained by a specific altered mental state related to critical healthy conditions. For instance, it is known that endorphins are released under stress (including extreme fear, such as the fear of dying) and are known to block pain and to induce feelings of well-being, acceptance, and even intense pleasure. This might be responsible for the positive emotional tone of most NDEs. In addition, cortical disinhibition associated with anoxia has been considered responsible for the perception of a tunnel and lights (Blackmore, 1996). The visual cortex is organized with many cells devoted to the center of the visual field and few to the periphery, therefore random excitation may produce the effect of a bright light in the center fading out toward darkness, creating a sort of tunnel effect.

Most of the “in-brain” theories are based on observing the statistical correlations between NDEs and some physiological anomalies. It has been advanced that the NDE may be caused by cerebral anoxia (Lempert, Bauer, & Schmidt, 1994), hypoxia (Blackmore & Troscianko, 1988), hypercarbia (Meduna, 1950), a massive release of endorphins (Carr, 1981; Morse, 1990), or a marked liberation of glutamate accompanied by the blockade of NMDA receptors (Jansen, 1989). Other pharmacological cerebral mediators seem to be crucial, particularly serotonin pathways (Persinger, 1983), and various hallucinogenic agents such as ketamine and phencyclidine (Jasper & Rasmussen, 1958). Recently, Klemenc-Ketis, Kersnik, and Grmec (2010a) suggested that also the high concentrations of carbon dioxide (CO₂) and high serum levels of potassium (K) may be important in provoking these experiences. However, these conclusions have been criticized recently by Greyson (2010a) on several points, namely the small sample size of the research, the contradictory evidence from previous studies, and the unclear association between levels of CO₂ in the brain.

There is evidence that the temporal lobe is involved in mystical and religious experiences (Daly, 1975; Devinsky, Feldman, & Burrowes, 1989; Jasper & Rasmussen, 1958) and its stimulation can induce hallucinations, memory flashbacks, body distortions, and out-of-body experiences (Penfield, 1955). In addition, the limbic system is involved in emotions and memory, therefore anoxia in this anatomical region might underlie “life review” phenomenon that sometimes occurs during NDEs (Blackmore, 1996). Britton and Botzin (2001) investigated temporal lobe functioning in individuals having had NDEs. The researchers reported that those experiencing NDEs had more temporal lobe epileptiform electroencephalographic activity than control subjects. It has been concluded that an altered temporal lobe functioning may underlie NDE and that individuals who had such experiences are distinct from the general population with respect to some physiological aspects. Nonetheless, as the authors outlined, it is not possible to establish precisely whether the differences reported in

the study are a generalized result of trauma rather than specific to the NDE itself.

Beauregard, Courtemanche, and Paquette (2009) recruited those with NDEs who reported a “sense of light” during the experience. Participants claimed to be able to mentally visualize and connect with this sense of light during a state of meditation. Brain activity during such a meditative state was measured, using functional magnetic resonance imaging (fMRI) and electroencephalogram (EEG). The meditative state was accompanied by hemodynamic and neuroelectric changes in various brain regions, including the temporal lobe. On the whole, the meditative state was associated with prominent hemodynamic and neuroelectric changes in brain regions known to be implicated in positive emotions, visual mental imagery, attention or spiritual experiences, suggesting a biological interpretation of NDE.

Neuroanatomical correlates of one of the main features of NDEs, the out-of-body experience, have been found in a 63-year-old man (De Ridder, van Laere, Dupont, Menovsky, & van de Heyning, 2007). The patient was required to indicate the start and end of an out-of-body experience by pressing a button, and his subjective reporting was registered after each scan. Functional neuroimaging (PET) has been used in a controlled design to capture the regions of the brain engaged. Results showed brain activation at the temporoparietal junction, suggesting that an out-of-body experience would be mediated by a specific region of the brain.

Previously, Nelson, Mattingly, Lee, and Schmitt (2006) asserted that rapid eye movement (REM) sleep may also have a key role in NDEs. After all, REM intrusion occurs frequently among normal healthy people and REM intrusion underlies other clinical conditions such as narcolepsy, Parkinson’s disease, and delirium tremens. The authors compared and contrasted NDE with REM patterns, asserting that some aspects of NDEs, including auto-scoping, light, visual experience, pleasant feelings, and transcendent qualities, occur in NDEs, but are not unique to them and can occur in other clinical conditions including some with an established association with REM intrusion. It has also been argued that danger might provoke the arousal of certain nerve pathways that are known to generate REM-associated physiological responses. The relation between NDEs and REM intrusion has been criticized recently by Long and Holden (2007), suggesting substantial weaknesses in the presented lines of evidence reported by Nelson and colleagues (2006).

