

## Near-death experiences in cardiac arrest: implications for the concept of non-local mind

Experiências de quase morte em parada cardíaca: implicações para o conceito de mente não local

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## Abstract

**Background:** Near-death experiences (NDE) are vivid, realistic, and often deeply life-changing experiences occurring to people who have been physiologically or psychologically close to death. NDE sometimes occur during cardiac arrest, in the absence of recordable brain activity. **Objective:** To review prospective studies of cardiac arrest-induced NDE and examine the implications of these studies for the concept of non-local mind. **Method:** PubMed was the main database used for this review. Key search terms included “cardiac arrest”, “near-death experiences”, “physiology of near-death experience”, and “veridical out-of-body-experiences”. **Results:** Several prospective studies show an average incidence of cardiac arrest-induced NDE of 10%-20%, irrespective of sociodemographic status, sex, religion, or any consistent medical, physiological, or pharmacological measures. NDEs are more likely than non-NDEs to have positive life changes lasting many years following the experience. **Discussion:** Physicalist theories of the mind cannot explain how NDEs can experience – while their hearts are stopped and brain activity is seemingly absent – vivid and complex thoughts, and acquire veridical information about objects or events remote from their bodies. NDE in cardiac arrest suggest that mind is non-local, i.e. it is not generated by the brain, and it is not confined to the brain and the body.

Von Haesler NT, Beauregard M / *Rev Psiq Clín.* 2013;40(5):197-202**Keywords:** Near-death experiences, cardiac arrest, out-of-body experiences, brain, non-local mind.

## Resumo

**Contexto:** Experiências de quase morte (EQM) são experiências vividas, realísticas, que frequentemente promovem mudanças profundas na vida de pessoas que estiveram fisiológica ou psicologicamente próximas da morte. As EQM por vezes ocorrem durante uma parada cardíaca, na ausência de atividade cerebral detectável. **Objetivo:** Revisar os estudos prospectivos de EQM induzidas por paradas cardíacas e examinar as implicações desses estudos para o conceito de mente não local. **Método:** PubMed foi a principal base de dados utilizada para esta revisão. Os termos-chave da busca incluíram “parada cardíaca”, “experiências de quase morte”, “fisiologia da experiência de quase morte” e “experiências fora do corpo verídicas”. **Resultados:** Vários estudos prospectivos mostram incidência média de 10% a 20% de EQM induzidas por paradas cardíacas, independentemente de aspectos sociodemográficos, sexo, religião ou quaisquer parâmetros médicos, fisiológicos ou farmacológicos consistentes. Pessoas que passaram por EQM são mais propensas a mudanças de vida positivas que podem durar muitos anos após a experiência do que aquelas que não a tiveram. **Conclusões:** As teorias fisicalistas da mente não são capazes de explicar como pessoas que tiveram EQM podem vivenciar – enquanto seus corações estão parados e sua atividade cerebral aparentemente ausente – pensamentos vívidos e complexos e adquirir informações verídicas a respeito de objetos ou eventos distantes de seus corpos. As EQM em paradas cardíacas sugerem que a mente é não local, isto é, não é gerada pelo cérebro e não está confinada a ele ou ao corpo.

Von Haesler NT, Beauregard M / *Rev Psiq Clín.* 2013;40(5):197-202**Palavras-chave:** Experiências de quase morte, parada cardíaca, experiências fora do corpo, cérebro, mente não local.

## Introduction

Near-death experiences (NDEs) are vivid, realistic, and often deeply life-changing experiences occurring to people who have been physiologically or psychologically close to death<sup>1</sup>. These experiences can be evoked by cardiac arrest and coma caused by brain damage, intoxication, or asphyxia. They can also happen following such events as electrocution, complications from surgery, or severe blood loss during or after a delivery.

