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Arousal and valence effects on event-related P3a and P3b during emotional categorization

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Abstract

Due to the adaptive value of emotional situations, categorizing along the valence dimension may be supported by critical brain functions. The present study examined emotion–cognition relationships by focusing on the influence of an emotional categorization task on the cognitive processing induced by an oddball-like paradigm. Event-related potentials (ERPs) were recorded from subjects explicitly asked to categorize along the valence dimension (unpleasant, neutral or pleasant) deviant target pictures embedded in a train of standard stimuli. Late positivities evoked in response to the target pictures were decomposed into a P3a and a P3b and topographical differences were observed according to the valence content of the stimuli. P3a showed enhanced amplitudes at posterior sites in response to unpleasant pictures as compared to both neutral and pleasant pictures. This effect is interpreted as a negativity bias related to attentional processing. The P3b component was sensitive to the arousal value of the stimulation, with higher amplitudes at several posterior sites for both types of emotional pictures. Moreover, unpleasant pictures evoked smaller amplitudes than pleasant ones at fronto-central sites. Thus, the context updating process may be differentially modulated by the affective arousal and valence of the stimulus. The present study supports the assumption that, during an emotional categorization, the emotional content of the stimulus may modulate the reorientation of attention and the subsequent updating process in a specific way.

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1. Introduction

In everyday life, humans interact with a large variety of stimulations which may have a highly adaptive value. In these conditions, humans have to discriminate and categorize significant stimuli, and to mobilize resources in order to cope with them. Individuals develop actions either to approach the stimuli that are necessary to maintain or enhance individual and species capabilities, or to withdraw from dangerous or nociceptive events (Cacioppo and Gardner, 1999). According to the widely accepted dimensional view of emotions (Lang et al., 1993), these actions or action dispositions are allowed by valence categorization processes (along the unpleasant/pleasant dimension) in relation with the

intensity (arousal) of the situation. In this context, recent experimental data indicate that the valence of the ongoing stimulus is taken into account at several points in the information processing stream, as indexed by the time course and the topography of event-related potentials (ERPs; Delplanque et al., 2004; Schupp et al., 2003; Smith et al., 2003). Several lines of evidence suggest that, in various tasks using emotional items, the valence and arousal dimensions of emotion can differentially affect the positive potentials elicited around 300 ms after the occurrence of the stimulus (see Dolcos and Cabeza, 2002 for a review). More precisely, valence effects can be reflected by amplitude modulations at frontal sites for the P3b (Delplanque et al., 2004) or for a positive slow wave (Diedrich et al., 1997), but a more consistent arousal effect is observed at posterior locations for several components, and in particular for the P300 (e.g. Johnston et al., 1986; Kayser et al., 1997; Keil et al., 2002; Palomba et al., 1997).

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During valence categorization tasks, higher positive amplitudes for emotional items are usually observed on components often referred as late positive potentials (Ito and Cacioppo, 2000), or slow positive voltages (Cuthbert et al., 2000), or positive slow waves (Diedrich et al., 1997). However, the identification of the cognitive processes reflected by those components is often difficult, and thus, the interpretation of their potential emotional modulations are constrained. For instance, the positive slow waves described by Diedrich et al. (1997) were modulated by the valence content of the stimulus at frontal sites and differed as a function of the arousal content at parietal sites. The authors reported the descriptive characteristics of this differentiation, but pointed out the lack of evidence concerning the functional significance of these effects. Moreover, the ERP components elicited in response to emotional target items are usually defined in such latency windows (from 200–300 ms up to 600–1000 ms after stimulus-onset) that they could often represent entangled electrical activities resulting from the engagement of several processes triggered very close together in time (Spencer et al., 1999, 2001). Thus, we would like to stress the possibility to reduce such conceptual and practical limits, on the one hand, by using a task structure that is designed to elicit specific cognitive processes indexed by well-defined ERPs components (Picton et al., 2000) and, on the other hand, by analyzing ERPs data with methods that enhance the probability to disentangle the partially superimposed components. Thus, we believe that such an approach can favor the observation of emotional influences on specific processes.