Beyond physiological correlates, other theories encompass a psychological reaction to approaching death (Appelby, 1989), a combination of such reaction and anoxia, or other psychological mechanisms occurring much later than the NDE. It may be that, on hearing about other survivors’ NDEs, some patients would start to imagine what it would have been like if they had a similar experience (French, 2001; Evans, 2002). Psychological studies have shown that simply imagining having had a specific experience (that in fact had never been encountered) will lead to the development of false memories for those experiences (Garry, Manning, Loftus, & Sherman, 1996; Loftus, 2001). It is interesting that susceptibility to false memories correlates with a tendency to dissociate, which sometimes seems to correlate with the tendency of reporting NDEs (Heaps & Nash, 1999; Hyman & Billings, 1999). Patients with a cardiac arrest may have a poor understanding of their condition and so impose a different interpretation upon

events, possibly one that subsequent interview and the interest of the clinicians may have inadvertently affected.

The question of the neural foundation of NDEs becomes more interesting if we focus on memory itself. As Braithwaite (2008) outlined, in order to have any experience to be remembered, the memory should encode and represent the experience in the first place. Applied to the NDE, this would imply that there should be enough neural activity to encode and represent the experience and subsequently store the experience. Out-of-brain theorists have argued that a near-death brain is too unstable to support vivid hallucination, and so cannot explain NDEs (Fenwick & Fenwick, 1995; Parnia & Fenwick, 2002; Parnia, Waller, Yeates, & Fenwick, 2001). Nonetheless, if the brain is too unstable to support hallucination, it becomes problematic to imagine where this mystical experience would be stored.

In addition, in-brain theorists remind us that the human brain is constantly trying to make sense of the ambiguous information it receives, in order to reach a stable and coherent interpretation, as Gestalt theory widely showed during the last century. This also fits with recent developments in cognitive psychology and neuroscience that views neurocognition as an active model-building process (Braithwaite, 2008). Once it is realized that normal perception itself can be viewed, to some degree, as a stable and successful hallucination, it would be a short step to view NDEs as an extension of this natural process. The NDE might merely be considered a sort of illusion serving as a temporary purpose for consciousness where it represents reality in the absence of the more usual and stable information provided by the senses (Blackmore, 1993; Claxton, 2005; Morgan, 2003).

Lastly, the changes in attitude toward life reported after NDEs are sometimes taken as evidence of their "heavenly" nature. However, "in-brain" theorists noted that simply facing up to death can bring about a change in personal values, and to date there is conflicting evidence in literature about whether an NDE is a very necessary condition for these psychological changes (Pope, 1994).

To conclude the list of arguments, I think it is worth mentioning Wettach's thoughts on the potential relation between religion and NDE. During his dissertation on the role of subcortical brain functions, Wettach (2000) proposed the intriguing idea that NDE may be the reason that religion developed. The author said (p. 89): *"Imagine a primitive, prehistoric tribe in which a medicine man has pronounced a tribal member dead, and the elders prepare a funeral ritual, certain of the mortal consequences. But the lifeless victim suddenly arises and, much to the astonishment of the tribal elders, begins to tell of mental travels to a strange and beautiful place. The elders cannot explain how this resurrection of the dead has occurred and, perhaps to insure their dominant position in the tribe, they invent the concept of God and an afterlife, and explain that only they can interpret God for the rest of the tribe. Thus, the children of the tribe are taught religious concepts to store in the primitive centers of their minds. If one of these children later becomes near dead, his or her mental trip to a beautiful place may be enriched by a spiritual visit with God, proving to the tribe that the elders were right and God exists"*.

The author raised a very interesting question on the origin of religions. However, the question on whether near-death experience is an example of spiritualism affecting abstraction or, on the contrary, of abstraction influencing spiritualism is totally open and I believe it is unlikely that we will have an answer soon.

Out-of-Brain Theories

NDEs pose challenges to the materialist brain-mind theory, according to which complex mental phenomena could be understood by reducing them to their individual components (and eventually to elementary material particles). After all, correlations of mental and biological processes do not necessarily imply that the former totally derive from the latter and does not prove any cause-effect relation. Therefore some other scientists believe that in-brain theories cannot fully take into account NDEs.