Enhanced mental activity, a clear memory of the experience, and a conviction that the experience is more real than ordinary waking consciousness are core features of NDEs. Other common features include an out-of-body experience (OBE), i.e. a sense of having left one's body and watching events going on around one's body and, occasionally, at some distant physical location; feelings of peace and joy; passage through a region of darkness or a dark tunnel; seeing an otherworldly realm of great beauty; encountering deceased relatives and friends; seeing an unusually bright light, sometimes experienced as a “Being of Light” that radiates complete acceptance and uncondi-

tional love and may communicate telepathically with the near-death experience (NDEr); seeing and reliving major and incidental events of one's life, sometimes from the perspective of the other people involved; sensing a border beyond which the NDEr cannot go; and returning to the physical body (oftentimes involuntarily)<sup>1</sup>.

NDEs frequently lead to a profound and permanent transformation. Common after effects include renewed appreciation for life and a heightened sense of purpose; increased spirituality; enhanced compassion for other people; reduced fear of death; and lower levels in competitiveness and materialistic attitudes<sup>1</sup>.

NDEs have been documented across cultures and throughout history<sup>2</sup>. However, it was not until the 1950s that modern cardiopulmonary resuscitation (CPR) techniques were implemented, leading to a corresponding increase in survivors of cardiac arrest<sup>3</sup>. In turn, an increasing number of people reported vivid conscious experiences following their resuscitation. It is noteworthy that during cardiac arrest, blood flow and oxygen uptake in the brain are rapidly interrupted. When this happens, electroencephalography (EEG)

becomes isoelectric (flat-line) within 10-20 seconds and brainstem reflexes disappear<sup>4,7</sup>. If CPR is not administered within 5-10 minutes, irreversible brain damage may occur, and the person will die<sup>8-10</sup>.

Because NDEs are largely subjective, they pose a challenge for scientific investigation. However, there are ways to validate the out-of-body aspect of the experience objectively. NDErs commonly report perceptions during their OBEs that could not possibly be perceived through normal sensory channels. These perceptions are called veridical when they are independently corroborated. There are two types of veridical OBEs: material veridical OBEs and transmateral veridical OBEs<sup>11</sup>. Material veridical OBEs occur in consensus physical reality, and usually involve the NDEr seeing their own body from an outside perspective, often while floating above<sup>11</sup>. In cases of cardiac arrest, OBEs frequently involve watching one's own resuscitation procedure<sup>12,13</sup>. Transmateral veridical perceptions, on the other hand, are those that occur outside of normal consensus physical reality<sup>11</sup>. An example of a transmateral veridical OBE is when the NDEr encounters a deceased relative or friend-outside of consensus reality-that was not known to be dead at the time of the experience.

The current review article focuses on NDEs specifically induced by cardiac arrest for the following reasons: 1) Cardiac arrest is the closest physiological model of the dying process<sup>10,14</sup>; 2) During cardiac arrest, the EEG is isoelectric and the cortical brain regions that supposedly produce higher mental functions are no longer active; 3) To focus on NDEs in cardiac arrest allows for control over potential psychological or physiological confounds that would be present if we collapsed across all NDEs (i.e. drug overdose, depression, drowning, car accidents etc.); 4) A number of prospective studies investigating cardiac arrest-induced NDEs have been conducted over the last 12 years. In this article we review those prospective studies, including instances of veridical OBEs. We also discuss the main physiological and psychological models proposed to explain NDEs, and examine the implications of the studies of cardiac arrest-induced NDEs for the concept of non-local mind.

## Methods

PubMed was the main database used for this review. The descriptors investigated were "cardiac arrest", "near-death experiences", "out-of-body-experiences", "veridical out-of-body-experiences", "physiology of near-death experience", and "neuroscience of near-death experience". Prospective studies on NDEs during cardiac arrest were prioritized.

## Results

Several prospective studies have investigated cardiac arrest-induced NDEs<sup>10,14-17</sup>. Here we report the NDE scales used; the study design and incidence of NDEs; demographics; any medical, physiological, and pharmacological measurements; veridical OBEs; and the long-term positive life changes following NDEs.

