Emotion, attention, and the ‘negativity bias’, studied through event-related potentials

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Abstract

Behavioral studies indicate that there exists a ‘negativity bias’ in the way surrounding events are processed. Particularly, it has been indicated that negative events elicit more rapid and more prominent responses than non-negative events. The objective of the present study was to explore the role of attention in relation to this negativity bias. Three groups of emotional pictures were used as stimuli: positive, negative and neutral. Event-related potentials were recorded from 35 subjects at F5, Fz, F6, C5, Cz, C6, P5, Pz and P6. Valence and arousal content of the stimulation was measured via a questionnaire. The experimental design ensured that subjects whose data were finally analyzed attended to the stimuli. ANOVAs showed that P200, an attention-related component, showed higher amplitudes and shorter latencies in response to negative stimuli than in response to positive stimuli. Additional partial correlation analyses indicated that P200 amplitude, but not latency, significantly associates at frontal and central sites with valence content of the stimulation. Therefore, due to the valence-related nature of the bias, it is concluded that intensity aspects (more than timing aspects) of the P200-related attentional processes are particularly involved in the negativity bias. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Several studies indicate that negative events elicit more rapid and more prominent responses than neutral or positive events. This ‘negativity bias’ is manifested through diverse response systems, including those related to cognitive, emotion-
rious event are often much more dramatic than the consequences of ignoring or reacting slowly to neutral or even appetitive stimuli (e.g. Ekman, 1992; Öhman, 1992). Though the negativity bias has received recent experimental support from research on brain activity (Ito et al., 1998; Northoff et al., 2000), its study has been mainly carried out through behavioral studies, and psychophysiological data are surprisingly scarce. Particularly, the neural mechanisms underlying this negativity bias have not been defined nor systematically explored.

The present study deals with a particular process within the emotional reaction that probably affects the negativity bias: the attention to affective stimuli. The attention-related brain activity in relation to this bias has not yet been studied directly, since the attentional phases or components of the brain response to emotional stimulation have not been taken into account in the experimental design nor in the analyses of previous experiments (Ito et al., 1998; Northoff et al., 2000). However, the privileged access of negative stimulation to attentional resources has been indirectly suggested by studies on autonomic physiological responses (Öhman et al., 1993) and behavioral studies using reaction time (Pratto and John, 1991) or visual fixation (Fiske, 1980) as dependent variables. Therefore, these data indirectly suggest that initial, attentional phases of the brain response to emotional stimulation significantly contribute to the negativity bias.

Electroencephalographic recording of event-related brain potentials (ERPs) elicited by visual stimulation will be employed in the present research. ERPs constitute a powerful and necessary tool for exploring the subjacent neural mechanisms of the negativity bias, and particularly those involving attentional processes, characterized by their short latency and duration. In fact, active, selective attention to visual stimuli associate with several ERP components occurring within the first 500 ms after stimulus onset (Mangun and Hillyard, 1995). The characteristics of these components vary according to the stimular parameter to be attended and to the experimental task. ERP data on attention towards visual emotional stimulation are conspicuously scarce, though recent data indicate that two components, P200 and P340, originated in the visual association cortex, reflect input processing-related attention towards affective pictures (Carretié et al., 2000). In this regard, the main objective of the present study was to explore the involvement of attentional processes in the negativity bias studying the attention-related ERP activity. Our hypothesis is that both amplitude and latency of this attention-related brain activity will support the involvement of attention in the negativity bias. Concretely, it may be expected that the attentional facilitation of urgent and prominent responses towards negative events will be reflected in higher amplitudes and shorter latencies in this attention-related ERP activity in response to negative emotional visual stimulation than in response to non-negative stimulation.

2. Methods

2.1. Subjects

Thirty-nine right-handed students from the Universidad Autónoma de Madrid took part in this experiment. The data from only 35 of them were eventually analyzed, as explained later. These 35 subjects, 29 women and 6 men, were aged between 20 and 29 years (mean = 21.46, S.D. = 1.99). They took part voluntarily in the experiment.