Firstly, among the numerous existing tasks, the categorization processes can be investigated with an oddball paradigm in which well-studied and functionally different ERPs components are elicited according to the category to which an event is assigned (Johnson and Donchin, 1980). In brief, the classical oddball task usually consists in detecting rare target stimuli in a train of frequent, standard stimuli. In this case, several studies have demonstrated that the rare target stimuli evoke both a P3a (or novelty P3, recent data pointing out that they are the same; Demiralp et al., 2001; Simons et al., 2001) and a P3b component (Goldstein et al., 2002; Spencer et al., 1999, 2001). In this framework, the P3a is supposed to reflect an involuntary switch of attention (or an attentional reallocation) to distraction from the primary task (Polich, 2003). Gaeta et al. (2003) reported that when a P3a is elicited, amplitudes at anterior sites are modulated by the degree of perceptual deviance between the standard stimulus and the deviant one, higher amplitudes being associated with higher deviance. In addition, the posterior sites of the P3a would be sensitive to the task-relevance of the deviant stimulus, with higher amplitudes when the stimulus is designated as a target. The P3b is thought to reflect the immediate memory mechanisms triggered when the mental model or schema of the environment is refreshed and updated (Donchin and Coles, 1988; Johnson, 1986; Polich, 2003) and its amplitude is mainly associated with the task-relevance of the stimulus (e.g. Polich, 2003).

Secondly, since the P3a and P3b components are evoked very close together in time, the classical baseline to peak measures performed on large temporal windows seem inadequate to clearly separate their superimposed activities (Hoormann et al., 1998). A better differentiation of those components can be achieved with a 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 well with the theoretical view of the component as a source of controlled and observable variability introduced in the data by the experimental manipulations (see Picton et al., 2000 or Kayser and Tenke, 2003 for a discussion on this issue). Indeed, PCA identifies the components by a systematic approach that analyzes the variations in all the ERPs in the analyzed set, and the overlapping components can be dissociated as a function of the experimental conditions and their topographical distributions, 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 the P3a and P3b components (e.g. Goldstein et al., 2002; Spencer et al., 1999, 2001). They have also been used in studies dealing with the emotional modulations of ERPs components (e.g., Carretie et al., 1998; Delplanque et al., 2004, 2005; Johnston et al., 1986; Kayser and Tenke, 2003).

In view of the above mentioned considerations, we expect that the oddball-like paradigm we propose and the use of a PCA analysis will allow distinguishing the emotional modulations of the P3a and a P3b components elicited by deviant target items during an emotional categorization task. Moreover, according to the P300 sensitiveness to the emotional arousal dimension observed in previous oddball tasks (e.g. Johnston et al., 1986), we expect higher posterior amplitudes when subjects will categorize unpleasant and pleasant arousing events. However, the absence of homogeneity in the existing data does not let us anticipate more precisely the relative influence of the two emotional dimensions on the P3a or the influence of the valence dimension on the P3b.

2. Materials and methods

2.1. Participants

Seventeen right-handed healthy undergraduate female students (21.47 ± 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 laterality (Hecaen's test, 1984) and to check that they had no history of neurological or psychiatric disorder, or drug abuse.

2.2. Stimuli and task

The oddball task comprised a total of 1080 stimuli, divided in two conditions: simple geometric surfaces served as standard items (std, $n=960$) whereas highly deviant complex pictures ($n=120$) served as targets (tgt). Target pictures were taken from the international affective picture system (IAPS; Lang et al.,

1988) and were distributed into three sets (unpleasant=U, neutral=N and pleasant=P),¹ in such a way that the sets, based on the IAPS scores for female, differed significantly in the valence dimension (on a scale ranging from 1—very unpleasant to 9—very pleasant, means: U=2.2, N=5, P=7.3; $F(2,117)=1067.62$; $p<0.001$). In the arousal dimension (scale ranging from 1—very relaxing to 9—very exciting), the unpleasant set and the pleasant set both differed from the neutral one (means: U=6, N=2.7, P=6.1; $F(2,117)=699.33$; $p<0.001$) but did not significantly differ between each other. The oddball sequence consisted of 4 blocks of 240 standard and 30 target stimuli (10 U, 10 N and 10 P), each block being separated by brief rest periods. Within each block, the standard stimulus was one of four blue geometric surfaces (square, circle, triangle and cross), all the stimuli were randomized for each participant and the sequence of block presentation was counterbalanced across subjects. Moreover, the 120 target pictures were distributed in the 4 blocks in such a way that (1) the mean arousal and valence level of the three sets did not differ from one block to another, and (2) in each block, the mean arousal and valence levels corresponded to the above-mentioned global selection.