### Near-death experience scales

The NDE Scale<sup>18</sup> was used to assess whether individuals qualified as having an NDE in all studies except for van Lommel *et al.*<sup>10</sup>, who used the Weighted Core Experience Index (WCEI) scale. Both scales are based on elements developed by Ring<sup>19</sup>. The WCEI measures the depth of the NDE by assigning weighted scores to 10 different elements common to NDEs, including an awareness of being dead, positive emotions, OBEs, a tunnel, communication with a light, observation of colors, observation of celestial landscape, meeting deceased people, a life review, and presence of a border<sup>10</sup>. A score between 1 and 5 represents a superficial experience, a score of 6 or more represents a core experience, and a score of 10 or greater represent deep experiences. Both the WCEI and NDE Scale feature many of the same elements common to NDEs<sup>19</sup>, and are strongly correlated to one another ( $r = 0.90$ ) with good reliability and validity<sup>10,18</sup>. The NDE Scale was developed partially because Greyson felt it was too

easy to meet criteria for an NDE using the WCEI<sup>18</sup>. The NDE Scale is a 16-item questionnaire that assesses cognitive processes, affective processes, paranormal experiences, and transcendental experiences relevant to NDEs. Each of the 4 categories contains 4 items that are assigned a score between 0-2 points. A strongly positive response is given 2 points, a moderately positive response is given 1 point, and a negative response is given 0 point. An overall score of greater than 7 represents an NDE.

### Study design and incidence of NDEs

The first prospective study of cardiac arrest-induced NDEs was conducted by Parnia *et al.* in 2001<sup>14</sup>. They interviewed survivors of cardiac arrest from the medical, emergency, and coronary care units of Southampton General Hospital over a 1-year period. Patients were excluded from the study if they did not get a 10/10 on the 10-point mini mental test, or if they were under 18 years of age. Of the 63 patients interviewed, 7 (11%) had some memory during the cardiac arrest, 4 of which met criteria for an NDE (6.3%). Unfortunately, due to their small sample size, statistical analysis was not possible between groups.

That same year another study was published with a larger sample size<sup>10</sup>. From 1988 to 1992, van Lommel *et al.* interviewed 344 patients in 10 hospitals in the Netherlands, who were clinically dead and underwent successful CPRs. Of the 344 patients included, 62 (18%) reported some recollection during the time of clinical death, with 21 (6% of total) having had a superficial NDE and 41 (12%) having a core NDE using the WCEI Scale. Of those that had a core experience, 23 (7% of total) reported a deep or very deep NDE.

The following year, Schwanager *et al.* published another prospective study of cardiac arrest-induced NDEs<sup>15</sup>. These researchers investigated the incidence of NDEs in the surgical intensive care unit of Barnes-Jewish Hospital from 1991 through 1994. Reasons for exclusion from the study included difficulty with tracking the occurrence of cardiac arrest in that unit, drug overdose, emotional instability with a prior psychiatric diagnosis, or medical instability that rendered the patients unable to answer questions. Of the 30 patients included in the study, 7 (23%) met criteria for an NDE. Four additional patients (13%) did not have an NDE during the cardiac arrest in question, but did have one during a prior life-threatening event.

In another investigation, Greyson interviewed patients within 6 days of admission to the cardiac care unit and the cardiology step-down unit of the University of Virginia Hospital<sup>16</sup>. Patients who were too ill, psychotic, or cognitively impaired were excluded from the study. Of the 1595 patients included, 27 patients (2%) met criteria for an NDE. Of those that had NDEs, 41% resulted from cardiac arrest, 26% from myocardial infarction, 22% from unstable angina, and 11% from other cardiac diagnoses. Of the 105 cardiac arrest patients, 10% had NDEs. An additional 81 additional patients (5%) described NDEs that had occurred during a prior life-threatening episode.

More recently, Klemenc-Ketis *et al.* studied out-of-hospital cardiac arrest survivors that were resuscitated and subsequently admitted to three large hospitals in Slovenia<sup>17</sup>. The specific aim of the study was to investigate the relationship between serum partial pressure of oxygen ( $pO_2$ ), carbon dioxide ( $pCO_2$ ), and the occurrence of NDEs. The study included 52 patients, and 11 (21.2%) met criteria for an NDE.

### Demographics

None of the studies found any correlation between incidence of NDEs and socioeconomic status or religious belief. Interestingly, two of the studies reported a higher incidence of NDEs in younger populations<sup>10,16</sup>. Women were more likely to have deeper NDEs than men<sup>10</sup>, but both sexes were equally likely to have an NDE in general<sup>10,14-17</sup>.

