The contribution of evoked variability quenching to working memory reactivations

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Stimulus information maintenance during working memory tasks has traditionally been linked to selective persistent activity in prefrontal cortex neurons. This view has recently been under debate. In novel imaging studies conducted in humans the failure to detect stimulus information during memory periods has been interpreted as evidence for memory storage through activity-silent mechanisms (i.e., in synaptic patterns changes, possibly through short-term synaptic plasticity) (LaRocque *et al.*, 2013). Moreover, these studies have shown that non-specific visual (Wolff *et al.*, 2017; Wolff *et al.*, 2015) or transcranial magnetic (Rose *et al.*, 2016) stimuli could reveal memory-specific information that was otherwise undetected by linear decoders.This increase in decodability following non-specific stimuli is being interpreted as memory reactivations from the so-called "hidden states".

In this study, we argue that stimulus-driven decrease in brain activity variability (Churchland et al. 2010) offers an alternative explanation. Intuitively, an increase in signal-to-noise ratio (SNR) can be achieved by an increase in signal, but also by a decrease in noise. We used simulated data to illustrate this effect, and to relate it to single-trial baselining procedures typically used in EEG decoding studies. Our simulations showed that both within-trial and across-trial variability reductions had an impact in decoder accuracy following the stimulus, provided there was stimulus signal at the time of stimulation or at the time taken for single-trial baseline. We next re-analyzed 4 existing datasets (Wolff *et al.*, 2017; Rose *et al.*, 2016; Foster *et al.*, 2016; Wolff *et al.*, 2015) and asked if both visual and magnetic stimuli could decrease the variability of EEG activity experimentally. We found that both stimulus types decreased mostly within-trial variability. Interestingly, this decrease was aligned with decodability increase associated with "memory reactivation" in the original papers. We thus show that quenching of EEG within-trial variability after stimulus onset could partly underlie previous findings: the non-specific evoked activity produced by external impulses could reduce noise measured with EEG, therefore facilitating information decoding, but without any real increase in stimulus-selective signal. We further warn about the importance of baselining procedures for proper interpretation of the results.

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References

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