Recently van Lommel and colleagues (2001) published a very much discussed paper arguing that physiological factors per se cannot explain the phenomenon. In this study, researchers included patients who were successfully resuscitated in coronary care units in Dutch hospitals. The authors conducted interviews with sufficiently well patients, within a few days of resuscitation, asking whether they recollected the period of unconsciousness, and eventually what was recalled. Eighteen per cent of patients reported some recollection of the time in which they were classified as clinically dead. In particular 12% had a core experience. The authors concluded: *"We did not show that psychological, neurophysiological, or physiological factors caused these experiences after cardiac arrest"* (van Lommel et al., 2001, p. 2044). Indeed, although all patients had been clinically dead, most did not have an NDE. Furthermore, the seriousness of the clinical condition was not related to the occurrence or depth of the experience. If purely physiological factors resulting from cerebral anoxia caused an NDE, most of patients were supposed to feel this experience.

Recently Braithwaite (2008) published a review paper criticizing the conclusions advanced by van Lommel and colleagues (2001). In particular, four different questions have been raised by the author: 1) van Lommel and colleagues (2001) would not have provided any direct measure of anoxia: the presence and the level of anoxia would have been indirectly inferred by questionnaire responses and medical information about the pattern of the cardiac arrest; 2) It would be the rate of change would be important, not the overall level of anoxia reached: van Lommel and his team (2001) would not have been focused on the right clinical information (rate of change), therefore their conclusions would be inappropriate; 3) the degrees of within-brain and between-brain heterogeneity would have been ignored, even though they may have important influences for the degree of anoxia; 4) why did only 18% reach this condition? If the afterlife hypothesis was true, it would be hard to understand why only a small percentage in the same "clinical death" status would experience it.

Regardless of the debate on this specific study, a number of objections against the "in-brain" explanations have been advanced. One of the most important objections to all reductionistic psychobiological theories is that mental clarity, vivid sensory imagery, a clear memory, and the conviction that the experience seems more real than ordinary consciousness, are the norm for NDEs, even when they occur in conditions of drastically altered cerebral physiology under which neuroscientists would traditionally believe any form of consciousness impossible (Greyson, 2010b). With regard to this point, a recent analysis of several hundred NDE cases showed that 80% of those experiencing NDEs described their thinking during the NDE as "clearer than usual"; 74% described them also as "faster than usual" or "more logical than usual" (Kelly, Greyson, & Kelly, 2007). In addition, an analysis of NDEs

with contemporaneous medical records showed that patients reported enhanced mental functioning more often when they were actually physiologically close to death than when they were not (Owens, Cook, & Stevenson, 1990). Therefore, NDEs seem to be characterized by heightened awareness, attention and consciousness at a time when consciousness and memory formation would not be expected to occur.

Dissociative symptoms have also been proposed by in-brain theorists to correlate with the frequency of NDEs. Indeed, since dissociation is often related to previous experiences of trauma and has been linked to altered states (Irwin, 1993), it has been suggested that people having NDEs might show high levels of dissociation. Greyson (2000) explored this hypothesis by observing the frequency of dissociative symptoms in people who reported NDEs. On the whole, participants do not show any evidence of a pathological type of dissociation or a manifestation of dissociative disorder; in contrast, it has been suggested that NDEs may be a nonpathological experience involving the psychological mechanism of dissociation as a normal response to the trauma.

With regard to the definition of clinical death, an objection has been that even in the presence of a flat-line EEG there could still be undetected brain activity occurring. However, out-of-brain theorists argued that the question is not whether there is brain activity of any kind whatsoever, but whether there is brain activity considered by modern neuroscientists a "*sine qua non*" condition of conscious experience (Greyson, 2010b). In addition, cells in the hippocampus—the region known to be crucial for memory formation—are especially vulnerable to the effects of anoxia (Vriens, Bakker, De Vries, Wieneke, & van Huffelin, 1996). Basically, it is hard to believe that NDEs can be entirely accounted for in terms of some hypothetical residual brain capacity to process and store such complex experiences under those critical conditions.

Scientists defending in-brain interpretations sometimes suppose that these experiences do not occur exactly when they are supposed to occur, during the actual clinical death, but at a different time, perhaps just before or just after the insult, when the brain is more or less functional. Unfortunately, it is not possible to provide compelling evidence. However, it has been reported that unconsciousness produced by cardiac arrest usually leaves patients amnesic and confused about events immediately preceding and following these episodes (Aminoff, Scheinman, Griffin, & Herre, 1988; Parnia & Fenwick, 2002; van Lommel et al., 2001), thus reducing the possibility that NDEs were stored before of after the insult.

