Reconstructing Stimulus Identity and Context Binding from the CDA

Keywords: visual short term memory, working memory, inverted encoding model, context binding, contralateral delay activity, EEG

Authors: Cai, Y., Samaha, J., Postle, B.R.

Abstract:

A recent fMRI study comparing working-memory activity for one motion patch (1M) vs. 3 motion patches (3M) vs. 1 motion and 2 color patches (1M2C) showed a pattern of parietal delay-period activity of 1M = 1M2C < 3M, suggesting that this activity was sensitive to demands on context binding rather than on stimulus representation per se (Gosseries, Yu, et al., 2018). Might the same be true for the contralateral delay activity (CDA) ERP component? To address this question we applied multivariate inverted encoding modeling (IEM) to EEG data collected while subjects performed a delayed recognition (DR; a.k.a. “change detection”) task. First, to train IEMs, subjects performed a perceptual task that entailed viewing a series of variously oriented black bars. The DR task began with an arrow cuing that trial’s critical hemifield, followed by two balanced arrays of 1 or 3 items, one in each visual field, with trial conditions of 1 orientation (1O), 3 orientations (3O), and 1O + 1 color patch (1C) + 1 luminance patch (1L; i.e., "1O1C1L" trials); 1O vs 1O1C1L operationalized load, and 1O1C1L vs. 3L operationalized context binding. DR performance followed the pattern 1O > 1O1C1L > 3O, with Cowan’s ks of for 2.13(SD=0.32)1O1C1L, and of 1.69(SD=0.42) for 3O. Before computing the CDA, we compared voltages from electrodes contralateral vs. ipsilateral to the cued hemifield, and noted patterns of increasing negativity from 1O < 1O1C1L < 3O from the final 500 msec of the 900 msec delay period, in both sets of electrodes. Subtracting ipsilateral from contralateral signals to compute the CDA removed the 1O1C1L vs. 3O difference, suggesting that this subtraction may remove some signal related to context binding. To assess the informational content of the CDA, we sought to reconstruct representations of orientation stimuli by feeding the subtracted values from contralateral electrodes into the IEM of orientation constructed from the perceptual task (perceptual IEM trained with (unsubtracted) voltages from the same electrodes as contralateral electrodes from DR task). Results revealed successful reconstruction of remembered orientations from the 1O and from 1O1C1L conditions, suggesting that the CDA can contain information that is specific to remembered stimuli. Furthermore, the width of the 1O1C1L reconstruction was broader than that from 1O trials, indicating a load-related decline in the precision of the neural representation. Finally, the superior IEM reconstruction of remembered orientation from 1O1C1L than from 3O trials suggests that the CDA contains information about the fidelity of stimulus representation that is not reflected in the first-order index of its magnitude.