All the stimuli were displayed on the centre of a computer screen (17 in.) on a background composed of small random dots of different colors. Standard geometric shapes were presented for 500 ms, occupying about 5° of horizontal visual angle. The duration of target pictures presentation was fixed at 750 ms, and they occupied about 15° of horizontal visual angle. The stimulus-onset asynchrony varied randomly between 900 and 1000 ms. However, the target pictures presentation was followed by 3000 ms of background presentation before the occurrence of the next item, in order to allow the subject's categorization response.

2.3. ERPs acquisition

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 artifacts were corrected from the EEG by a dynamic regression analysis in the frequency domain (Woestenburger et al., 1983). After this correction, trials with artifacts exceeding $\pm 100 \mu\text{V}$ 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. EEG epochs were included in the averaging routine only if the category of the picture presented during the trial and the subject's response were identical (for example, EEG epoch in response to a picture selected as pleasant based on the IAPS values and judged as neutral by the subject was not included in the averaging routine). A mean total of 29 ± 6 trials (as a function of the subject) was averaged for each of the four categories.

2.4. Procedure

Participants gave informed consent and seated in a reclining lounge chair located in a sound attenuated, electrically shielded and dimly lighted room where electrodes were attached. They were asked to judge the valence of the randomly presented pictures as quickly as possible according to a three levels scale composed by three keys in a computer keyboard (left arrow for U pictures, down arrow for N pictures and right arrow for P pictures for 8 participants, the reversed pattern for 9 participants). All the participants were also told to avoid blinking as much as possible and to maintain gaze on the black centered cross which appeared on the computer screen between the stimulus presentations.

2.5. Temporal PCA

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, four stimulus categories and twenty-eight electrode sites yielded a total of 1904 averaged waveforms which served as the data base for the PCA. A Varimax rotation was performed on factors which were characterized by an eigenvalue equal to or greater than the average variance of the original variables. Moreover, after this procedure, only the factors whose loadings (the correlation between the factor and the original variables) reached the 0.7 criterion² for at least one time point were kept for further analyses.

3. Results

The mean subjects' reaction times did not differ significantly across the three target conditions, with 1037 ± 206 ms to

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 and number of pixels (performed for each picture with the histogram function of Adobe PhotoShop® software) as dependant variable and emotional category as within factor did not reveal any significant effect (luminance: $F(2,117)=2.72$; ns, number of pixels: $F(2,117)=0.74$; ns).

² The 0.7 criterion (i.e. loading ≥ 0.707 , square root of 0.5), means that at least 50% of the total variance in the data is explained by the factor at this particular time point. During the temporal window delimited by the loading values of 0.707 as boundaries, the factor alone explains at least 50% of the variance present in the data set. The remaining variance is explained by all the other factors taken together.

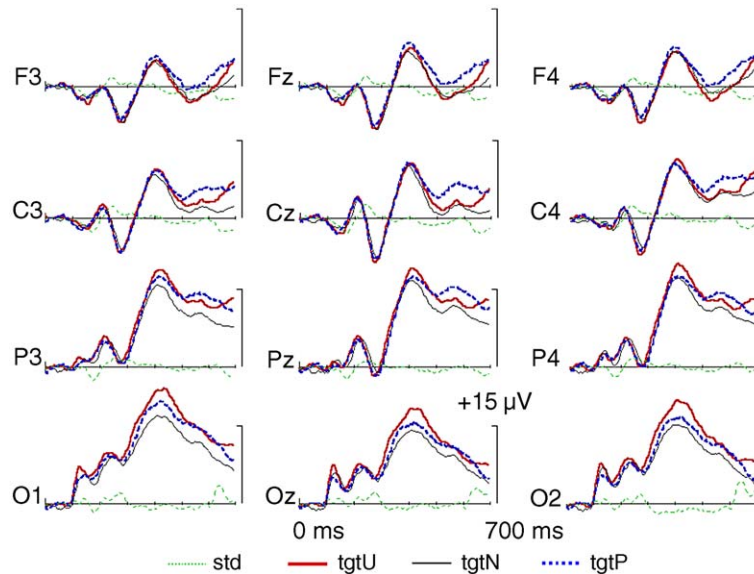


Fig. 1. Averaged ERPs for the standard, and the three categories of target stimuli at 12 electrode sites. std=standard, tgt=target, U=unpleasant, N=neutral and P=pleasant.

unpleasant, 1041 ± 194 ms to neutral and 1058 ± 169 ms to pleasant pictures ($F(2,38)=0.37$; ns).

