Psychophysiology, 45 (2008), 188–196. Blackwell Publishing Inc. Printed in the USA.

DOI: 10.1111/j.1469-8986.2007.00617.x

Modulation of ongoing cognitive processes by emotionally intense words

LUIS CARRETIÉ,[a] JOSÉ A. HINOJOSA,[b] JACOBO ALBERT,[a] SARA LÓPEZ-MARTÍN,[a] BELÉN S. DE LA GÁNDARA,[a] JOSÉ M. IGOA,[a] AND MARÍA SOTILLO[a]
[a]Facultad de Psicología, Universidad Autónoma de Madrid, Madrid, Spain
[b]Instituto Pluridisciplinar, Universidad Complutense de Madrid, Madrid, Spain

Abstract

Contrary to what occurs with negative pictures, negative words are, in general, not capable of interfering with performance in ongoing cognitive tasks in normal subjects. A probable explanation is the limited arousing power of linguistic material. Especially intense words (insults and compliments), neutral personal adjectives, and pseudowords were presented to 28 participants while they executed a lexical decision task. Insults were associated with the poorest performance in the task and compliments with the best. Amplitude of the late positive component of the event-related potentials, originating at parietal areas, was maximal in response to compliments and insults, but latencies were delayed in response to the latter. Results suggest that intense emotional words modulate ongoing cognitive processes through both bottom-up (attentional capture by insults) and top-down (facilitation of cognitive processing by arousing words) mechanisms.

Descriptors: Insults, Compliments, Attentional capture, Affective lexical decision (ALD) task, Parietal cortex, LPC

Many emotional events show a capability for disrupting an ongoing task. This effect allows cognitive resources to be reoriented to those events and allows organisms to rapidly process and react to this type of stimuli, which are often critical for the individual, such as threat or danger. It is usually assumed that the main factor underlying this interference caused by the onset of a salient or signal event is a reorientation of attention (Graham & Hackley, 1991; Ohman, Hamm, & Hugdahl, 2000; Siddle, Stephenson, & Spinks, 1983; Sokolov, 1963). However, emotional stimuli need to exceed a critical threshold value before they capture attention (Koster, Crombez, Van Damme, Verschuere, & De Houwer, 2004; Mogg & Bradley, 1998). This threshold depends on several factors, such as level of involvement in the ongoing cognitive task (Schwartz et al., 2005) and the individual's state and trait characteristics (Mogg & Bradley, 1998). The third factor, particularly relevant for this study, is the nature and intensity of the emotional stimulus itself.

There is a wide agreement that verbal emotional material is less arousing than other types of visual affective items such as facial expressions or emotional scenes (Keil, 2006; Kissler, Assadollahi, & Herbert, 2006; Mogg & Bradley, 1998; Vanderploeg, Brown, & Marsh, 1987). Consequently, verbal emotional material would be less capable of disrupting an ongoing cognitive task due to attentional capture than emotional pictorial stimuli. This disadvantage for emotional words is particularly evident in the case of negative (unpleasant) stimulation. Although negative pictures clearly interfere with different cognitive tasks due to attentional capture (Constantine, McNally, & Hornig, 2001; Doallo, Holguin, & Cadaveira, 2006; Vuilleumier, Armony, Driver, & Dolan, 2001), negative words produce less clear effects.

Studies on cognitive interference by emotional words due to attentional capture usually employ standardized experimental paradigms such as emotional Stroop or affective lexical decision. Although data exist showing that negative words are indeed able to attract enhanced attention as compared to neutral words (see studies on attentional blink: Anderson & Phelps, 2001; Keil & Ihssen, 2004; Keil, Ihssen, & Heim, 2006), this enhancement appears not to be enough to produce interference effects in these standardized paradigms. As indicated, one of them is the *emotional Stroop task* or its variations, such as the emotional counting Stroop task (Whalen, Bush, Shin, & Rauch, 2006; Williams, Mathews, & MacLeod, 1996). This procedure explores whether performance in the ongoing cognitive task (color naming) is interfered with by bottom-up processes triggered by the emotional content of words whose color must be named. Whereas in subjects showing affective disorders such as anxiety or posttraumatic stress disorder there is a significant delay in color naming when negative nouns are presented, normal or control participants usually fail to show such interference (for a review, see Williams et al., 1996;see also Whalen et al., 2006, with

This work was supported by the grants SEJ2005-08461-C02-01/PSIC and SEJ2004-07774/PSIC from the Ministerio de Educación y Ciencia of Spain, as well as by grant CCG06-UAM/SAL-0287 from the Comunidad de Madrid/Universidad Autónoma de Madrid.

Address reprint requests to: Luis Carretié, Facultad de Psicología, Universidad Autónoma de Madrid, 28049 Madrid, Spain. E-mail: carretie@uam.es

respect to the emotional counting Stroop task). Some exceptions exist to this rule, as explained later.

A parallel story may be told for another experimental paradigm useful to test cognitive interference by attentional capture: the *affective lexical decision task* (ALD). In it, participants are asked to categorize verbal items as words and nonwords as in classical lexical decision tasks, but, in ALD, words consist of emotional and neutral nouns or adjectives. As in the case of emotional Stroop, the extent to which performance in lexical decision is interfered with by bottom-up processes elicited by negative words is explored (Siegle, Ingram, & Matt, 2002). And also as in the case of emotional Stroop, whereas individuals with affective disorders (mainly depression or dysphoria) show a poorer performance (e.g., longer reaction times) in response to negative than in response to neutral words, normal participants fail to show any neutral versus negative differences (for a review of seven ALD studies, see Siegle et al., 2002; see also recent studies by Kanske & Kotz, 2007; Kuchinke et al., 2005; Nakic, Smith, Busis, Vythilingam, & Blair, 2006).

Thus, according to literature, negative words seem not to significantly disrupt active cognitive processes in normal populations. However, a few data exist suggesting a different trend: When highly intense stimuli such as taboo words or personal traits (e.g., "sadistic," "stupid") are presented, interference with the ongoing task is reported (MacKay et al., 2004; Pratto & John, 1991). These data suggest a close interaction between emotional intensity of stimulation and interference with the ongoing cognitive task. In other words, only those linguistic items with intense affective charge appear to be salient enough to reorient attention in a bottom-up fashion, thereby disrupting the ongoing task.

