

# Intracranial electrical brain stimulation as an approach to studying the (dis)continuum of memory experiential phenomena

(Commentary on Barzykowski & Moulin)

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## Abstract

Déjà-vu and IAM can be induced by intracranial electric brain stimulations in epileptic patients, sometimes in the same individual. We suggest there may be different types of IAM that ought to be taken into account and provide several ideas to test the hypothesis of a continuity between IAM and déjà-vu phenomena.

## Commentary

Are déjà-vu and involuntary autobiographical memories (IAM) based on the same continuum of retrieval processes? This is the core hypothesis proposed by the intellectually stimulating paper by Barzykowski and Moulin that we will discuss, however, within the particular spectrum of déjà-vu and IAM induced by intracranial electrical brain stimulation (iEBS) in epileptic patients.

There is an undeniable proximity between déjà-vu and IAM with strong arguments set out in Barzykowski and Moulin's proposal. However, conceptual proximity does not mean mechanistic similarity. For instance, the authors emphasise that IAM are frequent, in contrast to déjà-vu, which are much rarer. One can wonder why phenomena sharing common mechanisms do not follow a correlated prevalence. How this is taken into account is not yet clear. We first call for a better definition of IAM to solve this issue. Indeed, there are also inconsistencies in the reported frequency of IAM across studies: while some studies report high frequency, of up to 20 per day (Rasmussen & Berntsen, 2011), others report only one per week or month (Moulin et al., 2014). Does such a discrepancy mean that there are different types of IAM, right now poorly differentiated in the literature?

Barzykowski and Moulin mainly focus on IAM occurring several times a day during mind-wandering due to the associative nature of memory processes (Plimpton et al., 2015). But what about IAM like the memory of Tante Leonie's home in Combray, which popped up in Marcel Proust's mind thanks to a madeleine? Proust's IAM was sufficiently intrusive, unusual and disturbing, that he wrote 2,400 pages largely inspired by this phenomenon. And what about memories that are just as intense and intrusive but without any associative trigger in the environment? We argue that such "pop-up" IAM are rare and do not correspond to the first type of "mind-wandering" IAM. These pop-up IAM seem to have a prevalence close to that of the déjà-vu experience reported in the healthy population. Indeed, pop-up IAM not triggered

by an environmental or goal-directed memory cue are a minority (approximately 15%) of the IAM experienced in everyday life of healthy subjects (Ball & Little, 2006).

Distinguishing between the two types, “pop-up” and “mind-wandering” IAM (this terminology may need to be revised), may be all the more relevant as they do not seem to serve the same purpose. While reminiscing autobiographical memory during mind-wandering episodes is assumed to play a fundamental role in memory consolidation (Wamsley, 2019) and possibly in personality construction, whether pop-up IAM have an adaptive or ecological function is not obvious. This latter, in terms of functionality, seems again closer to *déjà-vu*, which Barzykowski and Moulin describe as the result of a metamemory error. Pop-up IAM may also lead to some level of surprise, alike to *déjà-vu*.

*Déjà-vu* and experiential phenomena in epileptic patients, either occurring spontaneously during seizures or after iEBS, offer informative snapshots into these highly subjective memory phenomena, which can be phenomenologically very rich (Curot et al, 2018). They are important to complement cognitive psychology experiments, to discuss the reality of theoretical models, and to get clues about the physiological mechanisms underlying such phenomena.

Like the memory of Tante Leonie’s home for Proust, epileptic subjects may also experience pop-up IAM after an EBS and get literally invaded by such memories, unexpectedly and involuntarily (for verbatim details, see Curot et al., 2017 and corresponding online database <https://figshare.com/s/923f93555a0ce51426e4> of >370 experiential phenomena reported in >110 patients; Bartolomei et al., 2017). Their attention is suddenly projected towards their internal world, leading to the proposition of mental diplopia, or a dissociation process, in these patients. Patients often spontaneously describe a feeling of temporal and/or spatial projection to their own past. During these pop-up IAM, the intention to remember is absent, which may explain why it is such a surprise: there is no *madeleine* or environmental trigger. Interestingly, while Barzykowski and Moulin mention that one of the limitations of the literature is that *déjà-vu* and IAM are studied separately, the model of *déjà-vu* and IAM induced by EBS allows studying them together in the same patients. We, therefore, propose to use this approach to investigate the possible continuum between *déjà-vu* and IAM. From the observations made in epileptic patients after iEBS, we propose that there may be different types of IAM, including pop-up IAM, which may be closer to *déjà-vu* than the other type of mind-wandering IAM. We agree that *déjà-vu* and IAM could be part of a continuum involving retrieval processes, but that this could be the case for a certain type of IAM only, those popping up in mind without any obvious memory cue.

To investigate this hypothesis, we could (1) calculate the intra-individual correlation between the number of IAM and *déjà-vu* induced by iEBS in the same brain region. (2) investigate the correlation between the prevalence of these pop-up IAM and experiential phenomena like *déjà-vu* occurring during spontaneous seizures, at the individual and group levels. If pop-up IAM and *déjà-vu* experiences rely on shared underlying mechanisms, we expect a significant positive correlation between their prevalence, but no correlation with mind-wandering IAM. (3) iEBS are performed during intracranial EEG recordings, enabling trapping the neural correlates of the fleeting moments corresponding to IAM and *déjà-vu* (Barbeau et al, 2005; Bartolomei et al, 2012). Functional connectivity networks during each phenomenon could be compared to search for common or different connectivity patterns. Each network could also

be compared to those of episodic memory and mind-wandering to assess the specificity of pop-up IAM. (4) Finally, we had proposed a classification in 2017 of the different types of memories induced by EBS according to their content and current main conceptions of long-term memory (Curot et al. 2017, see online database). This classification could be reviewed in light of the propositions made by Barzykowski and Moulin to check how they fit with the verbatim of the patients.

### **Competing interest statement**

The authors do not have any competing interests to declare.

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