Behavioural Brain Research 297 (2016) 231–240

Contents lists available at ScienceDirect

Behavioural Brain Research

journal homepage: www.elsevier.com/locate/bbr

Research report

N270 sensitivity to conflict strength and working memory: A combined ERP and sLORETA study

Sébastien Scannella[a,b,*], Jérémie Pariente[b], Xavier De Boissezon[b], Evelyne Castel-Lacanal[b], Nicolas Chauveau[b], Mickaël Causse[a], Frédéric Dehais[a], Josette Pastor[b]

[a] DCAS, ISAE, Université de Toulouse, 10 Avenue E. Belin, 31055 Toulouse cedex 4, France
[b] INSERM, UMRS 825, Université de Toulouse, CHU Purpan, Pavillon Baudot, 31024 Toulouse cedex 3, France

HIGHLIGHTS

- We create an audiovisual conflict task with simultaneous target and distractor.
- We assess the N270 sensitivity to the conflict strength and the working memory.
- The conflict cost is higher for the auditory target than for the visual target.
- The N270 is sensitive to the conflict strength and the load in working memory.
- Conflict processing and working memory share common neural subtract.

ARTICLE INFO

Article history:
Received 29 April 2015
Received in revised form
12 September 2015
Accepted 5 October 2015
Available online 23 October 2015

Keywords:
N270
Supramodal conflict processing
Working memory
Executive attention
Dorsolateral prefrontal cortex
sLORETA

ABSTRACT

The event-related potential N270 component is known to be an electrophysiological marker of the supramodal conflict processing. However little is know about the factors that may modulate its amplitude. In particular, among all studies that have investigated the N270, little or no control of the conflict strength and of the load in working memory have been done leaving a lack in the understanding of this component. We designed a spatial audiovisual conflict task with simultaneous target and cross-modal distractor to evaluate the N270 sensitivity to the conflict strength (i.e., visual target with auditory distractor or auditory target with visual distractor) and the load in working memory (goal task maintenance with frequent change in the target modality). In a first session, participants had to focus on one modality for the target position to be considered (left-hand or right-hand) while the distractor could be at the same side (compatible) or at opposite side (incompatible). In a second session, we used the same set of stimuli as in the first session with an additional distinct auditory signal that clued the participants to frequently switch between the auditory and the visual targets. We found that (1) reaction times and N270 amplitudes for conflicting situations were larger within the auditory target condition compared to the visual one, (2) the increase in target maintenance effort led to equivalent increase of both reaction times and N270 amplitudes within all conditions and (3) the right dorsolateral prefrontal cortex current density was higher for both conflicting and active maintenance of the target situations. These results provide new evidence that the N270 component is an electrophysiological marker of the supramodal conflict processing that is sensitive to the conflict strength and that conflict processing and active maintenance of the task goal are two functions of a common executive attention system.

1. Introduction

In the spatial domain, the human attentional system often has to integrate concurrent stimulation from different modalities (e.g., visual and auditory) at one single location, which helps spatial orienting [22] and allows a plausible interpretation of the world. Although this integration is efficient most of the time, the spatial discrepancy between two modalities may lead to perceptual illusions like those observed in the ventriloquism [3] where the vision (puppet's mouth movements) "captures" the sound [35]. Since the princeps work of Colavita [7], the visual dominance over other modalities and particularly over hearing in most of spatial tasks has

* Corresponding author at: DCAS, ISAE, 10 Avenue E. Belin, 31055 Toulouse cedex 4, France.
E-mail address: s.scannella@isae.fr (S. Scannella).

http://dx.doi.org/10.1016/j.bbr.2015.10.014
0166-4328/

been largely demonstrated (for a review see [14]). Consequently, inhibiting a visual distractor when focusing on an auditory target in spatial tasks often implies a higher behavioral cost than the reciprocal – at least when visual and auditory stimuli are equisalient and well localized [1,4]. Over the last decades several researchers have tackled the neural and electrophysiological correlates of the conflict processing. It has been proposed that the N200 and N270 components of the event related potentials (ERPs) correspond to the electrophysiological markers of the conflict monitoring [11,13,30] and conflict processing [33,34,39] respectively. The studies focusing on the N200 revealed that this component is generated by the dorsal anterior cingulate cortec (dACC) (for a review see [13]). In parallel, Zhang et al. [39] showed that a N200 associated with a subsequent N270 could be elicited by the incongruent situation in a visual matching task. Using the same task in a fMRI study [38], they showed that conflicting information increased activation in the ACC (BA 24/32) together with the right dorsolateral prefrontal cortex (DLPFC, BA 9/46). Along with the strong effective connectivity existing between the ACC and the DLPFC [31], these results suggest that the N270 could correspond to a downstream process – based upon afferent ACC signal – that takes place within the DLPFC to select the appropriate motor response.