The present study attempted to confirm this hypothesis through the analysis of electrophysiological (event-related potentials or ERPs) and behavioral responses to emotionally intense words. Three issues concerning the experimental design were particularly important for our purposes. First, positive stimuli were employed along with negative and neutral words. Although positive words are not included in research on affective language as frequently as negative words, some previous data indicate that they elicit significant responses both at a behavioral and at a neural level. These data suggest a "processing facilitation" effect of positive words on ongoing cognitive processes (Fossati et al., 2003; Herbert, Kissler, Junghofer, Peyk, & Rockstroh, 2006; Kuchinke et al., 2005; Schapkin, Gusev, & Kuhl, 2000). The second methodological issue concerned the nature of the stimuli. Some discrete linguistic items are specially and specifically designed to elicit intense emotional reactions in the receiver. Probably the best examples are insults and compliments: A single word can produce intense negative or positive reactions. These "made-to-affect" linguistic items have not previously been studied, to the best of our knowledge, in relation to emotional processes in general, or, consequently, in relation to emotional modulation. Finally, the third issue dealt with the experimental task selected to test emotional interference. An important prerequisite for a task that aims at studying cognitive interference by affective words is the need to ensure that subjects consciously read these words while executing the cognitive task. Although at least an automatic reading may be assumed in the emotional Stroop task, ALD *necessarily* requires from participants conscious or controlled reading of each word so that they can accomplish the task correctly. For this reason, the ALD task was employed.

Methods

Participants

Twenty-eight right-handed female students from the Universidad Autónoma de Madrid took part in the present experiment. These 28 participants, aged between 20 and 35 years (mean: 22.36; standard deviation, 3.19), were all native Spanish speakers. They took part in the experiment voluntarily and provided informed consent to participate, reporting normal or corrected-to-normal visual acuity. The reason for recruiting only women was the fact that gender differences have been observed in neural activity underlying lexical decision tasks (Hill, Ott, Herbert, & Weisbrod, 2006).

Stimuli and Procedure

An ALD task was requested from participants, who were instructed to press a button whenever a Spanish word was presented and a different button if a pseudoword appeared instead, with their right hand in both cases. They were told that words consisted of personal adjectives in order to avoid semantic misinterpretations. Words and pseudowords were presented in semirandom order, so more than two consecutive words of the same emotional category were never presented. A complete list of the words and pseudowords employed in the present experiment as well as an approximate translation into English is available at http://www.uam.es/carretie/grupo/adjectives.htm. Words consisted of insults ($n = 10$), compliments ($n = 10$), and neutral adjectives ($n = 10$). Pseudowords consisted of 30 legible strings of characters. Each stimulus (including pseudowords) was presented three times; therefore, a total of 180 trials was presented. Each stimulus was presented for a period of 650 ms and was displayed in white letters on a black background (the first letter was capitalized). Stimulus onset asynchrony was set to 2500 ms. Participants were instructed to look continuously at a small mark located in the center of the screen and to blink only after a beep that sounded 1650 ms after each stimulus onset.

The selection of the final list of adjectives described above was guided by several emotional and lexical criteria. Thus, two independent samples of 37 and 50 women (different from those participating in the recording phase) had previously filled out a questionnaire using a 5-point scale in which they evaluated, respectively, the arousal and valence associated with an initial list of 50 insults, 50 compliments, and 50 neutral adjectives. Valence and arousal are two affective dimensions widely considered to explain most of the variance of emotional meaning (Lang, Greenwald, Bradley, & Hamm, 1993; Osgood, Suci, & Tannenbaum, 1957; Russell, 1979; Smith & Ellsworth, 1985). Independent samples were employed in order to avoid the "halo effect" (Saal, Downey, & Lahey, 1980; multidimensional assessments provided by the same subject to the same item tend to be similar and to show inflated intercorrelations). With the aim of disentangling valence and arousal effects, insults and compliments were selected in such a way that they were opposite in valence assessments (though symmetrical, i.e., equally distant from the midpoint of the valence dimension) and balanced in arousal (Table 1).

Additionally, and in order to avoid the influence of lexical factors on potential experimental effects, the final list of insults, compliments, and neutral adjectives was defined in such a way that they were balanced for frequency of use in Spanish (Alameda & Cuetos, 1995; see Table 1). Types of words, as well as pseudowords, were also balanced in number of syllables (which ranged from one to four), as can be seen in Table 1.

Table 1. *Characteristics of Stimuli*

	Arousal (1–5)	Valence(1–5)	Syllables	Frequency of use (per 2,000,000 words)
Insults	3.75 (0.16)	1.62 (0.31)	2.80 (0.63)	21.60 (35.94)
Neutral adjectives	2.75 (0.34)	3.21 (0.27)	3.30 (0.95)	24.50 (39.00)
Compliments	3.65 (0.27)	4.37 (0.34)	3.50 (0.97)	37.40 (32.49)
Pseudowords	—	—	3.17 (0.87)	—
One-way ANOVA on each factor	$F(2,18) = 37.54$, $p < .001$	$F(2,18) = 174.34$, $p < .001$	$F(3,27) = 1.37$, $p = 0.28$, n.s.	$F(2,18) = 0.61$, $p = 0.55$, n.s.

Note. Means and standard deviations (in parentheses) of arousal (1, *calming* to 5, *arousing*) and valence (1, *negative* to 5, *positive*) assessments given by the independent samples of subjects to each stimulus type (more details are given in the main text). Number of syllables and frequency of use are also provided. The last row shows the results of the statistical contrasts concerning each of these variables. Post hoc Bonferroni analyses on these contrasts are described in the main text.