2.2. Stimuli

Our stimuli consisted of 3 groups of 4 slides each. Each slide presented a colour image in the left half of the slide (as seen from subjects’ point of view) and a photographic negative (also in color) of the same or a different image in the right half. Moreover, this negative was in an inverted position (i.e., with the top part of the original image at the bottom: see a black and white version of one of the stimuli in Fig. 1). The task for which this stimular configuration was designed will be described later. In each of the three groups, the four slides derived from only two original images: one of the slides was formed...
with the first of these images and its negative version, another with the second image and its negative version (these two slides were stimuli ‘with correspondence’), the third slide was again composed of the first image, but with the negative version of the second one, and the fourth slide showed the second image and the negative version of the first one (these two were stimuli ‘with no correspondence’).

The original images were different for each group of stimuli: those of the first group consisted of two different photographs of buildings (hereafter labeled V0 or ‘zero valence’), the two images of the second group showed nude models of the opposite sex (V+ or ‘positive valence’), and those of the third group represented different kinds of beetles (V− or ‘negative valence’). Stimuli of each of the three groups appeared 32 times (8 times each slide), and presentation order was random.

The 35 subjects whose data were finally analyzed completed a multidimensional scaling test for each group of pictures after the recording sessions. This test assessed the valence (negative-to-positive) and the arousal (calming to arousing) content of the pictures, two affective dimensions considered to explain the principal variance of the emotional meaning (Lang et al., 1993; Osgood et al., 1957; Russell, 1979; Smith and Ellsworth, 1985). Results from this test will be described later.

2.3. Recording

Nine locations (F5, Fz, F6, C5, Cz, C6, P5, Pz and P6) were used to record the ERPs using Ag/ClAg electrodes, the nosetip being the reference. Impedance was balanced and below 7 KΩ. High- and low-pass filters were set to 0.23 and 70 Hz, respectively, and the EEG was sampled at 105 Hz for 1000 ms (150 ms being prior to stimulus onset). An EOG was recorded supra- and infra-orbitally at the left eye. Trials where EOG activity was greater than 40 μV were automatically rejected and repeated. Subjects whose data were finally analyzed (35, as previously indicated) were those whose ocular artifact rate was less than 15% of the trials.

2.4. Procedure

Subjects were placed in an electrically and acoustically isolated room, and they sat in a comfortable chair, 1 m from the screen. They were told to look at a point located in the center of the screen during the recording session. The slides were shown with a projector located in the apparatus room 1.20 m from a back projection screen. The center of the projection was at subjects’ eye level. The resulting angle of vision was 10° (with respect to the long side of the slide). Stimuli presentations lasted 150 ms each.

Subjects were told that the experiment dealt with ability in a perceptive-visual task. They were instructed to say ‘si’ (yes) whenever a stimulus ‘with correspondence’ appeared, and ‘no’ if the presented stimulus was one ‘with no correspondence’ (Section 2.2). Subjects were also instructed to wait, before giving any response, until they heard a ‘beep’, which sounded 2 s after the stimulus onset. Finally, they were told to blink only after this beep. The next stimulus appeared 3 s later, so that the total interstimulus interval was 5 s. Before data collection, subjects were familiarized with the procedure through a block of eight training trials.

This task pursued several objectives. Firstly, it
was useful for ensuring attention to stimuli and for facilitating the detection of those subjects whose level of attention may have been too low. None of the 35 subjects who completed the experiment under the ocular artifact limit made errors in the task for more than 5% of the stimuli. Task’s second objective was to avoid making it easy for subjects to consider that some of the stimuli were more important than others (e.g. emotional stimuli more important than neutral), in order to prevent the relevance-for-task effect, often described in previous studies (Carretié et al., 1997; Duncan-Johnson and Donchin, 1977: the stimuli on which task focuses tend to elicit the highest amplitudes in certain endogenous components). Additionally, the slide design (normal picture plus an inverted photographic negative) ensured the presentation of images with the same emotional content, allowed for the formation of 12 combinations from only six different motifs, and introduced a similar level of difficulty for stimuli both with and without correspondence.