Another feature that in-brain arguments cannot easily account for is the experience of being out of the body and perceiving events that one could not normally have perceived. It has been argued that patients may have ascribed witnessing events going on around their body to a retrospective imaginative reconstruction attributable to a persisting ability to hear, even when unconscious, or to the memory of objects or events that one might have perceived just before losing consciousness, or to expectations about what was likely to have occurred (Blackmore, 1993; Saavedra-Aguilar & Gómez-Jeria, 1989; Woerlee, 2004). However, such claims are considered less credible by out-of-brain theorists when the specific sensory channels involved in the reported experience have been blocked as part of the surgical routine, for instance when visual experiences are reported by patients whose eyes were taped shut. In addition, Ring and Cooper (1997) reported 31 cases of blind

individuals, nearly half of them blind from birth, who during their NDEs experienced quasi-visual and sometimes veridical perceptions of objects and events. Sometimes patients even reported that, while out of the body, they became aware of events occurring at a distance beyond the reach of their ordinary senses. In a recent review of more than 90 reports of potentially verifiable out-of-body perceptions during NDEs, Holden (2009) found that a large amount of them had been subsequently corroborated by an independent informant.

With regard to the vision of deceased acquaintances, scientists supporting in-brain interpretations viewed them as hallucinations caused by drugs, physiological conditions, or by the person's wishes to be reunited with deceased relatives. On this topic it has been reported that people close to death are more likely to perceive deceased persons than people who are not close to death. On the contrary, people not close to death having waking hallucinations are more likely to report seeing living persons (Osís & Haraldsson, 1977). The "expectation hypothesis" has been weakened by a subsequent study that showed a more frequent occurrence of visions of deceased persons in cases of the sudden onset of cardiac arrest (Kelly, 2001). In these circumstances, there is presumably less time for psychological expectations, such as the expectation of dying, therefore it sounds improbable that a person's hopes of being reunited with deceased loved ones can explain the phenomenon alone (Kelly, 2001). Furthermore it has been argued that, if expectation alone was underlying the whole process, people would very often recognize the hallucinatory figures, either as actual deceased or living people or, at least, as known religious/mystic figures. On the contrary, numerous people also perceive figures other than known deceased persons and some of these are totally unrecognized. Even more interestingly, in some clinical cases it has been reported that the dying person apparently saw a person whom he or she thought was living, but who had in fact recently died (Greyson, 2010b). As in these cases, the patients had no knowledge of the death of the recently deceased person, such a vision cannot plausibly be attributed to the expectation hypothesis. Lastly, many people are emotionally close to their pets and hope to be reunited with them, as well as with people, after death. Therefore, in accordance with the expectation hypothesis, it would be reasonable also to find a large number of hallucinations of deceased pets, as outlined by Greyson (2010b). Nonetheless, Kelly (2001) reported that, among almost 300 cases, only two people reported seeing their pets.

Conclusions

The study of NDEs represents one of the main challenges of modern neuroscience, given the high scientific, theological and philosophical implications related to this topic. Many popular books on NDEs have become best-sellers, probably because a large number of people wants to believe that immortality is scientifically possible, so lessening and making more tolerable our fear of death. From a traditional scientific perspective, the occurrence of these experiences might initially be considered improbable or paradoxical. However, the incidence of the phenomenon and the partially similar features reported among cultures have raised some questions regarding the biological/psychological interpretations of NDEs, as well as the nature of human consciousness and its relationship with the brain.

Even adopting a rigorous scientific methodology, the theoretical debate is largely open and, to date, it is not possible to draw any

firm conclusions about the origin of such experiences. According to out-of-brain theorists, the mind might be separable from the brain and therefore survive even after body death; others (in-brain theorists) suggest that these experiences may be mainly a by-product of biological processes or psychological reactions to death. Lights and tunnels would merely be hallucinations or final visions produced by a dying brain (see Table 3 for a short summary about the two perspectives).