The grand average ERP waveforms to standard, unpleasant target, neutral target and pleasant target pictures recorded at 12 locations are presented in Fig. 1.

3.1. PCA results

The PCA led to the extraction of seven temporal factors (TF) shown in Fig. 2. The first factor (TF1) and the sixth one (TF6) were excluded from the analyses, the former as it is the result of the auto-correlated nature of the EEG time-series data (Kayser and Tenke, 2003; Van Boxtel, 1998; Wastell, 1981), the later as it is commonly observed for PCA solutions based on covariance matrix with standardized loadings (Kayser and Tenke, 2003) and it is not related to ERP components. The seventh factor (TF7) was also excluded since it never reaches the 0.7 criterion. Considering our objectives, we only report the results associated with the factors that were assumed to be related to the P3a and the P3b.³ The topographical distributions of the factor scores obtained for the temporal factor associated with TF4 and TF2 are presented in Fig. 3. More precisely, this figure shows the contribution of each mean electrode score to the temporal factor for the standard condition and the three target conditions averaged together. Regarding their latency window, their distribution and their apparent sensitivity to the conditions, TF4 may represent the fronto-central positive P3a (Gaeta et al., 2003), and TF2 the parietal positive P3b (Spencer et al., 2001). Moreover, a statistical authentication of the P3a

and P3b elicitation was performed. The contribution (measured by the factor scores) of midline sites (where P3a and P3b showed their maximum amplitudes) in standard and target conditions to the temporal factor TF4 (P3a) and TF2 (P3b) were analyzed with a Greenhouse–Geisser corrected analysis of variance (ANOVA) with Conditions (std/tgt) and Electrodes (Fz/Cz/Pz/Oz) as between-subject variables (the values for the targets were the mean of the factor scores obtained in the three emotional conditions). For TF4 (P3a), the comparison between the target condition and the standard one revealed a significant main effect of Conditions ($F(1,16)=17.45$; $p<0.001$), with higher factor scores for the target condition. The significant main effect of Electrodes ($F(1,16)=12.4$; $p<0.01$) pointed to higher factor scores for frontal and central sites, which is consistent with the classical P3a amplitude distribution (see Fig. 4; $Fz \approx Cz > Pz \approx Oz$, post hoc Tukey's HSD test). For TF2 (P3b), the comparison between the standard and the target conditions showed a significant Conditions \times Electrodes interaction ($F(3,48)=19.75$; $p<0.001$). The highest factor scores were obtained on parietal sites for the target condition, which is consistent with the classical frontal to parietal increase in P3b amplitudes (see Fig. 4; $Fz < Cz \approx Oz < Pz$, post hoc Tukey's HSD test).

3.2. Amplitudes calculation

The above-mentioned procedure allowed us to disentangle the components according to their sensitivity to the experimental conditions and their topographical distribution in order 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 stimulations. Thus, the mean amplitude was calculated for each factor in the temporal window in which the contribution of the component to the voltage reached the 0.7 criterion. The

³ The two other factors extracted by the PCA (TF3 and TF5) were also analyzed. Regarding their latency window, their distribution and their apparent sensitivity to the conditions, TF5 may represent the centrally peaking positive P2 (e.g., Crowley and Colrain, 2004) and TF3 the centrally peaking negative N2 (e.g., Suwazono et al., 2000). Moreover, for the mean voltages obtained in the 185–224 ms window for TF5 (P2) and the 243–310 ms window for TF3 (N2), no significant effects involving the emotional factor were observed.

