Article

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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

(neutral condition). Their analyses showed that an early and a late P3 were evoked by such an implicit evaluation task and were both sensitive to the emotional load of the faces, with greater amplitudes in response to the unpleasant ones. Unfortunately, both components were defined on the basis of their peak latency and were most positive at parietal sites. Thus, it can not be concluded that these components are the topographically distinctive fronto-central P3a and parietal P3b. Moreover, the presence of unpleasant and neutral stimulations only did not allow to extract information about the influence of the valence dimension on these components. In the same vein, Keil et al. (2002) reported the elicitation of both an early and a late P3 while subjects passively viewed unpleasant, neutral or pleasant pictures. Both components were modulated by the emotional arousal dimension of the stimulus, since unpleasant and pleasant pictures evoked higher positivities than neutral ones. However, the same authors mentioned that the posterior–superior sites contributed the most to the potentials of both the early and the late P3. Consequently, it remained unlikely that the early P3 described by these authors could represent the fronto-central P3a. Recently, using homogenous arousing stimuli across valence levels and considering the topographical aspect of ERPs, Delplanque et al. (2004) showed that both a P3a and a P3b could be evoked by emotional target pictures in a classical oddball task, the categorization being merely based on a rare/frequent distinction. Moreover, although the P3a did not differ significantly between the emotional conditions, the P3b component was sensitive to the valence dimension of the stimulations. Indeed, the authors found differences in the scalp topography of the P3b amplitude between pleasant and unpleasant conditions. In sum, when the task is not based on an explicit emotional categorization, as it is the case in the majority of the ecological emotional situations, target stimulations processing still involves cognitive processes related to the reallocation of attentional resources or inhibitory process (indexed by the P3a) and context or memory updating (indexed by the P3b). Moreover, the updating process seems to integrate the valence of the target even if the valence categorization is implicit.

To summarize, all these data pointed out the fact that a P3a and a P3b can be elicited during the processing of target emotional stimulations, whether the subject is engaged in an explicit emotional categorization or not. However, as underlined above, in natural situations, occurrences of emotional stimulations are unpredictably distributed in time and often disrupt ongoing cognitive activities. Such situations can be advantageously studied by the introduction of unpredictable non-target emotional stimulations in a three-stimulus oddball task. The main objective of the present study is then to investigate whether the P3a and the P3b would be elicited and modulated in response to deviant unpredictable emotional and neutral pictures introduced in a oddball paradigm in which the explicit task does not require any emotional categorization.

2. Methods

Seventeen right-handed healthy undergraduate female students (21.7 ± 2.2 years) were included in the study. They all had normal or corrected-to-normal vision. Prior to the experiment, participants were given questionnaires to test their handedness (Hécaen's test, 1984) and to verify that they had no history of neurological or psychiatric disorder, or drug abuse.

The oddball task comprised a total of 1200 stimuli, divided in three conditions: simple geometric surfaces served, respectively, as standard ($n = 960$) and target ($n = 120$) whereas highly deviant complex pictures ($n = 120$) served as novels. This oddball sequence consisted of 4 blocks of 240 standard (std), 30 target (tgt) and 30 novel (n) stimuli, each block being separated by brief rest periods. All the stimuli were randomised within each block for each participant and the sequence of block presentation was counterbalanced across subjects. In order to maximize the probability to obtain a clear and reliable P3a, a difficult target/standard discrimination task was built (Katayama and Polich, 1998). Thus, within each block, the standard stimulus was one of four blue geometric surfaces (square, circle, triangle and cross) and small target/standard differences were obtained by an increase of 5% of the wide of the surface from the standard to the target.