Recording

Subjects were placed in an electrically shielded, sound-attenuated room. Behavioral activity was recorded through a two-button keypad whose electrical output was continuously digitized at a sampling rate of 800 Hz. Electroencephalographic (EEG) activity was recorded using an electrode cap (ElectroCap International) with tin electrodes. Thirty electrodes were placed at the scalp following a homogeneous distribution. All scalp electrodes were referenced to the nosetip. Electrooculographic (EOG) data were recorded supra- and infraorbitally (vertical EOG), as well as from the left versus right orbital rim (horizontal EOG). Electrode impedances were always kept below 5 K. A bandpass filter of 0.3 to 40 Hz was applied. Recordings were continuously digitized at a sampling rate of 200 Hz throughout the recording session. The continuous recording was divided into 1000-ms epochs for each trial, beginning 200 ms before stimulus onset. Trials for which subjects responded either out of time ($>$2500 ms) or erroneously were eliminated. Visual inspection was also carried out in order to delete epochs containing eye movements or blinks. This artifact and error rejection led to the average admission of 23.89 insult trials ($SD = 3.48$), 25.89 neutral adjective trials ($SD = 3.47$), 25.75 compliment trials ($SD = 3.38$), and 68.75 pseudoword trials ($SD = 12.13$).

Results

A two-step analysis was carried out both for behavioral data and for electrophysiological recordings. First, the effect of the lexical decision task was examined through repeated-measures analyses of variance (ANOVAs) with respect to lexical category (word vs. pseudoword). Second, we observed the experimental effect produced by the emotional content of adjectives. In this case, the factor introduced in the ANOVAs was adjective type (insults, compliments, and neutral adjectives). The Greenhouse–Geisser (GG) epsilon correction was applied to adjust the degrees of freedom of the F ratios where necessary, and post hoc comparisons for determining the significance of pairwise contrasts were made using the Bonferroni procedure (alpha $< .05$).

Behavioral Data

Miss ratio and error ratio (i.e., no responses and incorrect button presses, respectively, divided by the number of trials; this measure ranges from 0 to 1), as well as reaction times (RTs), were analyzed. Table 2 shows means and standard deviations of these behavioral parameters as a function of stimulus type, and Table 3 displays statistical details of all ANOVA contrasts. First, ANOVAs with respect to lexical category (two levels: word, pseudoword) were computed on these three behavioral indices. As regards RTs, the usual effect was observed (e.g., Fiebach, Friederici, Muller, & von Cramon, 2002; Kuchinke et al., 2005; Meyer & Schvaneveldt, 1971; Neely, 1977): Lexical decision took more time in response to pseudowords than in response to words (Tables 2 and 3). A similar result was obtained with respect to miss ratio and error ratio: In both cases, pseudowords produced significantly greater ratios than adjectives.

Second, repeated-measures ANOVAs on the three behavioral indices with respect to adjective type (three levels: insults, compliments, and neutral adjectives) were carried out. With respect to RTs, differences were significant (Table 3). The shortest RTs were produced in response to compliments, which significantly differed from the rest, according to Bonferroni post hoc tests. Insults caused the longest RTs, also differing from the rest. As regards error ratios, differences were also significant (Table 3). The lowest error ratio was produced by compliments and neutral adjectives. In this case, Bonferroni tests did not detect any difference between these two conditions. According to these post hoc contrasts, negative stimuli were associated with a significantly greater error ratio than both compliments and neutral adjectives. Finally, no differences between insults, compliments, and neutral adjectives were observed with respect to miss ratio.

ERP data: Analyses of Experimental Effects

Figure 1 shows a selection of grand averages once the baseline value (prestimulus recording) had been subtracted from each ERP. These grand averages suggest that, in line with previous ERP studies employing emotional words (Herbert et al., 2006; Kanske & Kotz, 2007; Schapkin et al., 2000), P2 and, mainly, LPC were those components showing more sensitivity to experimental manipulations. Moreover, grand averages suggest that not only amplitude but also latency would apparently manifest this sensitivity. Therefore, two-way repeated-measures ANOVAs were carried out on P2 and LPC amplitudes and latencies. To that aim, peak voltages (and their associated latencies) were detected within the 235–275-ms interval for P2 and within the 520–800-ms interval for LPC. Along with lexical category or, alternatively, adjective type, the second factor submitted to ANOVAs was electrode (i.e., the scalp location of each recording). Prior to statistical analyses, recordings were grouped into different scalp regions, because ERP components frequently behave differently in some scalp areas than in others (e.g., they present opposite polarity or react differently to experimental manipulations). Thus, statistical analyses were carried out separately for four different regions (Figure 2). The validity of this regional division was supported by the fact that 93.75% of

Table 2. *Means and Standard Deviations (in Parentheses) of Behavioral and Electrophysiological Recordings*

	Insults	Neutral adjectives	Compliments	Pseudowords
Behavior				
Error ratio (0–1)	0.07 (0.05)	0.02 (0.04)	0.01 (0.02)	0.10 (0.12)
Miss ratio (0–1)	0.01 (0.03)	0.02 (0.04)	0.02 (0.06)	0.16 (0.22)
RT (ms)	915.33 (188.58)	869.08 (177.60)	843.49 (183.52)	1030.97 (224.59)
P2				
Amplitude (μV)				
Region 1	1.08 (2.48)	1.23 (3.31)	1.23 (3.16)	1.10 (2.41)
Region 2	0.99 (2.94)	1.11 (3.17)	0.84 (2.87)	0.41 (2.36)
Region 3	2.04 (3.61)	1.50 (3.04)	1.60 (3.21)	1.10 (2.51)
Region 4	3.30 (4.27)	2.32 (3.66)	3.03 (4.27)	2.16 (3.68)
Latency (ms)				
Region 1	268.75 (11.22)	266.74 (14.06)	265.04 (14.97)	269.42 (11.50)
Region 2	264.03 (12.93)	263.09 (14.62)	263.41 (14.38)	264.58 (14.50)
Region 3	257.98 (14.40)	256.65 (15.17)	258.17 (14.47)	258.13 (14.72)
Region 4	253.12 (14.13)	252.54 (14.91)	253.70 (14.92)	252.54 (14.75)
LPC				
Amplitude (μV)				
Region 1	2.84 (3.59)	2.00 (3.73)	3.71 (4.26)	2.24 (3.56)
Region 2	2.71 (4.46)	1.21 (4.09)	2.75 (4.77)	0.58 (4.41)
Region 3	4.24 (4.82)	2.14 (5.45)	4.74 (5.36)	1.74 (5.12)
Region 4	4.50 (4.81)	3.22 (5.90)	6.18 (5.42)	2.56 (5.24)
Latency (ms)				
Region 1	665.58 (103.48)	640.71 (95.67)	640.00 (90.79)	689.15 (119.49)
Region 2	705.69 (76.38)	653.87 (97.22)	656.59 (81.83)	707.36 (106.34)
Region 3	718.31 (62.11)	671.94 (85.17)	675.24 (68.99)	726.71 (85.55)
Region 4	699.64 (76.65)	653.93 (94.37)	668.93 (72.73)	682.05 (109.89)