3. Results

Fig. 2 shows the grand averages obtained once the baseline (average of the prestimulus recording) had been subtracted from each ERP. The most prominent deflection is a positive wave occurring at approximately 200 ms, which will be labeled P200 hereafter. As already indicated, this is an attention-related component, according to previous literature. In order to analyze it, the amplitude and latency of the most prominent peak occurring within the 150–250-ms interval

![Fig. 2. Grand averages in response to the three groups of stimuli obtained from the 35 subjects at each of the 9 ERP locations employed in the present experiment stimuli (V− or negative, V+ or positive, V0 or neutral). Scale (the same for all locations) and legend appear in Pz grand averages.](image)
was computed for each individual ERP. Several control analyses were initially carried out in order to better interpret the results on the effects of emotional stimulation on P200.

3.1. Control analyses

As explained in the Methods section, each subject filled out a bidimensional scaling test for each group of pictures after the recording sessions. This test assessed the valence and the arousal content of the pictures presented as targets. First control analyses were ANOVAs on the assessments given by subjects to each group of stimuli in order to confirm, firstly, that their affective valence was the one supposed a priori and, secondly, that positive and negative stimuli were balanced with respect to their arousal. Fig. 3 represents the means and standard error of means of both dimensions for each type of stimulus. One-way repeated-measures ANOVAs were computed for valence and for arousal dimensions, using Stimuli (three levels: V0, V+, V−) as factor. The Greenhouse Geisser (GG) epsilon correction was applied to adjust the degrees of freedom of the F-ratios. Post-hoc comparisons were made to determine the significance of pairwise contrasts, using Tukey’s one-factor HSD procedure (alpha = 0.05). ANOVAs indicated that Stimuli differed so in valence as in arousal ($F_{2,68} = 67.57$, GG epsilon = 0.90, $P < 0.001$ and $F_{2,68} = 23.57$, GG epsilon = 0.97, $P < 0.001$, respectively). Post-hoc contrasts indicated that V− and V+ showed distinct valence but not distinct arousal. V− and V+ differed from V0 both in arousal and valence.

Secondly, differences with respect to the task difficulty associated with each group of pictures were analyzed, in order to ensure that the possible effects elicited by the stimuli were not due to this factor. The presence of differences may indicate that level of difficulty and, consequently, of attentional demands, is different for each stimular category. Therefore, the number of errors in the task with respect to each group of stimuli was analyzed via one-way repeated-measures ANOVA on factor Stimuli (means, standard error of means, and standard deviations of incorrect answers in

<table>
<thead>
<tr>
<th>Stimuli</th>
<th>Mean</th>
<th>S.E.M.</th>
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<tbody>
<tr>
<td>Buildings</td>
<td>1.54</td>
<td>0.29</td>
<td>1.72</td>
</tr>
<tr>
<td>Nudes</td>
<td>1.48</td>
<td>0.32</td>
<td>1.87</td>
</tr>
<tr>
<td>Insects</td>
<td>0.80</td>
<td>0.17</td>
<td>0.99</td>
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Fig. 3. Means (bars) and standard error of means (lines on the bar extremes) of valence (−3, negative to +3, positive) and arousal (−3, calming to +3, arousing) assessments given by the 35 subjects to the three types of stimuli.

Finally, the possible interaction of gender with the type of stimulation and with the ERP location was analyzed for each P200 amplitude and latency. This analysis was carried out due to the
fact that gender differences in brain activity elicited by emotional stimulation have been previously reported (Lang et al., 1998). In order to decide whether this factor should be included or discarded in main analyses, three-way splitplot ANOVAs, one for P200 amplitude and the other for P200 latency, were computed. Within-subject factors were Stimuli and Channel (9 levels). Inter-subject factor was Gender. Gender did not interact with Stimuli with respect to P200 latency (F_{2,66} = 1.54, GG epsilon = 0.92, P > 0.2) nor with respect to P200 amplitude (F_{2,66} = 0.58, GG epsilon = 0.88, P > 0.5). Interaction Gender by Stimuli by Location was neither significant with respect to latency (F_{16,528} = 0.52, GG epsilon = 0.59, P > 0.8) nor with respect to amplitude (F_{16,528} = 1.49, GG epsilon = 0.48, P > 0.15).

