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Event-related P3a and P3b in response to unpredictable emotional stimuli

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Abstract

In natural situations, unpredictable events processing often interacts with the ongoing cognitive activities. In a similar manner, the insertion of deviant unpredictable stimuli into a classical oddball task evokes both the P3a and P3b event-related potentials (ERPs) components that are, respectively, thought to index reallocation of attentional resources or inhibitory process and memory updating mechanism. This study aims at characterising the influence of the emotional arousal and valence of a deviant and unpredictable non-target stimulus on these components. ERPs were recorded from 28 sites during a visual three-stimulus oddball paradigm. Unpleasant, neutral and pleasant pictures served as non-target unpredictable items and subjects were asked to realize a perceptually difficult standard/target discrimination task. A temporal principal component analysis (PCA) allowed us to show that non-target pictures elicited both a P3a and a P3b. Moreover, the P3b component was modulated by the emotional arousal and the valence of the pictures. Thus, the memory updating process may be modulated by the affective arousal and valence of unpredictable disturbing stimuli, even if the task does not require any explicit emotional categorization.

Keywords: Emotion; ERPs; P3b; P3a; Oddball task; Implicit categorization

1. Introduction

In daily life, unpleasant and pleasant stimuli occurrences are unpredictably distributed in time and often disrupt ongoing cognitive activities. The event-related potentials (ERPs) that reflect the interruption of a current cognitive task by an unpredictable stimulus is typically studied through the three-stimulus oddball paradigm, i.e. through the insertion

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of perceptually deviant distracters into a sequence of target and standard stimuli during a classical oddball task. In this case, non-target deviant stimuli that disrupt the ongoing oddball task generate both a large fronto-central P3a or Novelty P3 (the two components being the same brain potentials, Simons et al., 2001) and a later parietal P3b (Spencer et al., 1999, 2001; Goldstein et al., 2002). The functional significance of the P3a is not as well understood as that of the P3b. Indeed, the former component could reflect involuntary switching of attention (or attentional reallocation) to distraction from the primary task (Polich, 2003). Another interpretation is that the P3a could reflect the inhibition of response processes that normally follow the detection of target stimuli (Goldstein et al., 2002). The P3b is thought to reflect immediate memory mechanisms triggered when the mental model or schema of the stimulus environment is refreshed and updated (Donchin and Coles, 1988). The wide corpus of studies dealing with these two components has mainly focused on attentional, stimulus probability structure or task structure-related variables that might influence their elicitation and/or modulation. Nonetheless, P3a and P3b have also been identified as two successive but overlapping components triggered during an emotional reaction to a stimulus (Halgren and Marinkovic, 1995). Then, it would be interesting to examine the elicitation and/or modulation of the two above mentioned ERPs components in response to unexpected non-target stimulations with different emotional value.

Using other paradigms than the three-stimulus oddball, previous data suggest that a categorization task based on emotional features can also evoke both the P3a and the P3b components. Indeed, in Campanella et al. (2002) study, a cognitive and emotional context was established by a negative facial expression and subjects had to point out, as quickly and as accurately as possible, the occurrence of a deviant stimulus (the same face with another facial expression). The deviance detection, explicitly based on the emotional content of the stimulus, evoked both the P3a and the P3b components. However, since these authors exclusively used sad and fearful facial expressions, this study did not provide information regarding the modulation of the two components as a function of the emotional valence dimension. In another study exploring the influence of the emotional load of pleasant (phenylethylalcohol, rose) and unpleasant (butyraldehyde, rancid butter) odours on chemosensory event-related potentials, Pause and Krauel (2000) showed larger P3b amplitude to pleasant odours than to unpleasant ones, whereas the amplitude of the P3a did not significantly differ between the odours valence's levels. During the EEG recordings, the subjects had to identify the two odours. However, prior to the recordings, they had to judge the valence and the intensity of the odours in an explicit manner, which might have influenced the subsequent identification task. In other words, it can not be definitively excluded that this identification was sustained by an emotional categorization. In such a case, these two studies showed that the cognitive processing reflected by the P3a and the P3b may be triggered by the explicit evaluation of the emotional load of the stimuli.

However, when an emotional stimulation occurs, individuals are usually not involved in an explicit affective categorization task. Thus, it would be relevant to examine the influence of the affective value of the stimuli on the elicitation and/or modulation of the P3a and the P3b, when the task does not require an explicit emotional categorization. Data exist when the subject is passively viewing emotional faces or pictures. For instance, Kayser et al. (2000) studied the influence of the emotional load of pictures of patients with dermatological diseases (unpleasant condition) as compared to these same faces after surgical treatments