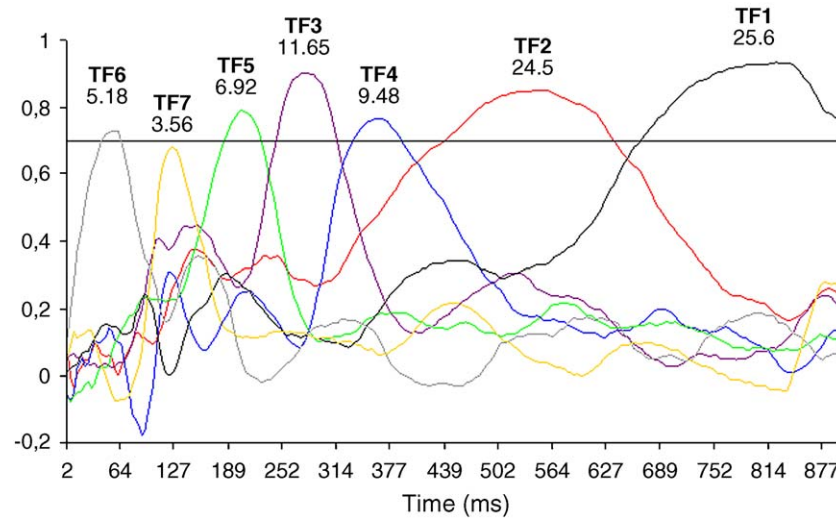


Fig. 2. Loadings as a function of time for the rotated factors. The percentage of total variance explained by each factor is also indicated.

mean voltages were obtained in a 333–384 ms window for TF4 (P3a) and a 439–630 ms window for TF2 (P3b). Greenhouse–Geisser corrected ANOVAs were conducted on the mean amplitudes of those time windows, with Conditions (U/N/P) and Electrodes (28) as between-subject variables. When suitable, comparisons between paired levels of valence were performed with a Conditions (2) \times Electrodes (28) ANOVA. For each ANOVA, we assessed scalp distribution differences across variable levels using McCarthy and Wood's normalization procedure (McCarthy and Wood, 1985). This vector transformation removed overall amplitude differences between conditions to allow statistical comparisons of the scalp potential distributions. All the post hoc comparisons were

made with the Tukey's HSD test on raw amplitudes (Picton et al., 2000). Statistical results are summarized in Table 1.

3.3. P3a amplitudes

The Conditions (U/N) \times Electrodes (28) ANOVA, as well as the Conditions (U/P) \times Electrodes (28) ANOVA revealed significant Conditions by Electrodes interactions whereas the Conditions (P/N) \times Electrodes (28) ANOVA did not reveal any significant effect in relation with the variable Condition (see Table 1). Post hoc comparisons revealed higher P3a amplitudes for unpleasant pictures at posterior locations (P8, O1, O2 and Oz), as compared to neutral and pleasant pictures averaged together, whereas there was no significant difference at anterior locations.

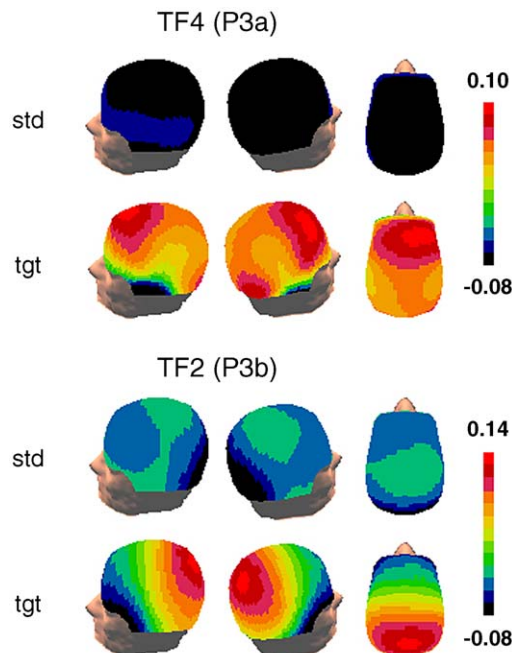


Fig. 3. Topographical distributions of the factor scores as a function of the experimental conditions obtained with Statmap 3D[®]. Factor scores ranges are also indicated. std=standard, tgt=target.

Table 1

Summary of the *F* ratios obtained for the ANOVAs performed on the averaged amplitudes

		P3a (333–384 ms)	P3b (439–630 ms)
U/N/P	C	0.72	5.4*
	E	38.44***	37.48***
	C \times E	3.18*	5.47***
	nC \times E	2.69*	4.14***
U/N	C	1.02	0.86
	E	41.25***	40.84***
	C \times E	7.2***	7.5***
	nC \times E	4.72*	2.74*
P/N	C	1.53	14.72**
	E	31.98***	33.3***
	C \times E	1.44	3.32*
	nC \times E		3.8**
U/P	C	0.02	5.11*
	E	39.12***	36.08***
	C \times E	2.7*	6.29***
	nC \times E	2.71*	6.03***

C=condition; E=Electrode; n=after normalisation; U=unpleasant; N=neutral; P=pleasant.