## Medical, physiological, and pharmacological measurements

Medical, physiological and pharmacological measurements were reported in some, but not all of the studies. Inclusion of these measurements is important to account for potential relationships between NDEs and physiological processes that may differ between experiencers and non-experiencers.

Parnia *et al.* study did not yield a sufficient number of NDEs to be able to statistically compare across measures<sup>14</sup>. However, there was little difference between groups in mean sodium and potassium levels, partial pressure of carbon dioxide (paCO<sub>2</sub>), or drugs administered during the cardiac arrest. Interestingly, NDEs had a partial *pressure of oxygen in the arterial blood* (PaO<sub>2</sub>) that was twice as high as that of the control group (33.1 kPa vs. 16.8 kPa).

No reported physiological or pharmacological measures correlated with having an NDE in van Lommel *et al.* study<sup>10</sup>. Patients who had NDEs were more likely to have had multiple CPRs, and were more likely to die within 30 days of the cardiac arrest. Potassium, sodium, oxygen, or carbon dioxide levels were not reported.

Greyson reported multiple medical measures, including objective proximity to death (*e.g.* vital signs lost), Coronary Prognosis Index, and classification of cardiac function<sup>16</sup>. No correlation was found between any of these measures and the incidence of NDEs. However, patients admitted with cardiac arrest reported significantly more NDEs (10%) than patients admitted with other cardiac diagnoses (3%). Furthermore, patients with NDEs were more likely to report feeling closer to death, but were not medically closer to death. No physiological or pharmacological measures were reported.

Klemenc-Ketis *et al.* were mainly interested in physiological measures, and reported partial pressure of end-tide CO<sub>2</sub> (petCO<sub>2</sub>), pCO<sub>2</sub>, pO<sub>2</sub>, and serum sodium and potassium<sup>17</sup>. Patients with higher petCO<sub>2</sub> and higher pCO<sub>2</sub> reported significantly more NDEs. NDE scores were also positively correlated with both pCO<sub>2</sub> and serum levels of potassium. Although patients with lower pO<sub>2</sub> had more NDEs, the difference was not significant.

## Veridical OBEs

An extensive review of the veridical OBE literature by Holden from 1975 to 2006 reported that the number of NDE cases involving veridical OBE perception greatly outweighed those involving inaccurate perceptions<sup>11</sup>. Specifically, only 8% of material and 11% of transmateral OBE cases involved some error, and 38% of material and 33% of transmateral cases were completely accurate according to objective corroboration<sup>11</sup>. However, most of these cases were retrospective and not cardiac arrest-induced, and so we cannot know the extent of possible embellishment over time, nor whether the brain was functioning normally.

Nearly half of the NDEs report an OBE<sup>20</sup>. Studies have shown that the incidence of OBE ranges between 24% and 90% during cardiac arrest<sup>10,15,16</sup>. Of note, one case of veridical OBE perception was reported by a nurse and occurred during the pilot phase of the study carried out by van Lommel *et al.*<sup>10</sup>. Here is a brief description of the report made by the nurse:

*"During a night shift an ambulance brought in a 44-year-old cyanotic, comatose man into the coronary care unit. He had been found about an hour before in a meadow by passers-by. After admission, he received artificial respiration without intubation, while heart massage and defibrillation were applied. He had dentures in his mouth so the nurse removed them and put them onto the crash cart. CPR continued for another hour and a half until the patient had sufficient heart rhythm and blood pressure. The nurse met the patient more than a week later, which upon seeing him said 'Oh, that nurse knows where my dentures are'. 'Yes, you were there when I was brought into hospital and you took my dentures out of my mouth and put them onto that cart, it had all these bottles on it and there was this sliding drawer underneath and there you put my teeth.'"*

The nurse was amazed because he was in deep coma and receiving CPR when he took his dentures. The man said he had perceived everything from above his body and saw the nurses and doctors administering CPR. He was able to describe everything correctly and in great detail<sup>10</sup>.