Unlike the studies of the N200 component, the study of the N270 has essentially been done using sequential *Same Different Judgment* (SDJ) tasks. In these tasks, a first stimulus (S1) is presented and followed by a second stimulus (S2) some hundred milliseconds later that is either the same (match) or different (mismatch) in a given dimension. The matching comparison has been assessed over different modalities and dimensions like the crossmodal gender match [34,25], visual color or shape match [32], number magnitude [16], arithmetic conflicts [33], and spatial matching [18,36]. All these studies have shown that the mismatch condition elicited a large negative amplitude in the fronto-central region of the scalp (although some authors [18,23] have found a more parietal topography) around 270 ms after the onset of S2. This component has been since called supramodal (i.e., independent of the stimulus modality) conflict processing component. As reported by Zhang et al. [37], one problem with the sequential SDJ tasks is that comparing the S2 stimulus to the previous S1 is necessarily a sequential process. Hence, the effects over the N270 observed in the aforementioned spatial mismatch studies could result from a comparison process between a cued attribute of a stimulus and a subsequent target stimulus – referred to as the "template mismatch" by Folstein and Van Petten [13] – than about a stimulus or response conflict processing between two competitive sensory-motor plans.

Based on this work, some authors have tackled the question to what extent the conflict-related N270 amplitude is modulated by the experimental context. To our knowledge only selective attention and cumulative mismatch effects have been evaluated. First, it has been shown that the N270 amplitude could be modulated by selective attention [32,18,37]. In these studies, the mismatch between S1 and S2 was assessed for both a relevant attribute of the visual stimulus (e.g., the shape) and an irrelevant one (e.g., the color) and led to N270 effects in both cases (i.e., larger N270 amplitude within the mismatching condition) albeit weaker within the irrelevant condition. This result indicates that mismatches in task-relevant and task-irrelevant dimensions are processed automatically and independently. In another study, Bennett et al. [2] found that the presentation of a visual distractor enhanced the N270 amplitude both in a perceptual match and mismatch conditions compared to situations with no distractor. They concluded that the distractors may differentially affect the N270 through the generation of task-irrelevant mismatch responses. Finally, Wang et al. [32] showed no effect of cumulative relevant mismatches over the N270 amplitude when it concerned two attributes of a same visual stimulus (i.e., shape + color) compared to the situations with only one attribute that mismatched. Instead, they found that the conjunction condition elicited an additional negative peak following the N270, leading to the conclusion that the two mismatches have been processed successively.

These findings provide crucial information about the N270 characteristics and conflict processing, however, there are still several questions that need answers regarding this component. One of a great importance is to know whether the N270 is sensitive to the conflict strength. Indeed, research has often provided evidence that the N270 is an electrophysiological marker of the supramodal conflict processing but no indication about its sensitivity to the strength of the conflict for task-relevant stimuli has been provided yet. In addition, in all conflict tasks, the active maintenance of the pertinent attributes is mandatory to achieve the goal. Thus, if the N270 is generated by the DLPFC – as already suggested [38] – it is legitimate to consider that manipulating the working memory in terms of active maintenance levels of the relevant attributes in a conflict task could interfere with the conflict processing at the electrophysiological level namely via N270 modulations.

In the present study, we considered Zhang et al. [37] argument – regarding the sequential presentation used in most of the SDJ tasks – and proposed to investigate the electrophysiological mechanisms underlying the spatial audiovisual conflict with simultaneous cross-modal target and distractor presentation. More precisely, we first evaluated the responsiveness of the N270 to the strength of the conflict by manipulating the target and distractor modalities. According to the literature [1,4,7,14] the visual dominance should lead to a larger behavioral conflict cost for the auditory target with a visual distractor than for the visual target with an auditory distractor. Thus we hypothesized that a larger N270 amplitude for the stronger conflict would reflect a conflict processing cost at the electrophysiological level. Additionally, we evaluated the impact of increasing the target maintenance effort over the N270 using a target-modality switching task to dissociate working memory from conflict processing effects. It was expected that keeping the current target-modality in working memory within a two target-modality conflict task could interfere with the conflict processing observed in a single target-modality task. This would be observed as an increase in the conflict cost at the behavioral level, associated to larger N270 conflict effects. Finally, a source localization analysis was used to pinpoint the N270 cortical generators.

2. Method

2.1. participants

Sixteen healthy volunteers (8 women, mean age: 50.1, SD: 5.8) received a financial compensation for participating in this study. All were right-handed, as measured by the Edinburgh Handedness Inventory [24] and native French speakers, with normal or corrected-to-normal vision and normal hearing. No participant had a history of neurological disease, psychiatric disturbance or substance abuse, or taking psychoactive medications. This research was approved by the French "Southwest and Overseas Person Protection Committee number 1" and was conducted in accordance with the Declaration of Helsinki.

2.2. Spatial audiovisual conflict tasks

Stimuli were delivered with Presentation software (Neurobehavioral system®). Auditory stimuli were 1000 Hz normalized pure tones (78 dB SPL) presented *via* binaural earplugs (Nordic-NeuroLab) and visual stimuli were filled white circles (2-degree diameter), presented at a constant angle of 15 degrees from a white central fixation cross on an ACER 17″ monitor placed one meter