ANOVAs (30 out of 32) did not yield Electrode × Lexical Category or Electrode × Adjective Type differences. This suggests that, in general, each region behaved coherently and was homogeneously sensitive to each stimulus type. Table 2 shows means and standard deviations of P2 and LPC amplitudes and latencies as a function of stimulus type, and Table 4 presents statistical details of all ANOVA contrasts.

As appreciated in Table 4, P2 amplitude was not sensitive to lexical category nor to adjective type at any of the four scalp regions. With respect to P2 latency, a significant difference was observed only at region 1 for lexical category (shorter latencies to adjectives than to pseudowords), but no latency effects were observed for adjective type, the factor which is more important for our scope.

On the other hand, LPC showed clear differences as a function of stimulation (Table 4). Thus, LPC latency was sensitive to lexical category at scalp regions 1, 2, and 3 (shorter latencies to adjectives than to pseudowords) and to adjective type at regions 2, 3, and 4 (insults eliciting longer latencies than neutral adjectives and compliments in all cases, according to Bonferroni post hoc tests). Similarly, LPC amplitude was sensitive both to lexical category and to adjective type. In the former case, adjectives elicited greater amplitudes than pseudowords at regions 2, 3, and 4. In the latter, and according to post hoc tests, compliments were associated with greater amplitudes than neutral adjectives at regions 3 and 4, and insults elicited greater amplitudes than neutral adjectives at region 3. No amplitude differences were observed between insults and compliments. Figure 3 presents LPC amplitudes in the form of scalp maps.

Table 3. *Behavioral Results*

	Lexical category (words vs. pseudowords)		Adjective type (insults, neutral, compliments)	
	$F(1,27)$	p	$F(2,54)$	GG-corrected p
Error ratio	7.52	< .025	21.04	< .001
Miss ratio	11.64	< .01	0.71	.45, n.s.
RT	107.59	< .001	16.492	< .001

Note. F values corresponding to lexical category and adjective type yielded by one-way repeated-measures ANOVAs carried out on error rate, miss rate, and reaction time (RT). Post hoc Bonferroni analyses on these contrasts are described in the main text.
GG: Greenhouse-Geisser.

ERP Data: Source Location

The next step was to locate three-dimensionally the cortical sources of LPC in order to determine the origin of the above-described experimental effects. To that aim, the *standardized low-resolution brain electromagnetic tomography* (sLORETA) was applied to LPC amplitudes. sLORETA is a three-dimensional, discrete linear solution for the EEG inverse problem (Pascual-Marqui, 2002). Solutions are projected on the Montreal Neurological Institute (MNI) standard brain. As can be seen in Figure 4, this analysis suggested the superior parietal lobe/precuneus as the origin of the LPC and, consequently, of the significant experimental effects.

Discussion

Both behavioral and electrophysiological data suggest that insults and compliments significantly modulated cognitive processes involved in the lexical decision task. Results appear to indicate that two different processes underlie this modulation. One of them, manifested in behavioral data and in LPC latencies, points toward interference of insult trials with the ongoing cognitive task due to attentional capture. The other, associated with