In an early retrospective study, Sabom<sup>12</sup> interviewed individuals who had claimed to see parts of their own CPR. Patients' description of their resuscitation was compared with their medical records (which the patients never saw). However, most of the descriptions (26 of 32 patients) contained only general, non-detailed visual impressions that could not be verified. While these descriptions corresponded with the known facts of near-death crisis event, the accuracy of the accounts was not verifiable. In comparison, Sabom asked cardiac patients who did not report an NDE to describe a resuscitation procedure and found that 80% of the non-NDE group made errors in their descriptions. Despite these compelling findings, most of the control group cardiac patients had never actually been resuscitated; therefore, a more precise control group would consist of all patients that had received CPR without experiencing an NDE. This was performed decades later by Sartori<sup>13</sup>, who found that patients who reported observing their bodies during CPR could accurately describe their resuscitation, whereas those who also had CPR but did not claim to observe their resuscitation could not.

To the best of our knowledge, five prospective studies have been conducted specifically to investigate veridical OBEs through the use of planted targets in hospital rooms where cardiac arrests are either likely to occur or are medically induced. Researchers have used either static (hidden) targets, such as poster boards<sup>14,21,22</sup>, or running electronic targets (also hidden)<sup>23,24</sup>. Although some form of NDE or OBE was reported in most<sup>14,21-23</sup>, but not all of the studies<sup>24</sup>, none of the participants reported the presence of a hidden target.

## Long-term positive life changes following NDEs

All patients participating in the prospective studies of cardiac arrest-induced NDEs were assessed using the Life-Change Inventory Questionnaire developed by Ring<sup>18</sup>. This scale consists of 42 elements related to social attitude (*e.g.* acceptance of others), religious attitude (*e.g.* understanding purpose of life), attitude toward death (*e.g.* fear of death), and other qualities (*e.g.* appreciation of ordinary things).

Both Schwaninger *et al.*<sup>15</sup> and Klemenc-Ketis *et al.*<sup>25</sup> conducted follow up interviews 6 months after the NDEs. Patients with NDEs showed increases on many items of the questionnaire compared to patients who did not have NDEs<sup>15,25</sup>. For example, NDEs were more tolerant of others, more empathic, concerned with social justice, understanding of the meaning of life, appreciative of nature, and had a stronger belief in life after death<sup>15,25</sup>.

Van Lommel *et al.*<sup>10</sup> conducted both 2 year and 8 year follow up interviews with patients. At both the 2 and 8 year follow-ups, all patients recalled their experience almost exactly as they did years prior. After 2 years, there were significant differences in 13 items of the questionnaire between those that had NDEs and those that did not have NDEs. For example, patients that had NDEs felt more loving, empathic, understanding, and accepting of others. In addition, they felt they understood their purpose of life, sensed an inner meaning of life, were interested in spirituality, were less afraid of death, believed in life after death, were more interested in the meaning of life, felt they understood themselves, and had increased appreciation of ordinary things<sup>10</sup>.

Interestingly, all patients, including non-NDEs, showed increased positive changes 8 years after the cardiac arrest<sup>10</sup>. All were more empathic, understanding, more involved in family, interested in the meaning of life, and less afraid of death than 5 years prior. Overall, the positive life changes in the NDE group were more apparent 8 years later, revealing the persistence and growth of the profound transformative aspect of NDEs.

## Discussion

In this section, we discuss the strengths and limitations of psychological and physiological theories aimed at explaining the various features of NDEs. We also examine the implications of the studies of cardiac arrest-induced NDEs for the concept of non-local mind.

### Psychological theories

Psychological theories usually fall under expectation, depersonalization, dissociation, or personality factors as explanations for NDEs. In expectation-based theories, the expectation of what death will be like creates the experience, with NDEs being a psychological defense against death<sup>26,27</sup>. However, prior religious belief or knowledge of NDEs is not correlated with having an NDE<sup>12,14,15,17</sup>, although cultural and religious factors may influence the interpretation of the experience<sup>28</sup>. Regarding this issue, NDErs show significant belief in life after death following their NDE that they did not have before the experience<sup>10,15,25,29</sup>. Also, children, who are presumably less culturally conditioned with fewer expectations about death, describe NDEs that are similar to adults' descriptions<sup>30</sup>.