Novel pictures (800 × 600 pixels) were taken from the International Affective Picture System (IAPS, Lang et al., 1988) and were distributed into three groups of 40 pictures (novel unpleasant, nU; novel neutral, nN and novel pleasant, nP).[1] They were selected in such a way that they all differed significantly in the valence dimension (mean: nU = 2.2, nN = 5, nP = 7.3; $F(2, 117) = 1067.62$; $P < 0.001$). In the arousal dimension, the unpleasant and the pleasant pictures both differed from the neutral ones (mean: nU = 6, nN = 2.7, nP = 6.1; $F(2, 117) = 699.33$; $P < 0.001$) but did not significantly differ between each other. Moreover, the 120 pictures were distributed in the 4 blocks (each block contained 10 nU, 10 nN and 10 nP) in such a way that (1) the mean activation and valence level of the three groups did not differ from one block to another, and (2) in each block, the mean activation and valence levels corresponded to those of the above global selection.

Standard, target (both occupying about 5 degrees of horizontal angle) and novel pictures (occupying about 15 degrees of horizontal visual angle), were presented on the centre of a computer screen (17″) on a background composed of small random dots of different colours (800 × 600 pixels). The duration of novel pictures presentation was fixed at 750 ms whereas standard and target geometric shapes were presented with a duration of 500 ms. The stimulus-onset asynchrony varied randomly between 900 and 1000 ms.

Electroencephalographic (EEG) activity was recorded at 28 electrode sites of the extended 10–20 system (Fp1/2, AF3/4, Fz, F3/4, F7/8, FC3/4, Cz, C3/4, CP3/4, Pz, P3/4, T7/8, TP7/8, P7/8, Oz, O1/2) using tin electrodes referenced to linked-earlobes with a forehead ground (impedance <5 kΩ). Four additional electrodes were placed at the outer canthi of each eye and above and below the right eye for a bipolar recording of the electro-ocular activity. The EEG was recorded at a sampling rate of 256 Hz. The high–low bandpass was set between 0.016 and 30 Hz. Eye-movement artefacts were corrected from the EEG by a dynamic

[1] The IAPS identification numbers are the following: unpleasant pictures: 1070, 1310, 2053, 2900, 3051, 3061, 3140, 3160, 3180, 3261, 3550, 4621, 6212, 6410, 6610, 6821, 6831, 6940, 7361, 8230, 9040, 9042, 9050, 9160, 9181, 9252, 9300, 9320, 9405, 9415, 9417 ,9420 ,9421, 9433, 9520, 9561, 9570, 9571, 9611, 9921. Neutral pictures: 2190, 2381, 2440, 2480, 2570, 2840, 5130, 5510, 5530, 5740, 6150, 7000, 7002, 7004, 7006, 7009, 7010, 7020, 7031, 7035, 7040, 7050, 7060, 7080, 7090, 7100, 7110, 7130, 7140, 7150, 7175, 7185, 7187, 7217, 7224, 7235, 7490, 7491, 7590, 7950. Pleasant pictures: 4520, 4535, 4572, 4599, 4640, 4658, 4659, 4660, 4670, 4672, 5270, 5460, 5470, 5480, 5621, 5623, 5629, 5910, 7270, 7502, 8030, 8033, 8034, 8041, 8080, 8090, 8161, 8170, 8180, 8190, 8200, 8210, 8300, 8370, 8400, 8460, 8470, 8490, 8496, 8540. A one way ANOVA conducted with luminance measures (performed for each picture with the histogram function of Adobe Photoshop® Software) as dependent variable and emotional category as within factor did not reveal any significant effect ($F(2, 119) = 2.72$; NS).

regression analysis in the frequency domain (Woestenburg et al., 1983) and remaining trials with artefacts exceeding ±100 μV were excluded from the analysis in all channels. EEG epochs time-locked to the stimulus onset (−100 to 900 ms), were baseline corrected (−100 to 0 ms) and averaged offline.

Participants gave informed consent and seated in a reclining lounge chair located in a sound attenuated, electrically shielded and dimly lighted room. Electrodes were attached and participants were told to react as quickly as possible by pressing the spacebar of the keyboard, when they detected a geometric shape wider than the standard one. They were also told to avoid blinking and maintain gaze on the black centred cross, which occurred on the computer screen between the stimulus presentations.