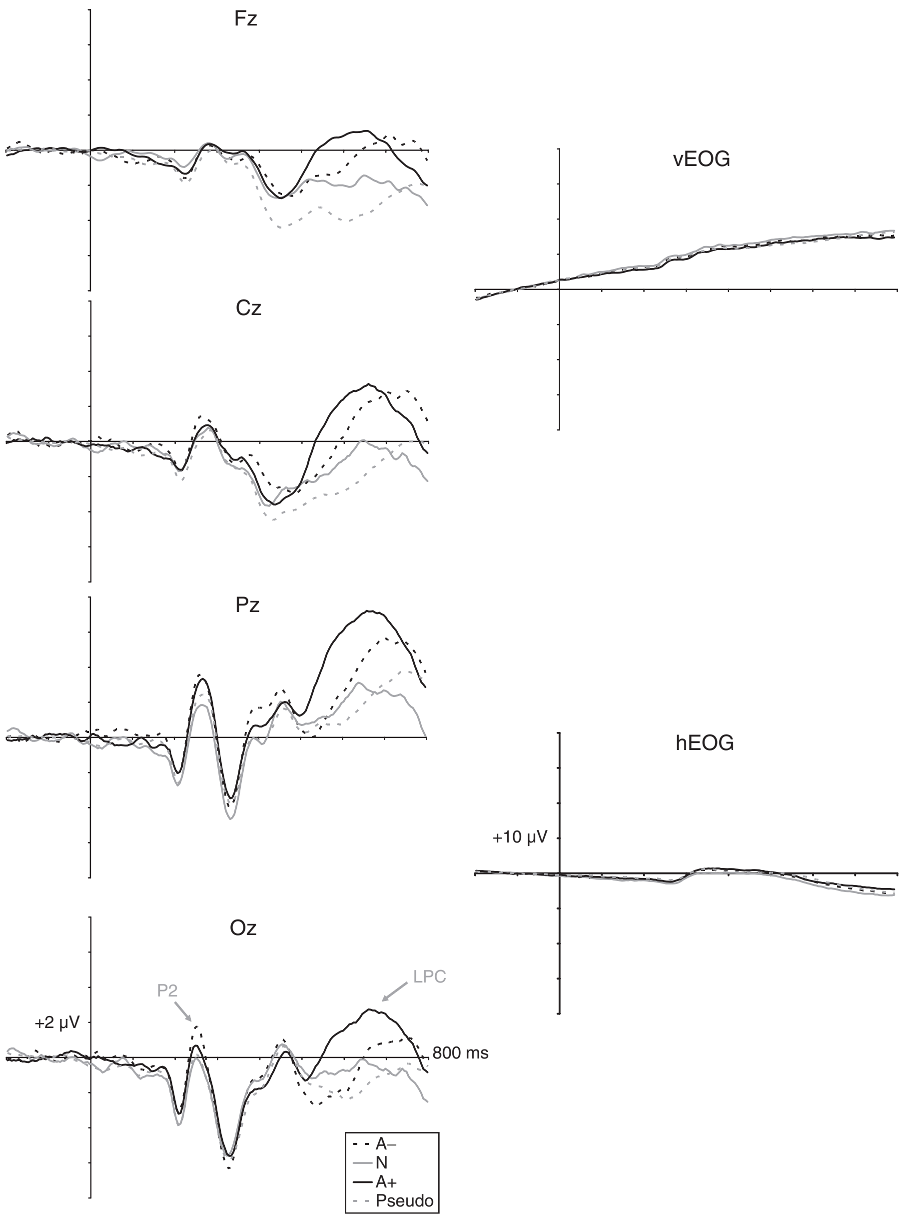

Figure 1. Grand average ERPs at midline sites (left) and mean vertical (v) and horizontal (h) EOGs (right) in response to the four types of stimuli. Scales for ERPs are represented in Oz grand averages and, for EOGs, in hEOG.

LPC amplitudes, would reflect facilitation of top-down cognitive processes by arousing adjectives (insults and compliments). Compliments would obtain a net benefit from both processes, yielding the best performance in the ALD task. This dual-process pattern is described in detail below.

Insult trials were associated with the largest LPC latency and the poorest performance in the ongoing cognitive task, RTs being longer and error ratios being greater than those associated with neutral and compliment trials. This effect would probably be related to the attentional capture effect caused by intense negative stimuli, which interferes with cognitive processes. As explained in the Introduction, and contrary to what occurs in the case of pictorial material, interference of negative words is usually not observed in subjects free of affective disorders (for reviews, see Siegle et al., 2002; Williams et al., 1996; see also Kanske & Kotz, 2007; Kuchinke et al., 2005; Nakic et al., 2006). The scarce studies that, as the present one, report affective interference also employ intense negative items such as taboo words (MacKay et al., 2004) or negative personal traits (Pratto & John 1991), rather than the usually employed emotional nouns (e.g., "murder," "pistol," etc.). Consequently, it may be interpreted that negative linguistic stimuli cause similar interference to negative pictorial stimuli only when the former are markedly intense. Only in this case is the critical threshold a stimulus needs to surpass in order to capture attention achieved (Koster et al., 2004; Mogg & Bradley, 1998).

Meanwhile, enhanced LPC amplitudes in response to arousing personal adjectives (both compliments and insults) with respect to neutral adjectives were observed. The fact that arousing verbal items, both positive and negative, elicit the greatest LPC amplitudes in ALD tasks has been recently reported (Kanske & Kotz, 2007). However, a certain advantage was observed in the

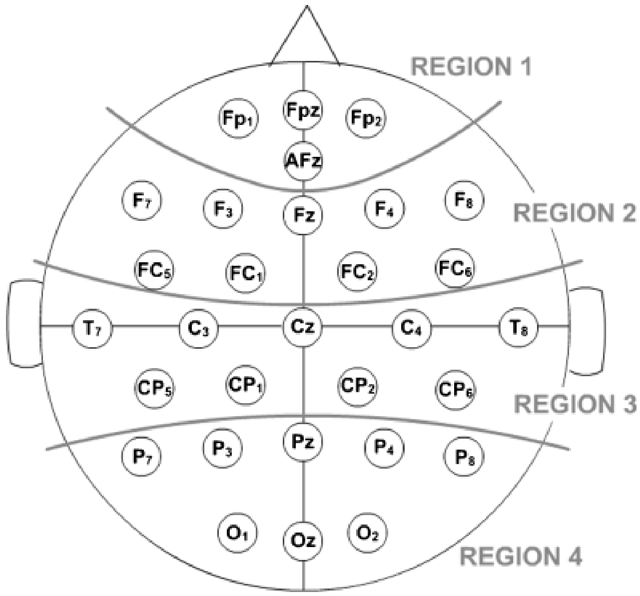

Figure 2. Scalp regions in which ERPs were grouped for statistical contrasts.

LPC response to compliments, in line with previous studies not employing ALD (Herbert et al., 2006; Schapkin et al., 2000). Thus, in spatial terms, whereas compliments elicited greater LPC amplitudes than neutral adjectives at the whole posterior half of the scalp, insults evoked greater amplitudes than neutral adjectives only at central and central-parietal positions. In temporal terms, and as already indicated, latency differences were observed: Peak LPC amplitudes were produced earlier in response to compliments than in response to insults.

The questions arise of which process is reflected in LPC amplitudes and of why it is facilitated by arousing stimuli. A plausible explanation is that LPC is reflecting an enhancement of top-down modulated attention related to the ongoing task, as interpreted in studies in which this type of attention must be directed toward emotional pictures (e.g., Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000; Schupp et al., 2000; Schupp, Junghofer, Weike, & Hamm, 2003). In them, LPC amplitude is also enhanced by arousing stimuli, both positive and negative. This explanation would be supported by spatial information, because the parietal areas suggested by source location algorithms as the origin of LPC, the superior parietal lobe and precuneus, have been consistently associated with top-down or goal-directed visual attention (for a review, see Behrmann, Geng, & Shomstein, 2004). Indeed, this type of attention is necessary for word recognition: Experiments manipulating the level of top-down attention while reading indicate that the parietal cortex reflects the recruitment of attentional processes when words are read (Braet & Humphreys, 2006; Mayall, Humphreys, Mechelli, Olson, & Price, 2001). These data suggest that the fact that arousing stimuli enhance the activity of this area could reflect a strengthening of top-down attentional mechanisms.