Other psychological theories assert that NDEs may be caused by pathological depersonalization or dissociation as a psychological defense mechanism against the threat of death<sup>26,27</sup>. However, there is no relation between likelihood of having an NDE and fear of death<sup>10,15-17</sup>. Moreover, NDErs scored higher than a control group on a dissociative scale, but their scores were much lower than those of individuals with pathological dissociative disorders<sup>31</sup>. In regard to this question, it is possible that NDErs may in fact be showing levels of dissociation that are adaptive in response to trauma. Importantly, NDErs are as psychologically healthy as non-NDErs on all measures tested, and do not differ on levels of intelligence, neuroticism, extroversion, or anxiety<sup>12,18</sup>.

### Physiological theories

One of the most popular physiological explanations is the "dying brain hypothesis", which states that NDEs are hallucinations produced by lowered levels of oxygen-hypoxia or anoxia-or an increase in carbon dioxide (i.e. hypercarbia)<sup>32-34</sup>. Evidence in favor of reduced oxygen levels comes from the rapid acceleration-induced anoxia of fighter pilots<sup>35</sup>. While their experiences include some elements of NDEs, such as tunnel vision, bright lights, and a sense of leaving the body, they also contain features that are not part of NDEs, such as jerking of the limbs, disorientation, and tingling of the extremities<sup>35</sup>. In addition, NDEs can occur in the absence of hypoxia or anoxia (as in non-life-threatening illnesses and near-accidents), and the subjective effects of hypoxia do not have much in common with NDEs<sup>1</sup>. Furthermore, when oxygen levels decrease markedly, individuals whose lungs or hearts do not work properly experience an "acute confusion state," during which they are highly confused and agitated, and have little or no memory recall. In stark contrast, during NDEs people experience lucid consciousness, well-structured thought processes, and clear reasoning<sup>14</sup>. As van Lommel *et al.*<sup>10</sup> note, if anoxia plays a central role in the production of NDEs, most cardiac arrest patients would report an NDE. Studies show that this is clearly not the case.

As for carbon dioxide, NDE-like features are rarely reported in hypercarbia. Moreover, while some found a correlation between CO<sub>2</sub> levels and the incidence of NDEs<sup>17</sup>, there have been instances in which arterial blood gases in NDErs did not reflect elevated carbon dioxide levels<sup>12,14,36</sup>.

At small doses, the anesthetic agent ketamine can induce experiences that bear some similarities with NDEs (e.g., feelings of being out of the body, believing that one has died). Ketamine is thought to act primarily by inhibiting N-Methyl-D-aspartic acid (NMDA) receptors, which normally open in response to binding of glutamate, the most abundant excitatory chemical messenger in the human brain. Jensen<sup>37</sup> has proposed that the blockade of NMDA receptors by a naturally occurring ketamine-like substance may induce an NDE. To

date, such a substance has not been found in humans. Furthermore, ketamine experiences are often frightening, producing weird images; and most ketamine users realize that the experiences produced by this drug are illusory<sup>38</sup>. In contrast, NDErs are strongly convinced of the reality of what they experienced. Additionally, many of the central features of NDEs are not reported with ketamine.

Abnormal activity in the temporal lobe (temporal lobe epilepsy; TLE) is sometimes suggested as a cause of NDEs<sup>36,39</sup>. Penfield's classic experiments with epileptic patients are frequently cited as evidence for the role of TLE in OBEs<sup>39,40</sup>. However, Penfield's experiments do not provide sufficient support for the theory that OBEs are the result of stimulation of the temporal lobe. Only two of his 1,132 patients reported feeling disconnected from their bodies<sup>41,42</sup> with vague descriptions unlike those typically reported by NDErs. Further, Michael Persinger has claimed that all NDEs can be elicited by transcranial magnetic stimulation (TMS) of the temporal lobe<sup>39,43</sup>. However, not only does his data not support his claim, but attempts at replicating his findings have failed<sup>44</sup>. In other respects, a review of the literature on epilepsy indicates that the typical features of NDEs are not associated with epileptic seizures located in the temporal lobes<sup>34</sup>. Experiential symptoms of such seizures include mental confusion, hallucinations, illusions, and negative emotional states.