3. Data reduction and analyses

Since P3a and P3b components are evoked very close together in time, voltage measures obtained by a classical baseline to peak analysis in their time range of expression may represent the superimposed activity of both components. In order to disentangle these overlapping portions of the waveform, we conducted a temporal principal component analysis (PCA, see Chapman and McCrary, 1995 for further details on this technique). This particular factor analysis is a "data-driven" procedure which fits with the theoretical view of the component concept, seen as a source of controlled and observable variability introduced in the data by the experimental manipulations (see Picton et al., 2000 for a discussion of this issue). Thus, PCA identifies what to measure by a systematic approach of the variance in the data and the overlapping components can be separated as a function of the experimental conditions, allowing purer measures of each underlying component. This property is of particular interest in our study and PCA techniques have already demonstrated their ability to disentangle P3a and P3b components (e.g. Spencer et al., 1999, 2001; Goldstein et al., 2002) and have been used in studies dealing with relation between ERPs and emotional stimulations (e.g. Johnston et al., 1986; Carretie et al., 1998; Kayser et al., 2000; Delplanque et al., 2004). The temporal PCA based on a covariance matrix was performed on the averaged waveforms, each being represented by 230 time points (from 0 to 900 ms averaged epoch). Seventeen subjects, five stimulus categories and twenty-eight electrode sites yielded a total of 2380 averaged waveforms which served as the data base for the PCA. A Varimax rotation was performed on factors which were characterised by an Eigen value equal to or greater than the average variance of the original variables. The number of those kept for further analysis was established when at least 90% of cumulative variance in the data set was explained. Moreover, loading of the factors (the contribution of each component to the voltage) had to reach the 0.7 criterion for at least one time point.

4. Results

The mean reaction time in response to target stimuli did not differ across blocks (block 1, 446 ± 41 ms; block 2, 449 ± 35 ms; block 3, 442 ± 38 ms; block 4, 440 ± 35 ms; $F(3, 48) = 0.5$; NS). The grand average ERP waveforms to standard, target, novel unpleasant, novel neutral and novel pleasant pictures recorded at 12 locations are represented in Fig. 1.

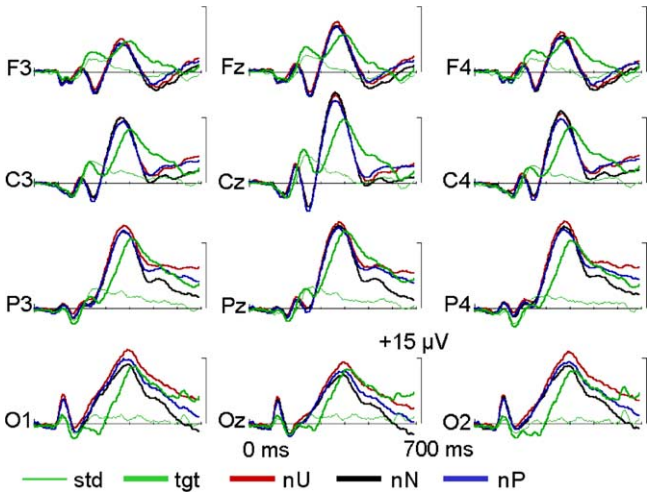

Fig. 1. Averaged ERPs for the standard, the target and the three novel categories of stimuli at 12 electrode sites. Std, standard; tgt, target; n, novel, U, unpleasant; N, neutral and P, pleasant.

The PCA led to the extraction of seven temporal factors showed in Fig. 2. The first factor (TF1) and the fifth one (TF5) were excluded as they were the result of the auto-correlated nature of the data (Wastell, 1981; Van Boxtel, 1998). Topographical distributions of the factor scores obtained for each temporal factor are represented in Fig. 3. They represent the contribution of each mean electrode's score in each condition to the temporal factor. Regarding their latency window, their distribution and their apparent sensibility to the conditions, TF6 may represent the occipitally peaking positive visual-related P100 evoked in response to all visual stimulations (Woldorff et al., 2002), TF7 the centrally peaking positive P200 evoked in response to novels (Crowley and Colrain, 2004), TF4 the same centrally peaking positive P200 evoked in response to targets and standards and negative N200 evoked in response to novels (Suwazano et al., 2000), TF3 the centrally peaking positive P3a evoked in response to novels (Polich and Comerchero, 2003; Spencer et al., 2001), and TF2 the parieto-occipitally peaking positive P3b evoked in response to targets and novels (Spencer et al., 2001).