* $p < 0.5$.

** $p < 0.01$.

*** $p < 0.001$.

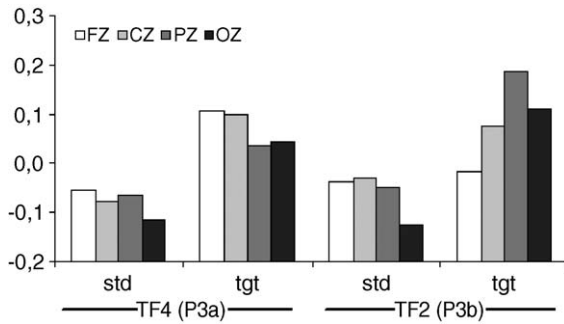


Fig. 4. Factor scores obtained at midline sites for TF4 (P3a) and TF2 (P3b) as a function of the condition. std=standard, tgt=target.

3.4. P3b amplitudes

The Conditions (U/N) \times Electrodes (28) ANOVA revealed a significant Conditions by Electrodes interaction reflecting higher amplitudes in response to the unpleasant pictures as compared to the neutral ones at P3, P7, O1 and O2 sites. Moreover, the Conditions (P/N) \times Electrodes (28) ANOVA revealed a significant Condition \times Electrode interaction reflecting higher amplitudes in response to the pleasant pictures than to the neutral ones at FC3, C3, CP3, CP4, CZ, P3, P7, PZ, TP7 and O1. Lastly, the Conditions (U/P) \times Electrodes (28) ANOVA revealed a significant Condition \times Electrode interaction reflecting lower amplitudes in response to the unpleasant pictures as compared to the pleasant ones at fronto-central locations (FP2, AF3, AF4, F4, FZ, FC3, FC4, C3 and CP3).

4. Discussion

Our main objective was to investigate whether the P3a and the P3b components of the ERPs could be modulated by the emotional content of target stimuli in an oddball task. Thus, subjects were explicitly asked to categorize as quickly as possible highly deviant emotional pictures embedded in a sequence of neutral standard items as a function of their valence level (unpleasant, neutral or pleasant). As expected, the results showed that both a P3a and a P3b component were evoked in the latency window of the late positive potentials. Moreover, the components were differentially sensitive to the emotional content of the stimuli. For the first time, the present findings allow to precise the emotional modulations of the P3a and P3b during an explicit emotional categorization task.

4.1. P3a and P3b elicitation in the emotional categorization task

This study was conducted to better depict the late positive potentials evoked in relation to the emotional categorization processes and elicited around 300 ms after the onset of task-relevant deviant items (e.g. Ito and Cacioppo, 2000). Our results showed that both a P3a and a P3b were elicited in response to the rare target pictures and are in accordance with previous ones (Goldstein et al., 2002; Spencer et al., 2001) showing that both irrelevant and target deviant stimuli can evoke a P3a and a P3b.

According to the P3a sensitivity to the perceptual deviance of a stimulus as compared with previous ones in the auditory (Cycowicz and Friedman, 2004; Gaeta et al., 2003) and in the visual modality (Comerchero and Polich, 1998, 1999), it is understandable that the highly perceptual deviant pictures we used as target stimuli evoked a P3a. This component could represent an involuntary shift or orientation of attention initiated by frontal lobes (Comerchero and Polich, 1998, 1999; Knight and Nakada, 1998; Polich, 2003; Yago et al., 2003). Besides, the P3b is thought to reflect the establishment of the connection with associative temporo-parietal storage areas (Polich, 2003) and would represent subsequent resources allocation to memory updating when the mental model or schema of the environment established by the frequent items needs to be refreshed, mainly as a function of the task-relevance, after stimulus evaluation (Donchin and Coles, 1988; Johnson and Donchin, 1980; Polich and Kok, 1995). Therefore, our results indicate that, during the emotional categorization task, target pictures would induce the attentional resources reallocation associated with a P3a, and the subsequent context updating for memory storage associated with a P3b.