3.2. ANOVAs on experimental effects

Two-way repeated measures ANOVAs were computed on both P200 latency and P200 amplitude. Figs. 4 and 5 show the mean values of these two parameters in response to the three types of stimuli. The factors were Stimuli (3 levels: V −, V + and V0) and Channel (9 levels). Also in this case, the GG epsilon correction was applied to adjust the degrees of freedom of the F-ratios. Post-hoc comparisons were made to determine the significance of pairwise contrasts, using the Bonferroni correction (alpha = 0.05). With respect to P200 latency, factor Stimuli produced significant effects (F_{2,68} = 9.40, GG epsilon = 0.93, P < 0.001). Post-hoc comparisons indicated that this component presented its shorter latencies in response to V − and V0, which differed significantly from latencies to V + (latencies to V − and V0 were not significantly distinct). The interaction Stimuli by Channel was also significant (F_{16,544} = 2.90, GG epsilon = 0.59, P < 0.005). Post-hoc contrasts found distinct significant differences between latencies to V − and to V + (the former being shorter) in the Stimuli by Channel interaction at Pz. Additionally, latency in response to V0 and V + differed at P5 and P6, and latency to V0 and V − differed at P6, being shorter in response to V0 in both cases. On the other hand, post-hoc analyses indicated that differences between hemispheres (between symmetrical locations) were not significant for factor Channel nor for the Stimuli by Channel interaction.

With respect to P200 amplitude, factor Stimuli did not produce significant effects, though a strong trend exists indicating that, in general, amplitude elicited by V − was higher than the rest (F_{2,68} = 2.61, GG epsilon = 0.88, P = 0.088). Additionally, the effect of the Stimuli by Channel interaction was clearly significant (F_{16,544} = 9.72, GG epsilon = 0.48, P < 0.001). Post-hoc contrasts revealed that P200 amplitudes shows significant divergences between V − and V + at Fz, C5, and Cz. Moreover, amplitudes elicited by V − were significantly distinct to those evoked by V0 at P5 and P6. In these two contrasts, V − elicited the highest amplitudes. Additionally, V0 and V + elicited distinct amplitudes at P5 and P6, the latter stimuli eliciting the highest values. Also in this case, post-hoc analyses indicated that differences between symmetrical locations were not produced for factor Channel nor for the interaction Stimuli by Channel in any of the two components.

3.3. Partial correlation analyses

An important question is to estimate the stimulus aspects explaining the differences observed in ANOVAs. Though both latency and amplitude showed indices of preferential attentional access to negative stimulation (being the former shorter and the latter higher), the association of both parameters with valence content of the stimulation (which is, as explained, the affective dimension underlying the negativity bias) may be dissimilar. In this sense, P200 amplitudes have followed, in frontal and central areas, a V − > V0 > V + pattern (Fig. 4), so it is reasonable to deduce that valence more than arousal explains these trends. On the other hand, P200 latencies have followed, both with respect to factor Stimuli and with respect to the interaction Stimuli × Channel (particularly at parietal areas) a V − = (or even > V0 < V + pattern (Fig. 5), that appears not to be as related to valence as in the previous case. However, these trends must be statistically confirmed. Therefore, the association between Va-
Fig. 4. Means of P200 amplitudes elicited by the three types of stimuli (V− or negative, V+ or positive, V0 or neutral) at the nine recording sites employed. The same scale, in microvolts, is provided for all locations.

Valence and P200 amplitudes/latencies was analyzed via partial correlation. Though Valence and Arousal were not significantly correlated in this particular case ($r = 0.11$, $P > 0.2$), partial correlations ensured, partiailling out the influence of Arousal, that the ‘pure’ Valence–ERP association was tested. Mean amplitudes and latencies corresponding to the frontal (F5, Fz, F6), central (C5, Cz, C6) and parietal (P5, Pz, P6) recordings were computed before correlations with Valence.
Fig. 5. Means of P200 latencies elicited by the three types of stimuli (V− or negative, V+ or positive, V0 or neutral) at the nine recording sites employed. Note that three different scales, in milliseconds, are provided: one for frontal locations, other for central locations, and a final one for parietal locations.