Some proponents of physiological theories of NDEs<sup>40,45</sup> argue that OBE perception of events happening around the NDEr's body is simply a retrospective imaginative reconstruction based on the memory of events that the NDEr might have witnessed just before losing consciousness or while regaining consciousness. We contend that this hypothesis is incorrect since, generally, memory of events occurring just before or after loss of consciousness is either confused or totally absent<sup>1,10,46,47</sup>. It is also important to note that confusional experiences remembered by individuals as they lose or regain consciousness do not have a life-transforming impact<sup>48</sup>. In addition, many veridical OBEs have time anchors, verified by hospital staff and medical records to have occurred during the actual cardiac arrest<sup>10,12,13,49,50</sup>.

Advocates of materialist theories of the mind frequently object that even if the EEG is isoelectric, there may be some residual brain activity in deeper brain regions (e.g. the brainstem) that goes undetected because of the limitations of scalp-EEG technology<sup>51</sup>. This is possible given that current scalp-EEG technology measures mainly the activity of large populations of cortical neurons. However, as Greyson<sup>48</sup> points out, the crucial "issue is not whether there is brain activity of any kind whatsoever, but whether there is brain activity of the specific form agreed upon by contemporary neuroscientists as the necessary condition of conscious experience" (p. 4688). This form of neuroelectrical activity, which is well detected via current EEG technology, is clearly abolished by cardiac arrest.

As it has been shown that the hippocampus, a cerebral structure critically involved in the formation of new memories, is highly vulnerable to damage from anoxia<sup>6</sup>, it is unlikely that NDEs occurring in cardiac arrest can be explained by "some hypothetical residual capacity of the brain to process and store complex information"<sup>48</sup> (p. 6).

### Implications for the concept of non-local mind

It is often argued that that the findings of neuroscience studies-obtained via recording, stimulation, lesion and pharmacological methods-provide convincing support for the physicalist views that all mental functions and events can be reduced to-or are produced by-physico-chemical processes in the brain<sup>52-54</sup>. In reality, these findings only indicate that under normal circumstances, mental processes are closely associated (correlated) with neuroelectrical and neurochemical activity.

Physicalist theories of the mind cannot explain how NDErs can experience-while their hearts are stopped and brain activity is seemingly absent-vivid and complex thoughts, and acquire veridical information about objects or events remote from their bodies. In fact, NDEs in cardiac arrest suggest that mind is non-local, i.e. it not generated by the brain, and it is not confined to the brain and

the body. Rather, the brain appears to act as an interface for mind and consciousness<sup>10,20,55-57</sup>. Another implication of NDEs in cardiac arrest is that the brain normally prevents the perception of other levels of reality that are non-physical. This filtering function can be modulated during altered states of consciousness induced by various means (e.g., entheogens, various forms of breathing, meditation).

To illustrate the concept of interface with regard to the relationship between mind and brain, this organ can be compared to a television (TV) set. This device receives broadcast signals (electromagnetic waves) and converts them into image and sound. If we damage the electronic components within the TV set, we may lose the image on the screen and the sound because the capacity of the TV to receive and decode the broadcast signals is impaired. But this does not imply that the broadcast signals are actually produced by the TV set. Likewise, damage to a specific region of the brain may disrupt specific cognitive processes mediated by this cerebral structure. But such disruption does not entail that these cognitive processes are strictly reducible to neural activity in this region.

## Conclusions

The fact that enhanced mental experiences and accurate OBE perception can occur during cardiac arrest, i.e. at a time when brain activity is undetectable, strongly challenges the prevalent physicalist view that mind and consciousness result solely from brain activity. This phenomenon also suggests that the brain exerts a filtering function that usually prevents the perception and experience of non-physical levels of reality.

NDEs in cardiac arrest have huge implications since they support the revolutionary concept that mind is non-local, i.e. not produced by the brain. The acknowledgment of this concept by the scientific community could eventually contribute to a major paradigm shift in science.

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