Considering our objectives, a statistical authentication of the P3a and the P3b elicitation was performed. Indeed, the contribution of midline sites[2] (where P3a and P3b showed their maximum amplitudes) and each condition (measured with the factor scores) to the temporal factor TF3 (P3a) and TF2 (P3b) were analysed with a Greenhouse Geisser corrected Analysis of Variance (ANOVA) with Conditions (std/tgt/n) and Electrodes (Fz/Cz/Pz/Oz) as between subject variables (the values for the novels were the mean factor scores obtained in the three emotional conditions). Where suitable, comparisons between the paired levels of the experimental conditions were studied with ANOVAs with Conditions (std/tgt, std/n) and Electrodes (Fz/Cz/Pz/Oz) as between subjects variables. *F* or TF3 (P3a), the comparisons

[2] The analyses have also been performed with all electrodes and yielded the same pattern of significant results: higher central amplitudes for the P3a in response to novel stimuli solely and higher parietal amplitudes for the P3b in response to both the target and the novel stimuli. Thus, only the results obtained at midline sites are presented.

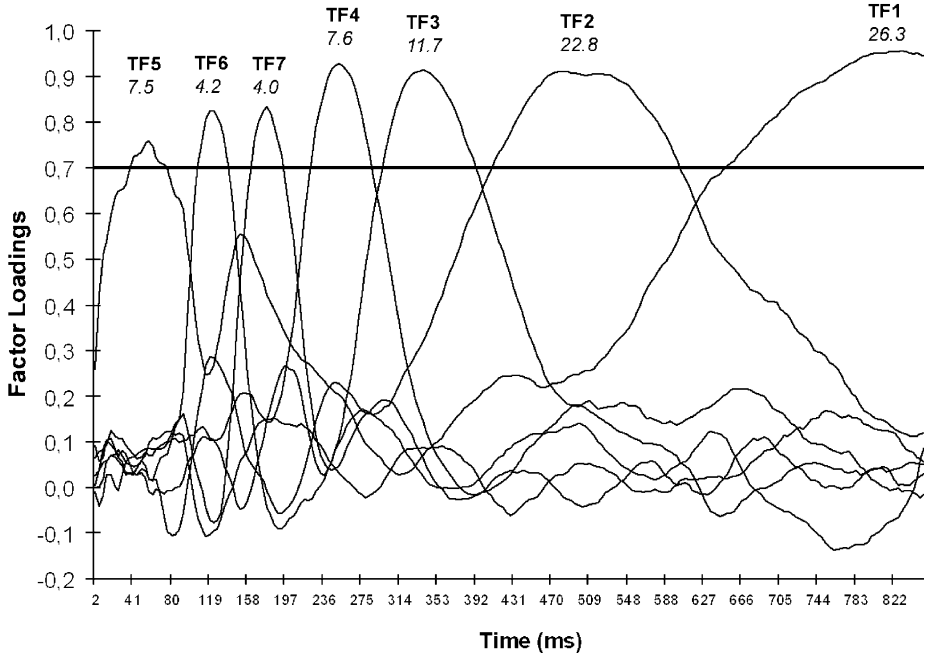

Fig. 2. Loadings as a function of time for the rotated factors. Percentage of variance explained by each factor is also indicated.

between the novel condition and the standard one revealed a highly significant Conditions × Electrodes interaction (see Table 1). In this case, higher factor scores were obtained in the novel condition with a maximum at central sites, confirming the P3a amplitude distribution (see Fig. 4). However, the comparison between the standard and the target conditions did not reveal a significant interaction. Thus, the contribution of the central sites to the temporal factor associated to the P3a appeared clear for the novel condition as compared to the

Table 1
Summary of the *F* ratio obtained for the ANOVAs performed on the temporal factor scores

		TF3 (P3a)	TF2 (P3b)
std/tgt/n	C	29.14**	17.11**
	E	7.99*	38.03**
	C × E	15.16**	11.56**
std/tgt	C	0.43	36.77**
	E	0.90	17.49**
	C × E	0.16	13.66**
std/n	C	37.84**	4.26
	E	18.10**	32.28**
	C × E	16.22**	17.97**

C, Condition; E, Electrode; std, standard; tgt, target, n, novels.
* $P < 0.01$.
** $P < 0.001$.