Valence ratings associated significantly with the P200 amplitudes elicited at frontal ($r = -0.26$, $P < 0.01$) and central ($r = 0.22$, $P < 0.025$) sites.
Fig. 6. Scatterplots of valence assessments and P200 amplitudes at frontal (top) and central (bottom) locations. These associations resulted significant in partial correlation analyses. Regression lines are also shown.

P200 latencies did not correlate with Valence. Fig. 6 illustrates the linear association pattern between Valence and frontal/central amplitudes.

4. Discussion

Results on P200 support the initial hypothesis indicating that attentional phases of the emotional response play an important role in the negativity bias. Thus, P200 amplitude has been higher and latency has been shorter in response to negative stimuli than in response to positive stimuli at several electrode locations. These results suggest that negative events elicit, to a greater extent and faster than positive ones, the mobilization of attentional resources. In this same sense, it should be indicated that a component similar to the one reported here (positive, maximal at posterior scalp sites and with a latency of 200 ms) has been recently described also as a part of the attentional response towards emotional visual stimulation. Interestingly, it showed its highest amplitude in response to negative stimulation (Carretié et al., 2000; differences in the latency of this component were not analyzed).

Results from partial correlation analyses are particularly interesting, since they inform on the affective processes subjacing the time- and amplitude-related aspects of the attentional processes involved in the negativity bias. Thus, P200 latency pattern did not associate with the valence content of the stimulation. On the other hand, valence associated with P200 amplitude recorded at frontal and central sites. This association was inverse: amplitude increases as valence is more negative. As already indicated, non-negative stimuli with similar arousal value do not trigger this bias (Cacioppo and Gardner, 1999; Mogg and Bradley, 1998; Mogg et al., 2000; Peeters and Czapinsky, 1990; Taylor, 1991), so it is implicitly assumed that this bias is particularly explained by the valence value of stimulation. Therefore, present results suggest that it is the magnitude (or amplitude), but not the latency, the aspect of the P200-related attentional processes that is mainly involved in this bias.

Some comments on absence of hemispheric differences observed in present recordings should be made. In this regard, brain activity during the emotional response has been hypothesized to be asymmetrical. The nature of the asymmetries is variable according to the different theoretical models, varying from a general right-hemisphere superiority for both positive and negative emotions (e.g. Borod et al., 1986; Etcoff, 1986; Heller, 1993 — with respect to posterior right-hemisphere) to a specialization of left hemisphere for positive (approach) emotions and right hemi-
sphericity for negative (withdrawal) emotions (Davidson, 1995). The absence of significant hemispheric differences in the present study may be due to the fact that asymmetry is not necessarily significant in certain phases of the emotional reaction (particularly in those related to initial processing, as is the case here), nor in some stimulus conditions (e.g. Davidson, 1995; Gainotti et al., 1993; Halgren and Marinovic, 1994; Spence et al., 1996). In this sense, bilateral, symmetric activity with respect to emotional content of visual stimulation is a relatively frequent finding in ERP research (e.g. Carretí et al., 1997; Diedrich et al., 1996). In this sense, bilateral, symmetric characteristics of the present experimental design (such as stimuli left side/right side configuration), not specifically developed to study laterality, make it necessary to be cautious in the interpretation of our symmetrical findings.

Though the neural activity associated with emotion and that related to attention have been mainly carried out separately, they constitute closely interrelated and mutually dependent processes. In natural environments, attention is preferentially sustained by stimuli that have affective significance, in contrast to routine, emotionally neutral events (Reiman et al., 1997; Lane et al., 1997; Reiman et al., 1997). However, certain characteristics of the present experimental design (such as stimuli left side/right side configuration), not specifically developed to study laterality, make it necessary to be cautious in the interpretation of our symmetrical findings.

References