We have to hope that physicians and other caregivers will be more and more aware of these experiences and advise patients accordingly. In general, more research involving cooperation among several hospitals and research groups is welcome in the effort to provide more exhaustive explanations of the occurrence and content of NDEs. In 2008 a new international project called AWARE—“AWAreness during REsuscitation”—was launched, with the purpose of studying the relationship between the brain and the mind during clinical death. This project, recruiting over 1,000 cardiac arrest survivors, is the first multidisciplinary study using both cerebral monitoring techniques and planning innovative tests. In one of these, for example, it is planned to install a small picture shelf above patients’ beds. This shelf will not be visible from the floor and it might be possible to have a glimpse of the picture only by “floating.” Researchers will try to see whether patients who report out-of-body experiences will be able to recall seeing the picture during the intermittent state. This would surely represent compelling evidence for the out-of-brain hypothesis, even though we would have to record that a null result (no recall of the picture) would not necessarily imply the absence of the phenomenon. Why would a dying individual have to focus attention on this nonrelevant cue when seeing his or her body from above and living such an unknown experience?

It is worth noting that most of the recurring features are visual experiences (seeing a light, seeing a tunnel, deceased people, or heavenly or hellish landscapes). This raises an interesting question: why would an out-of-body mind still perceive the reality mainly driven by visual information? Visual modality is the most important one used by humans to perceive the world. Nonetheless, there is no reason to believe that the same preference for visual inputs should be observed after biological death. For instance fewer

accounts on tactile or kinaesthetic information seem to be reported. This may be interpreted as indirect evidence of a mind still “trapped” in the brain. However, the problem may simply rely on the verbal account of patients. Indeed, when people have to describe a landscape, in general they tend to use words evoking images instead of tactile information or gustative information; therefore it becomes complicated to disentangle the effect of language (usually imagine-biased) and the real nature of perception in NDEs (that is supposed to be modality independent).

Even assuming the most intriguing hypothesis that NDEs are evidence of life after death, it would be unclear whether NDEs really support the belief in what we may call “maximal” life after death (immortality) or merely in a “minimal” life after death, a sort of limited consciousness for some time after death (Dell’Olio, 2009). Experiences themselves are a matter of minutes. As the brain can still survive for a few minutes in the absence of blood support, it is theoretically possible that the human mind might really be dissociable to the brain, but cannot survive for long in the absence of neuroanatomical structures.

Regardless of these speculations, it is undeniable that NDEs can help us to deepen our comprehension of human consciousness. It has been argued that consciousness is the result of interaction among large neural networks (Fenwick, 2000). This is supported by neuroimaging studies where, using functional MRI and PET, specific brain areas have been found to be active in response to a thought or feeling (Frackowiak, Friston, Frith, Dolan, & Mazziotta, 2003). However, those studies do not necessarily imply that neurons also produce consciousness; neuronal networks may be considered as a sort of an intermediary for the manifestation of consciousness. As outlined by Parnia and Fenwick (2002), direct evidence of how neural circuits can assess the subjective essence of the mind is currently lacking, and provides one of the biggest challenges to neuroscience. Gestalt theories have widely demonstrated that our ways to perceive reality are surely based on single elements of the whole scene but are not the mere sum of them. Similarly, the human mind is supported by neural networks but may not be only the sum of the single parts. The mind and the brain might not be related by one-to-one correspondence. The claims made by the out-of-brain theorists should not be underestimated by

Table 3
Some of the Arguments Traditionally Reported in NDEs

Topics	“In-brain” (biological/psychological hypothesis)	“Out-of-brain” (survival hypothesis)
Anatomical brain correlates	NDEs are a by-product of biological mechanisms of a dying brain.	Correlation does not mean anything about cause and development.
Flat EEG	It does not mean deeper structures of the brain are damaged, brain may be partially working.	There is no brain activity of the specific form agreed on by neuroscientists as the necessary condition of conscious experience.
Brain stimulation and similar experiences	Some similar experiences can be simulated through brain stimulation.	The two kinds of experience do not match.
Memory in a dying brain	a) If patients can recall NDEs, some parts of brain must still work. b) False memories could explain the phenomenon.	a) Enhanced mental clarity and clear memory during cerebral impairment. b) Cardiac arrest often leaves patients amnesic immediately preceding and following these episodes.
Visions	a) Hallucinations or patients’ wishes before death. b) Patients might perceive something and, subsequently, create a visual recall about.	a) Some perceived figures are unrecognized and are not related to specific patients’ wishes. b) Some cases of blind people reporting visual experiences have been described.

cognitive neuroscientists: if true, this would imply a new relation between the brain and consciousness.

In 1996 Blackmore said: “it is probably a matter of personal preference whether to interpret the NDE as a glimpse of the life beyond or the product of the dying brain” (p. 75). Unfortunately, even though more biological correlates have been reported during the last 14 years, we are far from solving the question. In the absence of a more adequate explanatory framework for NDEs, it will be useful to remain open to both interpretations.

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