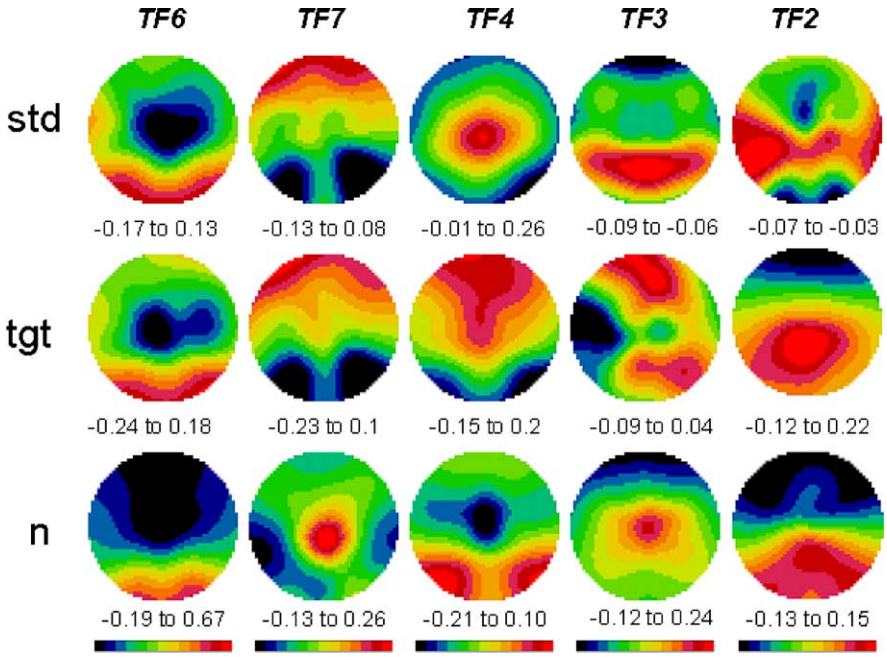

Fig. 3. Topographical distribution of the factor scores as a function of the experimental conditions obtained with Statmap 3D®. Factor scores ranges are also indicated.

standard condition whereas it did not appear to be the case for the target stimuli. In other words, novel deviant stimulations elicited a centrally P3a whereas the target stimuli did not. In contrast, for TF2 (P3b), all comparisons undertaken between the standard and the target or the novel conditions showed significant Conditions × Electrodes interaction (see Table 1) with higher factor scores obtained on parietal sites for the target and the novel stimuli as

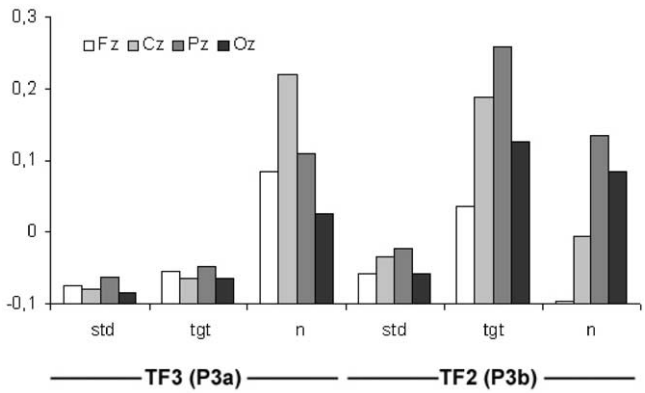

Fig. 4. Factor scores obtained at midline sites for TF3 (P3a) and TF2 (P3b) as a function of the condition. Std, standard; tgt, target; n, novel.

compared with the standard ones, confirming the classical frontal to parietal increase in P3b amplitudes (see Fig. 4). Thus, the contribution of the parietal sites to the P3b is important in the target condition as compared to the standard condition but also during the novel condition as compared to the standard one. In sum, the target stimuli evoke a clear P3b that is also evoked in the novel condition.