Alternatively, it is possible that LPC amplitude is reflecting top-down cognitive processes related to lexical search involved in the experimental task. Words have been reported to elicit greater positivities than pseudowords in nonaffective lexical decision tasks at latencies similar to those of present LPC (Holcomb & Neville, 1990; Pulvermüller, Mohr, & Lutzenberger, 2004; Pulvermüller, Lutzenberger, & Birbaumer, 1995). This positivity elicited by words but not by pseudowords has been associated with lexical search (Pulvermüller et al., 1995). Indeed, the fact that, as in the present experiment, lexical decision is faster for words than for pseudowords is a robust finding (Fiebach et al., 2002; Kuchinke et al., 2005; Meyer & Schvaneveldt, 1971; Neely, 1977). Spatial information also supports this alternative explanation, because recent hemodynamic studies find significant activations in the parietal lobe (precuneus) in lexical decision tasks (Kuchinke et al., 2005).

Whatever the nature of the top-down cognitive process enhanced by arousing stimulus is (attentional or linguistic or both), compliments would count with a double advantage. One would be "passive": Compliments did not reorient or capture attention, diverting it from the cognitive task, to the same extent as insults. The other would be "active": They enhanced top-down cognitive process involved in the ongoing task. This double advantage may explain why the best performance corresponded to compliments.

Table 4. *Electrophysiological Results*

Component and parameter	Scalp Region 1	Scalp Region 2	Scalp Region 3	Scalp Region 4
Lexical category[a]				
P2				
Latency	$F = 4.81$*	$F = 0.42$, n.s.	$F = 0.13$, n.s.	$F = 0.28$, n.s.
Amplitude	$F = 0.05$, n.s.	$F = 1.85$, n.s.	$F = 2.43$, n.s.	$F = 2.61$, n.s.
LPC				
Latency	$F = 4.85$*	$F = 7.16$*	$F = 12.75$***	$F = 0.32$, n.s.
Amplitude	$F = 1.22$, n.s.	$F = 6.57$*	$F = 8.41$**	$F = 10.72$**
Adjective type[b]				
P2				
Latency	$F = 1.04$, n.s.	$F = 0.11$, n.s.	$F = 0.39$, n.s.	$F = 0.41$, n.s.
Amplitude	$F = 0.05$, n.s.	$F = 0.12$, n.s.	$F = 0.45$, n.s.	$F = 0.97$, n.s.
LPC				
Latency	$F = 1.59$, n.s.	$F = 8.70$***	$F = 8.23$***	$F = 6.71$**
Amplitude	$F = 2.16$, n.s.	$F = 2.25$, n.s.	$F = 5.01$*	$F = 4.47$*

Note. *F* values corresponding to lexical category and adjective type yielded by two-way repeated-measures ANOVAs carried out on P2 and LPC amplitudes and latencies (more details in the text). Post hoc Bonferroni analyses on these contrasts are described in the main text.
[a]Two levels: word, pseudoword, *df*: 1,27.
[b]Three levels: insults, neutral, compliments, *df*: 2,54.
*$p < .05$, **$p < .01$, ***$p < .001$ (Greenhouse–Geiser correction in three-level contrasts).

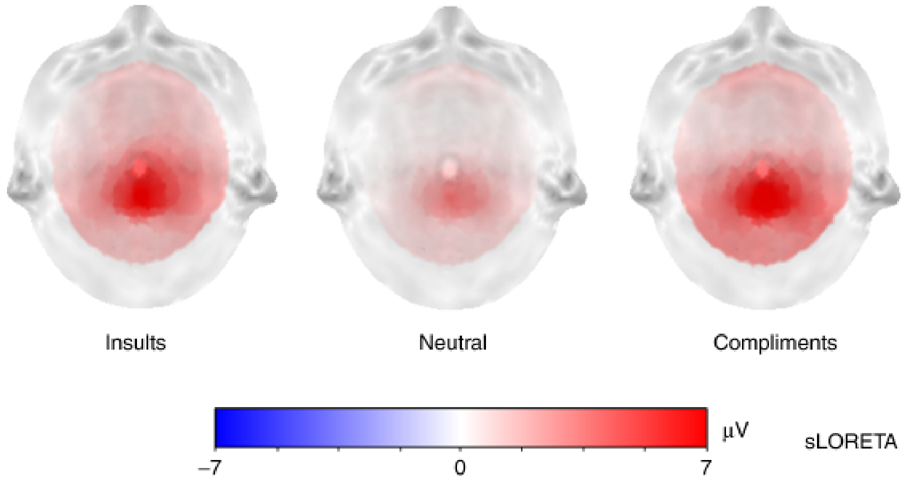

Figure 3. Mean LPC amplitudes in response to each adjetive type in the form of scalp maps.

In the case of reaction times, compliments even produced better performance than neutral adjectives, because the latter do not count with the ''active'' advantage described above. Although positive words are less employed than negative words in studies using linguistic material, some previous data suggest this same pattern. Thus, recently, Kanske and Kotz (2007) and Kuchinke et al. (2005) have reported shorter RTs in ALD tasks when words were positive nouns than when they were neutral or negative nouns. These studies and our present data suggest that positive language brings about a net facilitatory effect on execution in the ongoing cognitive task.

Because LPC was produced around 250 ms before the response is given, the possibility that LPC reflected some kind of motor preparation processes should be also discussed. Although the influence of this preparatory activity may not be completely discarded, some facts suggest that its weight in LPC behavior was, in any case, marginal. First, the origin of LPC is distant from contralateral (left, in this case) motor cortices, the reported source of motor preparation-related ERP components (e.g., Jankelowitz & Colebatch, 2002; Kunieda et al., 2004). Second, motor preparation-related potentials are characterized by having negative polarity (Deecke & Kornhuber, 1977), LPC being positive. Third, motor preparation-related ERP activity continues up until the motor response is produced; contrarily, LPC ends (i.e., its amplitude returns to baseline) before the response is given. Finally, RTs and latencies were not coincident in some aspects: Mainly, whereas compliments caused significantly shorter RTs than neutral adjectives, both categories elicited similar LPC latencies.

