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Short communication

Suppression of no-longer relevant information in Working Memory: An alpha-power related mechanism?

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ABSTRACT

Selective attention can enhance Working Memory (WM) performance by selecting relevant information, while preventing distracting items from encoding or from further maintenance. Alpha oscillatory modulations are a correlate of visuospatial attention. Specifically, an enhancement of alpha power is observed in the ipsilateral posterior cortex to the locus of attention, along with a suppression in the contralateral hemisphere. An influential model proposes that the alpha enhancement is functionally related to the suppression of information. However, whether ipsilateral alpha **power** represents a mechanism through which no longer relevant WM representations are inhibited has yet not been explored. Here we examined whether the amount of distractors to be suppressed during WM maintenance is functionally related to alpha **power** lateralized activity. We measure EEG activity while participants **(N = 36)** performed a retro-cue task in which the WM load was varied across the relevant/irrelevant post-cue hemifield. We found that alpha activity was lateralized respect to the locus of attention, but did not track post-cue irrelevant load. Additionally, non-lateralized alpha activity **increased with** post-cue relevant load. We propose that alpha lateralization associated to retro-cuing might be related to a general orienting mechanism toward relevant representation.

Selective attention enhances efficient use of limited storage resources of WM by facilitating the encoding of relevant information and preventing distractors from consuming capacity (Vogel, McCollough, & Machizawa, 2005). Alpha oscillations have been functionally linked to a filtering mechanism through which an increasing amount of distractors would be inhibited by a power enhancement (Bonnefond & Jensen, 2012). However, WM experiments have reported divergent results. Using a change detection paradigm in which participants were asked to memorize the items in the hemifield signaled by a preceding cue (pre-cue), some authors found that ipsilateral occipital alpha activity scaled with the number of distractors (Sauseng et al., 2009), while others have failed to find such modulation (Vissers, van Driel, & Slagter, 2016).

Selective attention can also operate over information that is no longer present in the environment, as demonstrated by studies where a cue presented after (i.e. retro-cue) rather than before encoding (i.e. pre-cue) enhances memory performance (Griffin & Nobre, 2003). Retro-cue studies find that the selection of a lateralized WM representation results in a reduction of alpha power in the contralateral occipital cortex along with an ipsilateral enhancement (Poch, Capilla, Hinojosa, & Campo, 2017). A question that remains unanswered is whether ipsilateral alpha oscillations represent a mechanism through which no longer relevant WM representations are inhibited. In this EEG study, we orthogonally manipulated the amount of items that becomes relevant or irrelevant after retro-cueing to elucidate the role of alpha lateralization in the inhibition of WM representations.

1. Methods

1.1. Participants

Thirty-six adult subjects [mean age, 20.86; standard deviation, 2.71; range, **19**–32 years; 20 females], without any history of neurological or psychiatric illness gave written consent, in accordance with the Declaration of Helsinki. Participants were right-handed according to the Edinburgh Handedness Inventory (Oldfield, 1971).

Experimental task: The experimental task is illustrated in Fig. 1. Stimuli characteristics are as in Poch, Carretie, and Campo (2017). The sample memory set consisted in either one or two rectangles in each hemifield with different orientations. After a delay interval,

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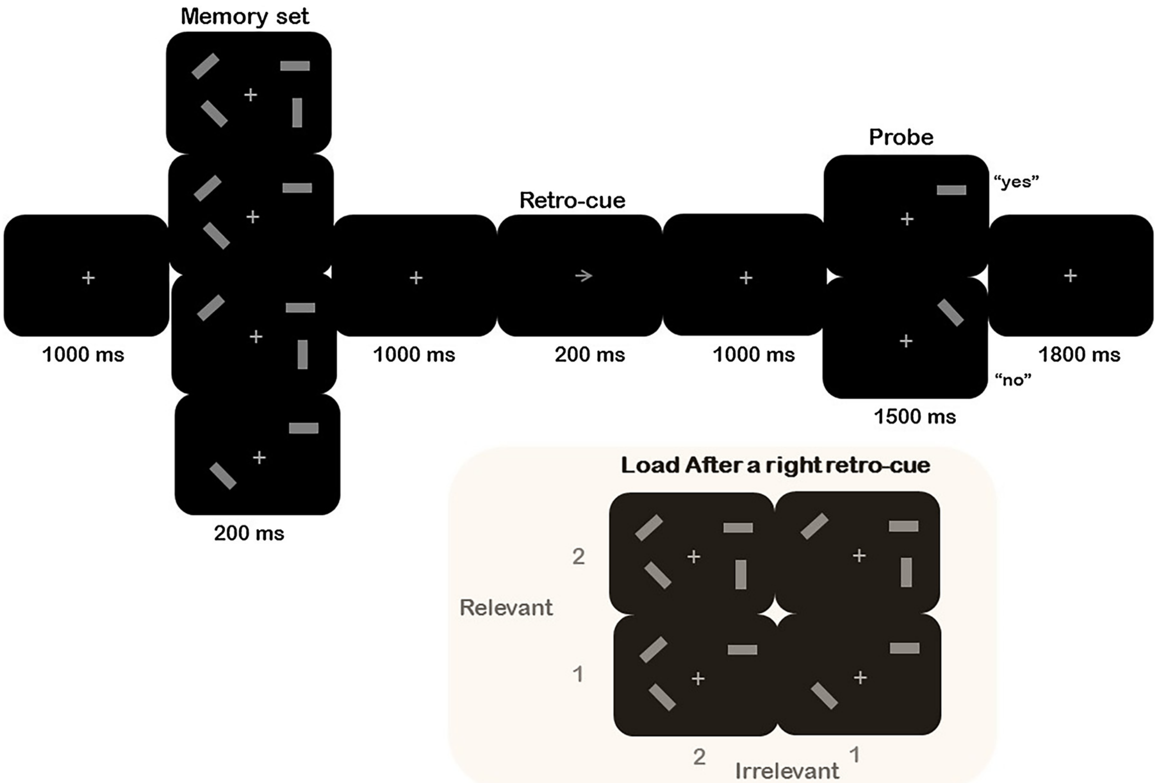