The above mentioned procedure allowed us to disentangle the components according to their sensibility to the experimental conditions and to equate their nature to the already known P3a and the P3b (Picton et al., 2000). In a second step we have used the results of this analysis to focus on pertinent ERP epochs in order to examine their variations according to the emotional content of the stimulation. Thus, the mean amplitude was calculated for each factor in the temporal window in which the contribution of the factor to the voltage exceeded the 0.7 criterion. The mean voltages were obtained in a 107–138 ms window for TF6 (P100), a 161–192 ms window for TF7 (P200), a 224–282 ms window for TF4 (N200/P200), a 298–388 ms window for TF3 (P3a) and a 411–599 ms for TF2 (P3b). Greenhouse Geisser corrected ANOVAs were conducted on the mean amplitudes of these five time windows, with Conditions (U/N/P) and Electrodes (28) as between subject variables. When suitable, comparisons between the paired three levels of valence were performed with a Conditions (U/N, N/P, U/P) × Electrodes (28) ANOVA. For each ANOVA, we assessed scalp distribution differences among variable levels using McCarthy and Wood's vector scaling normalization procedure (McCarthy and Wood, 1985). This manipulation removed overall amplitude differences between conditions or groups to allow statistical comparisons of the scalp potential distributions. There was no significant effect of emotion for the P100, P200, N200 and P3a. However, significant differences were obtained for the P3b component.

The Conditions (U/N) × Electrodes (28) ANOVA revealed a main effect of Conditions ($F(1, 16) = 14.98$; $P < 0.01$) reflecting higher amplitudes for the P3b associated with unpleasant novel stimulations as compared to neutral stimulations. In a similar way, the Conditions (N/P) × Electrodes (28) ANOVA revealed a main effect of Conditions ($F(1, 16) = 7.86$; $P < 0.05$) reflecting higher amplitudes for the P3b associated with pleasant novel stimulations as compared to neutral ones (see Fig. 5A).

Moreover, even if the amplitude was maximal at parietal sites for both conditions, unpleasant pictures evoked higher P3b than pleasant ones mainly at temporo-parieto-occipital sites

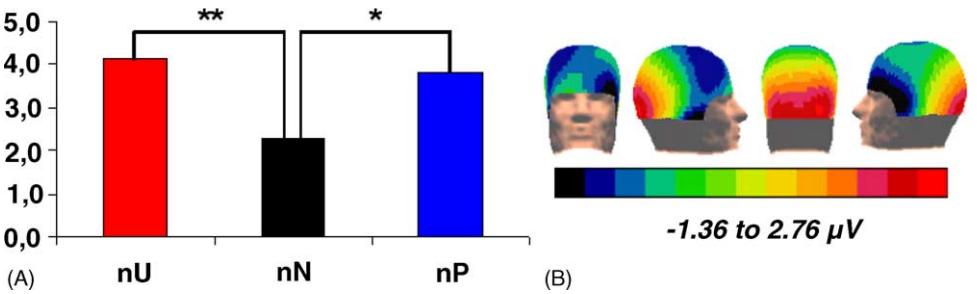

Fig. 5. (A) P3b mean amplitudes (in μV, all sites averaged) as a function of the emotional condition: $^{*}P < 0.05$, $^{**}P < 0.01$. (B) Topographical distribution of the P3b amplitude differences between the unpleasant and the pleasant conditions obtained with Statmap 3D®.

(before normalization: $F(27, 432) = 10.06$; $P < 0.001$; after the normalization: $F(27, 432) = 3.10$; $P < 0.05$). Indeed, Fig. 5B represents the difference mean amplitudes between the unpleasant novel and the pleasant novel conditions observed before the normalization (as recommended by Picton et al., 2000), and Tuckey HSD post hoc comparisons revealed significant differences at CP3/4, O1/2, Oz, P3/4, P8, Pz, T7/8, TP7/8.

