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## Correspondence

# Exploring awareness in cardiac arrest studies: Methodological challenges



To the Editor,

We read with interest the paper of Parnia et al.<sup>1</sup> which explores awareness and recall in cardiac arrest (CA) patients. We applaud the study's ambition, with its extensive collaboration across more than 20 sites and the use of diverse measurements like EEG in such critical situations. However, we have reservations about the study's methodological rigor, result interpretation, and instances of overstatement and inadequate conceptual clarity.

First, we are concerned that the opacity of the EEG section may indicate the utilization of overly simplistic analytical methods. Indeed, it seems that visual inspection of screenshot EEG images was used to classify EEG patterns, limiting the interpretation of these important data, that would have benefited from in-depth (time-)frequency analyses. Furthermore, the authors repeatedly presuppose that an "absence of cortical brain activity" is equivalent to "suppressed EEG". Burst-suppression refers to a precisely defined pattern of isoelectric EEG alternating with higher voltage activity, that can be observed in anesthesia and anoxic states.<sup>2</sup> Such overstatement may confuse readers. Finally, the substantial proportion of missing EEG data and its potential impact on study outcomes deserve discussion. While the EEG results are intriguing, insufficient detail hinders a comprehensive understanding.

Second, the authors' use of terminology exhibits inconsistencies and ambiguities. Expressions like "heightened lucid consciousness" or "heightened reality" lack scientific precision and clarity. The absence of defined meanings leaves room for potential misinterpretation. Furthermore, the expression "emergence from coma during CPR [cardiopulmonary resuscitation]" appears paradoxical in light of the established definition of coma. Indeed, only CPR during at least one hour could then be considered. Such linguistic ambiguities can be problematic, especially in the field of near-death experiences (NDEs), which has been known to move (too) easily into the sphere of personal interpretation and belief. Finally, we reiterate our concern regarding the use of the term "recalled experience of death", originally introduced by Parnia and colleagues<sup>3</sup> and based on scientifically inaccurate definition of brain and cardiac death concepts, therefore contributing to confusion in the field, as discussed in Martial et al.<sup>4</sup>

Third, no patient did explicitly recall "*seeing image on the tablet, nor hearing the auditory stimuli*".<sup>1</sup> Since this was one of the main aims of their study, we are surprised that the authors fail to discuss this (no) result. It would have been a unique opportunity to disentangle *disconnected* from *connected* states of consciousness in near-death conditions. It is also worth mentioning that the choice of the audio cues ("*apple-pear-banana*")<sup>1</sup> to test awareness during CPR (including implicit learning) might be seen as inappropriate, given that these words are very frequent and highly representatives of their semantic category, the fruits. Therefore, we cannot dismiss that the said memory of the patient was based on their expectation, prior knowledge, or even mere chance.

Finally, the authors argue that "[...]the paradoxical finding of lucidity and heightened reality when brain function is severely disordered, or has ceased raises the need to consider alternatives to the epiphenomenon theory."<sup>1</sup> This finding is not paradoxical to us. The literature has increasingly shown that only key temporo-parieto-occipital regions<sup>5</sup> are required for consciousness to arise—not the whole brain, as testified for example by severely brain-injured patients who show signs of consciousness<sup>6</sup> and patients responding to verbal commands with the isolated forearm technique during general anesthesia. Finally, it still cannot be excluded that NDEs occur before the CA, or upon recovery.

In conclusion, this multicentric study would have been a unique opportunity to provide significant insights, but some limitations regarding the methodology and the interpretation of the results may have hindered its full potential. This is unfortunate especially since inadequate conceptual clarity, and a lack of neuroscientific understanding may potentially impact the field's reputation.

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## CRedit authorship contribution statement

**Charlotte Martial:** Writing – original draft, Writing – review & editing.  
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## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## REFERENCES

- 1.. Parnia S, Keshavarz Shirazi T, Patel J, et al. AWAreness during REsuscitation - II: a multi-center study of consciousness and awareness in cardiac arrest. *Resuscitation* 2023;191:109903. <https://doi.org/10.1016/j.resuscitation.2023.109903>.
2. Amzica F. What does burst suppression really mean? *Epilepsy Behav* 2015;49:234–7. <https://doi.org/10.1016/j.yebeh.2015.06.012>.
3. Parnia S, Post SG, Lee MT, et al. Guidelines and standards for the study of death and recalled experiences of death—a multidisciplinary consensus statement and proposed future directions. *Ann N Y Acad Sci* 2022;1511:5–21. <https://doi.org/10.1111/NYAS.14740>.
4. Martial C, Gosseries O, Cassol H, Kondziella D. Studying death and near-death experiences requires neuroscientific expertise. *Ann N Y Acad Sci* 2022;1517:11–4. <https://doi.org/10.1111/nyas.14888>.
5. Koch C, Massimini M, Boly M, Tononi G. Neural correlates of consciousness: progress and problems. *Nature ReviewsNeurosci* 2016;17:307–21. <https://doi.org/10.1038/nrn.2016.22>.
6. Monti MM, Vanhaudenhuyse A, Coleman MR, et al. Willful modulation of brain activity in disorders of consciousness. *N Engl J Med* 2010;362:579–89. <https://doi.org/10.1056/NEJMoa0905370>.

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