Fig. 1. Schematic illustration of the experimental task.

participants were presented with a spatial cue (i.e. retro-cue) indicating the relevant hemifield (validity 100%) (Lepsien, Griffin, Devlin, & Nobre, 2005). Load in the post-cue relevant hemifield could be one or two items, and load in the irrelevant hemifield could be one or two items. After another delay, participants were presented with a single rectangle and were required to respond whether the orientation of the probe was the same as at encoding. A total of 100 trials for each of the 4 conditions were presented.

1.2. EEG recording and preprocessing

Data were acquired using a Biosemi Active Two system with 128 electrodes. Additional EOG −vertical and horizontal- electrodes and a tip-nose reference were also recorded. The data were digitalized at a sampling rate of 2048 Hz and filtered between 0.16 Hz and 100 Hz. Finally, data were offline re-referenced to the nose tip and down-sampled to 250 Hz in MATLAB using Fieldtrip (www.fieldtriptoolbox.org). Subsequent analyses were also carried with Fieldtrip toolbox.

1.3. Time-frequency analysis

Time-frequency representations of the data were made on epoched artifact free data. The analysis was done in 4200 ms epochs- 2200 ms before cue onset and 2000 ms after cue onset. Epochs were visually inspected for artifacts. The eye blink component was extracted out of the signal using Independent Component Analysis ('runica' EEGlab implemented in Fieldtrip.) Time-frequency representations of individual trials were then calculated using Morlet wavelet analysis with a wavelet width set to 7. Trials were then averaged for each condition −right and left- and normalized to decibels using a baseline from −500 to −200 ms before memory array presentation (10*log*10 (power/baseline)). Subsequently, activity contralateral and ipsilateral to the attended representation was calculated, by collapsing the left condition electrodes with a mirrored version of right condition electrodes. Contralateral activity is then represented in right electrodes by averaging right electrodes of the left condition with left electrodes of the right condition. In analog way, ipsilateral activity is represented in left electrodes.

1.4. Statistical analysis

Accuracy and reaction times (RTs) were submitted to a 2 × 2 ANOVA (Relevant load x Irrelevant load).

Statistical analysis of alpha power was performed using non-parametric cluster analysis as implemented in fieldtrip (Maris & Oostenveld, 2007) which controls for Type I error. First, time-frequency data were averaged in the alpha range (8–14 Hz). A *t*-test was then computed between each sensor-time point. P-values below 0.05 were used to form clusters of adjacent time points and electrodes. A minimum of two channels were used to form a cluster. Cluster-level statistic was calculated by summing t-values within a cluster. Significance of the cluster statistic was evaluated by a permutation test. The permutation distribution was obtained by randomly assigning the data to two subsets and calculating the maximum cluster statistic. A histogram of cluster statistics was obtained by repeating the previous step 1000 times. Cluster p-value was then obtained as the proportion of randomizations that are above the observed cluster-level statistic.

2. Results

2.1. Behavioral results

Accuracy and reaction times (RTs) are shown in Fig. 2. We found a significant main effect of Relevant Load for accuracy ($F(1, 35) = 33.73$, $p < 0.001$) and RT ($F(1, 35) = 22.7$, $p < 0.001$), but not of Irrelevant Load [accuracy ($F(1, 35) = 0.146$, $p > 0.05$); RT ($F(1, 35) = 4.06$, $p > 0.05$)].