5. Discussion

The main objective of the present study was to investigate whether the P3a and the P3b components of the ERPs would be sensitive to the emotional arousal and valence of unexpected stimuli. To this purpose, we have chosen to introduce non-target highly deviant emotional and neutral stimulations in a perceptually difficult target/standard discrimination oddball task. Resulting data were analysed with a temporal PCA which allows to disentangle overlapping components according to their temporal distribution and/or reactivity to the experimental conditions (e.g. Simons et al., 2001; Spencer et al., 2001). Three main conclusions emerged from this study.

First, present results showed that highly deviant unpredictable pictures, whether they were emotional or neutral, elicited both a centrally distributed P3a and a parietally distributed P3b. This result is in accordance with previous ones (Spencer et al., 1999, 2001; Goldstein et al., 2002) reporting that deviant non-target stimuli elicited both a P3a and a P3b, particularly when the perceptual discrimination between target and standard was difficult (Katayama and Polich, 1998). It is also in agreement with the now growing number of results pointing out the benefit of using ERP decomposition techniques to disentangle overlapping but functionally distinct components. As suggested by Polich (2003), the P3a and P3b elicitation would be the result of frontal and parietal lobe interactions as a function of the task structure, this result being in accordance with preceding studies showing that novel stimuli activated a distributed network involving frontal and posterior association cortex (e.g. Knight and Nakada, 1998).

According to the P3a sensibility to the perceptual deviance of a stimulus as compared with previous ones in auditory (Gaeta et al., 2003; Cycowicz and Friedman, 2004) and in visual modality (Comerchero and Polich, 1998, 1999), it appears logical that the highly perceptual deviant pictures used as novel stimuli evoked a clear and reliable P3a. This component would represent an involuntary switching or reorientation of attention initiated by frontal lobes (Escera et al., 2000; Polich, 2003). In fact, deviant stimulus would trigger a switching of the subject's attentional resources from the current attended task. Another interpretation is that the P3a could be a manifestation of an inhibitory process engaged to control response mechanisms normally associated with the target deviant stimulus (see Goldstein et al., 2002 for a discussion). In this view, the detection of a deviant stimulus, be it a target or not, would activate response mechanisms. But the correct identification of deviant non-target stimulus would indicate that a response has not to be executed. Then, a process is needed to inhibit the response mechanisms activated during the deviance detection of the non-target stimulus. Thus, the P3a could represents either an automatic attentional switching or inhibitory process, but the present results could not rule out any of these two major interpretations. The P3b is thought to reflect the establishment of the connection with associational temporo-parietal storage areas (Polich, 2003) and would represent subsequent

resources allocation to memory updating when the mental model or schema of the stimulus environment needs to be refreshed after stimulus evaluation (Donchin and Coles, 1988). In this frame, it is not surprising that the novel deviant stimulus elicit a P3b in our paradigm as it does in various tasks (Katayama and Polich, 1996). Therefore, our results indicate that both emotional and neutral highly deviant, non-target and unpredictable pictures introduced in the classical oddball, do not only activate frontal functions associated with attentional resources reallocation or inhibitory process but also activate subsequent context updating for memory storage.