4.2. P3a amplitudes in relation to the emotional content of the target

The amplitudes of the P3a did not show any significant difference across valence levels on fronto-central sites, whereas they were greater in response to unpleasant pictures than in response to neutral and pleasant ones on several posterior sites. Topographical effects can be observed when the underlying combinations of brain sources activities are different (Johnson, 1993; Picton et al., 2000; Ruchkin et al., 1990). Thus, the configuration of the cerebral sources activated by the attentional reallocation during an explicit emotional categorization seems to be not exactly the same for unpleasant arousing stimuli and for pleasant and neutral ones.

Functionally, this result can be interpreted on the basis of Gaeta's proposal (Gaeta et al., 2003) that P3a amplitudes at anterior sites vary as a function of the mere perceptual deviance of the target from the context, and amplitudes at posterior sites vary as a function of the task-relevance of the deviant item. In this framework, the fact that each rare target picture possesses a high degree of deviance as compared to the standard geometric shapes could explain the apparent homogeneity of the amplitudes across the three levels of valence at fronto-central sites. On the contrary, the results we obtained for posterior sites demonstrated that the task-relevance aspect of the P3a is modulated by the emotional value of the stimulation, unpleasant situations being differentially processed as compared with the other valence levels. The fact that unpleasant situations or stimuli often lead to more rapid and/or more prominent cognitive, behavioral and physiological responses than neutral and/or pleasant ones has been conceptualized under the negativity bias terminology (Cacioppo and Gardner, 1999). Our results could thus reflect a negativity bias in the reallocation of attentional resources to cope with the emotional targets, in line with the idea that many aspects of attentional

processes are automatically drawn to negative information more strongly than to positive or neutral information (Delplanque et al., 2004; Smith et al., 2003).

4.3. P3b amplitudes in relation to the emotional content of the target

We have demonstrated that the P3b was larger for the unpleasant pictures than for the neutral ones at parieto-occipital sites. This component was also larger for the pleasant pictures than for the neutral ones at several central, and parieto-occipital sites. Previous studies have demonstrated that the P300 component elicited by rare target stimuli is sensitive to the arousal dimension, higher amplitudes being obtained for highly arousing target stimulations than for less arousing ones (Diedrich et al., 1997; Johnston et al., 1986). Besides, our results indicate that the distribution of the P3b amplitudes differs in response to pleasant and unpleasant pictures, with frontal and central sites showing smaller P3b amplitudes in response to unpleasant pictures as compared to pleasant ones. This fronto-central effect has already been observed during an implicit emotional categorization of low-arousing stimuli (Delplanque et al., 2004). Topographical effects on P3b can be obtained when two different types of stimulus lead to a difference in the relative contribution of different intracranial sources (Johnson, 1993; Ruchkin et al., 1990). Thus, our data suggest that the context updating process could take into account the valence content of the stimulation, with a frontal portion of the P3b neuronal network being differentially activated as a function of the valence level and therefore producing topographical differences. Functionally, this fronto-central positivity is considered to be a prerequisite for motor inhibition (Diedrich et al., 1997), the categorization of unpleasant stimulation being associated with a weaker motor inhibition than the categorization of pleasant situations. However, the lack of significant difference in reaction time does not help us to confirm nor to rule out such a hypothesis.

In sum, when one have to categorize a stimulus according to its emotional content, both the valence and the arousal dimensions of the emotional stimuli seem to be taken into account by the context updating process reflected by the P3b component. The respective influence of those dimensions on P3b amplitudes appears topographically restricted: the valence variations were mainly associated with fronto-central sites whereas the arousal variations were mainly observed at parieto-occipital sites.

5. Conclusion

The main objective of this study was to better depict the late positivities triggered by emotional categorization tasks since they could reflect the superimposed electrical activities elicited by several cognitive processing, and especially those evoking the P3a and the P3b components. This purpose was fulfilled in our oddball task, since the categorization process elicited both a P3a and a P3b component. This allows making more precise inferences about the cognitive processes involved in categori-

zation tasks and their modulation as a function of the emotional content of the stimulations. Thus, results are in line with previous ones (Delplanque et al., 2004, 2005; Smith et al., 2003) suggesting that the valence and arousal dimensions of the ongoing stimulus interact with many cognitive processes along the information processing stream. However, since a negativity bias was observed on the P3a and since the P3b was sensitive to both the valence and the arousal dimension of emotion, the present study supports the idea that emotional content may modulate the reorientation of attention and the subsequent updating process in a specific way.

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