Another relevant point to be discussed is the fact that emotional modulation by personal adjectives has been reflected relatively late in ERPs: No effects were observed in P2. This component has been shown to be sensitive to the emotional content of words in previous experiments (Kanske & Kotz, 2007; Schapkin et al., 2000). However, it is important to indicate that, in these studies, P2 amplitude was enhanced in response to positive words, an effect that has been interpreted as a manifestation of the ''positive offset'' (Kanske & Kotz, 2007). The positive offset refers to the fact that the positive motivational approach system is activated more strongly than the negative motivational withdrawal system by low levels of arousal input (Cacioppo & Gardner, 1999). Because verbal material is relatively low in arousal terms, it presents a general bias toward positivity (Kissler et al., 2006). Therefore, the absence of P2 sensitivity to the emo-

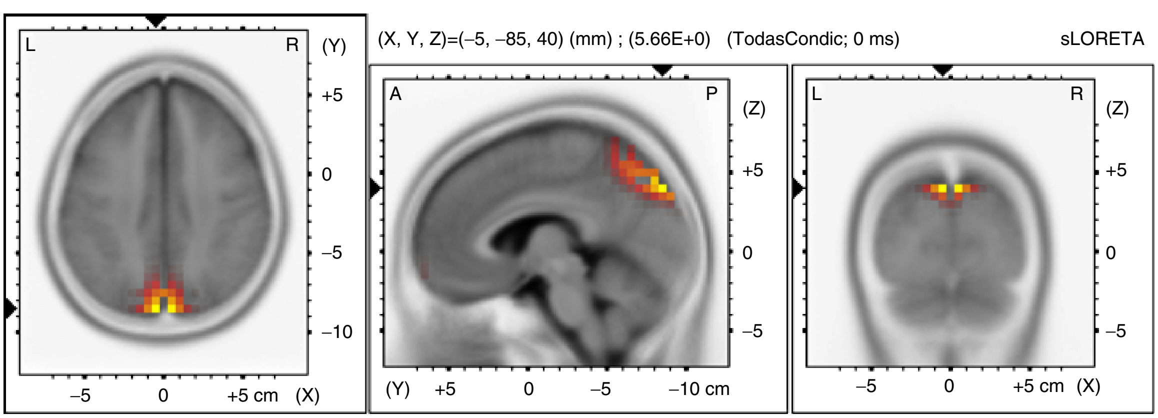

Figure 4. Images of neural activity computed with sLORETA for LPC amplitudes. Source is represented through three orthogonal brain views in NMI space, sliced through the region of the maximum activity. As may be appreciated, it is located at the superior parietal lobe/precuneus.

tional content of words in our study would support the idea that insults and compliments indeed surpassed the low arousal level required by positive offset to be manifested.

In sum, behavioral and electrophysiological data show that top-down cognitive processes involved in the ongoing task are modulated by intense emotional words: Whereas insults interfered with these processes probably due to attentional capture, compliments yielded the best performance in the task because they did not cause interference and actively facilitated top-down cognitive processing. The present study suggests that ALD constitutes an advisable tool to further study the interference of affective words with cognitive processes, even taking into account word and pseudoword repetition, a potential limitation of this experiment. However, related tasks such as emotional Stroop or others could also be employed in order to explore this field from complementary perspectives. This multitask approach could aid in disentangling some open issues, such as which particular cognitive process (e.g., attention vs. lexical search) is mainly modulated by the emotional content of words while we process them.

REFERENCES

Alameda, J. R., & Cuetos, F. (1995). *Diccionario de frecuencias de las unidades lingüísticas en castellano*. Oviedo: Universidad de Oviedo.

Anderson, A. K., & Phelps, E. A. (2001). Lesions of the human amygdala impair enhanced perception of emotionally salient events. *Nature*, *411*, 305–309.

Behrmann, M., Geng, J. J., & Shomstein, S. (2004). Parietal cortex and attention. *Current Opinion in Neurobiology*, *14*, 212–217.

Braet, W., & Humphreys, G. W. (2006). Case mixing and the right parietal cortex: Evidence from rTMS. *Experimental Brain Research*, *168*, 265–271.

Cacioppo, J. T., & Gardner, W. L. (1999). Emotion. *Annual Review of Psychology*, *50*, 191–214.

Constantine, R., McNally, R. J., & Hornig, C. D. (2001). Snake fear and the pictorial emotional stroop paradigm. *Cognitive Therapy and Research*, *25*, 757–764.

Cuthbert, B. N., Schupp, H. T., Bradley, M. M., Birbaumer, N., & Lang, P. J. (2000). Brain potentials in affective picture processing: Covariation with autonomic arousal and affective report. *Biological Psychology*, *52*, 95–111.

Deecke, L., & Kornhuber, H. H. (1977). Event-related cerebral potentials and the initiation of voluntary contraction. In E. Desmedt (Ed.), *Progress in clinical neurophysiology* (pp. 132–150). Basel: Karger.

Doallo, S., Holguin, S. R., & Cadaveira, F. (2006). Attentional load affects automatic emotional processing: Evidence from event-related potentials. *NeuroReport*, *17*, 1797–1801.

Fiebach, C. J., Friederici, A. D., Muller, K., & von Cramon, D. Y. (2002). fMRI evidence for dual routes to the mental lexicon in visual word recognition. *Journal of Cognitive Neuroscience*, *14*, 11–23.

Fossati, P., Hevenor, S. J., Graham, S. J., Grady, C., Keightley, M. L., Craik, F., et al. (2003). In search of the emotional self: An fMRI study using positive and negative emotional words. *American Journal of Psychiatry*, *160*, 1938–1945.

Graham, F. K., & Hackley, S. A. (1991). Passive and active attention to input. In J. R. Jennings & M. G. H. Coles (Eds.), *Handbook of cognitive psychophysiology* (pp. 251–356). Chichester: Wiley.

Herbert, C., Kissler, J., Junghofer, M., Peyk, P., & Rockstroh, B. (2006). Processing of emotional adjectives: Evidence from startle EMG and ERPs. *Psychophysiology*, *43*, 197–206.