Second, we have demonstrated that the P3b component alone was sensitive to the emotional arousal of unpredictable and disturbing pictures. Indeed, its amplitude was larger for the unpleasant and pleasant arousing stimuli as compared to the neutral ones. This effect was observed at all electrode sites, and thus may represent a global increase in the strength of the resulting dipole engaged during the activity of the P3b intracranial sources. Previous studies have already demonstrated that the P3b component elicited by rare target stimuli was sensitive to the emotional arousal, with higher amplitudes obtained for high arousing target stimulations as compared to low arousing ones (Johnston et al., 1986). A similar emotional arousal effect has also been obtained with simple presentation paradigms with explicit emotional categorization tasks (e.g. Cuthbert et al., 2000; Schupp et al., 2000) or passive viewing (e.g. Mini et al., 1996; Keil et al., 2002). Results have been interpreted as the reflect of the functional mobilization of resources in affective engagement, regardless of whether the current motivational direction is toward (appetitive, pleasant) or away from (aversive, unpleasant) the stimulation (Schupp et al., 1997). Taking into account the functional role of the P3b, our results indicate that the resources allocated to the context updating of highly deviant non-target stimulations are also more important for the high arousing stimulations than for the low arousing ones. In an adaptative point of view, it is of particular interest for the individual that the context updating process integrates the arousing value of the situation that interrupts the ongoing task. This could allow a processing of better quality (Palomba et al., 1997; Polich and Herbst, 2000), an improvement of memory storage (Bradley et al., 1992; Dolcos and Cabeza, 2002) and could be accompanied with enhanced autonomic activities (Cuthbert et al., 2000).

Third, regarding the variations among the valence levels, we have demonstrated that the amplitudes of the parietal P3b were higher for the unpleasant pictures than for the pleasant ones. This effect was topographically restricted to some temporal, parietal and occipital sites whereas there were no significant differences at frontal and central sites. One can first wonder how topographical effects could be observed in the unpleasant/pleasant comparison while at the same time, there was no significant differences between the topographical distribution of the P3b amplitudes in the unpleasant/neutral and pleasant/neutral comparisons. A plausible interpretation would be that topographical differences existed between neutral and unpleasant conditions as well as between neutral and pleasant conditions, but those differences were too subtle to reach statistical significance. The topographical effect became significant when P3b amplitudes distribution in response to the unpleasant stimulations were compared to the distribution in response to the pleasant stimulations. This could result from the fact that the unpleasant/neutral and the pleasant/neutral comparisons confounds variability due to both the arousal and the valence dimensions whereas the unpleasant/pleasant comparison does not.

The fact that unpleasant pictures led to higher posterior positivities than pleasant and/or neutral ones could be a manifestation of the more prominent cognitive, behavioural and physiological responses to unpleasant events that has been conceptualised under the negativity bias terminology (Cacioppo and Gardner, 1999). Such effects have already been reported during the processing of IAPS pictures on several components (Lane et al., 1997; Smith et al., 2003; Delplanque et al., 2004). Topographical effects on P3b can be observed when two different types of stimuli lead to a difference in the relative contribution of different intracranial sources (Ruchkin et al., 1990; Johnson, 1993). Thus, our data suggest that the context updating process could take into account the valence content of the stimulation, with a portion of the P3b neuronal network being differentially activated as a function of the valence level and therefore producing topographical differences. However, this interpretation must be moderated since recent data have pointed out the ineptitude of normalization procedures to reliably allow to infer the existence of differences in spatial configurations of neuroelectric generators from differences in scalp distributions (Urbach and Kutas, 2002).

The last point we would like to discuss is the possibility for the observed valence effect to be due to a posterior component that overlaps the P3b. This question arises since the valence effect has a slightly different topography distribution than the P3b. The present data do not allow us to argue in this sense nor to rule out this hypothesis. We used a PCA to disentangle the overlapping components according to their differential sensibility to the experimental conditions in the temporal domain. This analysis did not isolated a component that would be specifically sensitive to the valence content of the stimulation. This may be a consequence of the use of the PCA that could have favoured the variability introduced by the rare/target/novel experimental conditions and could have been blind to the variability due to the emotional valence manipulations. Moreover, the variability introduced in the data by the emotional content could be more represented in the spatial domain than in the temporal domain. Thus, further studies are needed in order to disentangle the components according to the spatial dimension of the data with high density ERP techniques (Spencer et al., 1999, 2001).

In sum, consequently to their high degree of perceptual deviance from the context, the unpredictable novel stimuli we introduced led to an attentional reallocation or an inhibitory process indexed by the P3a, that does not seem to be sensitive to the emotional load of the stimulus. By contrast, the subsequent memory updating process indexed by the P3b appears to be engaged as a function of the emotional value of the stimulation, even if the subject is not engaged in an explicit emotional categorization task.

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