Hill, H., Ott, F., Herbert, C., & Weisbrod, M. (2006). Response execution in lexical decision tasks obscures sex-specific lateralization effects in language processing: Evidence from event-related potential measures during word reading. *Cerebral Cortex*, *16*, 978–989.

Holcomb, P. J., & Neville, H. J. (1990). Auditory and visual semantic priming in lexical decision: A comparison using event-related brain potentials. *Language and Cognitive Processes*, *5*, 281–312.

Jankelowitz, S. K., & Colebatch, J. G. (2002). Movement-related potentials associated with self-paced, cued and imagined arm movements. *Experimental Brain Research*, *147*, 98–107.

Kanske, P., & Kotz, S. A. (2007). Concreteness in emotional words: ERP evidence from a hemifield study. *Brain Research*, *1148*, 138–148.

Keil, A. (2006). Macroscopic brain dynamics during verbal and pictorial processing of affective stimuli. *Progress in Brain Research*, *156*, 217–232.

Keil, A., & Ihssen, N. (2004). Identification facilitation for emotionally arousing verbs during the attentional blink. *Emotion*, *4*, 23–35.

Keil, A., Ihssen, N., & Heim, S. (2006). Early cortical facilitation for emotionally arousing targets during the attentional blink. *BMC Biology*, *4*, 23.

Kissler, J., Assadollahi, R., & Herbert, C. (2006). Emotional and semantic networks in visual word processing: Insights from ERP studies. *Progress in Brain Research*, *156*, 147–183.

Koster, E. H., Crombez, G., Van Damme, S., Verschuere, B., & De Houwer, J. (2004). Does imminent threat capture and hold attention? *Emotion*, *4*, 312–317.

Kuchinke, L., Jacobs, A. M., Grubich, C., Vo, M. L., Conrad, M., & Herrmann, M. (2005). Incidental effects of emotional valence in single word processing: An fMRI study. *NeuroImage*, *28*, 1022–1032.

Kunieda, T., Ikeda, A., Ohara, S., Matsumoto, R., Taki, W., Hashimoto, N., et al. (2004). Role of lateral non-primary motor cortex in humans as revealed by epicortical recording of bereitschaftspotentials. *Experimental Brain Research*, *156*, 135–148.

Lang, P. J., Greenwald, M. K., Bradley, M. M., & Hamm, A. O. (1993). Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology*, *30*, 261–273.

MacKay, D. G., Shafto, M., Taylor, J. K., Marian, D. E., Abrams, L., & Dyer, J. R. (2004). Relations between emotion, memory, and attention: Evidence from taboo Stroop, lexical decision, and immediate memory tasks. *Memory & Cognition*, *32*, 474–488.

Mayall, K., Humphreys, G. W., Mechelli, A., Olson, A., & Price, C. J. (2001). The effects of case mixing on word recognition: Evidence from a PET study. *Journal of Cognitive Neuroscience*, *13*, 844–853.

Meyer, D. E., & Schvaneveldt, R. W. (1971). Facilitation in recognizing pairs of words: Evidence of a dependence between retrieval operations. *Journal of Experimental Psychology*, *90*, 227–234.

Mogg, K., & Bradley, B. P. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy*, *36*, 809–848.

Nakic, M., Smith, B. W., Busis, S., Vythilingam, M., & Blair, R. J. (2006). The impact of affect and frequency on lexical decision: The role of the amygdala and inferior frontal cortex. *NeuroImage*, *31*, 1752–1761.

Neely, J. H. (1977). Semantic priming and retrieval from lexical memory: Roles of inhibitionless spreading activation and limited-capacity attention. *Journal of Experimental Psychology: General*, *106*, 226–254.

Ohman, A., Hamm, A., & Hugdahl, K. (2000). Cognition and the autonomic nervous system: Orienting, anticipation, and conditioning. In J. T. Cacioppo, L. G. Tassinary, & G. G. Bernston (Eds.), *Handbook of psychophysiology* (2nd ed, pp. 533–575). Cambridge, UK: Cambridge University Press.

Osgood, C. E., Suci, G. J., & Tannenbaum, P. H. (1957). *The measurement of meaning.*. Champaign, IL: University of Illinois Press.

Pascual-Marqui, R. D. (2002). Standardized low-resolution brain electromagnetic tomography (sLORETA): Technical details. *Methods and Findings in Experimental and Clinical Pharmacology*, *24*(Suppl D), 5–12.

Pratto, F., & John, O. P. (1991). Automatic vigilance: The attention-grabbing power of negative social information. *Journal of Personality and Social Psychology*, *61*, 380–391.

Pulvermüller, F., Lutzenberger, W., & Birbaumer, N. (1995). Electrocortical distinction of vocabulary types. *Electroencephalography and Clinical Neurophysiology*, *94*, 357–370.

Pulvermüller, F., Mohr, B., & Lutzenberger, W. (2004). Neurophysiological correlates of word and pseudo-word processing in well-recovered aphasics and patients with right-hemispheric stroke. *Psychophysiology*, *41*, 584–591.

Russell, J. A. (1979). Affective space is bipolar. *Journal of Personality and Social Psychology*, *37*, 345–356.

Saal, F. E., Downey, R. G., & Lahey, M. A. (1980). Rating the ratings: Assessing the psychometric quality of rating data. *Psychological Bulletin*, *88*, 413–428.

Schapkin, S. A., Gusev, A. N., & Kuhl, J. (2000). Categorization of unilaterally presented emotional words: An ERP analysis. *Acta Neurobiologiae Experimentalis*, *60*, 17–28.

Schupp, H. T., Cuthbert, B. N., Bradley, M. M., Cacioppo, J. T., Ito, T., & Lang, P. J. (2000). Affective picture processing: The late positive potential is modulated by motivational relevance. *Psychophysiology*, *37*, 257–261.

Schupp, H. T., Junghofer, M., Weike, A. I., & Hamm, A. O. (2003). Emotional facilitation of sensory processing in the visual cortex. *Psychological Science*, *14*, 7–13.

Schwartz, S., Vuilleumier, P., Hutton, C., Maravita, A., Dolan, R. J., & Driver, J. (2005). Attentional load and sensory competition in human vision: Modulation of fMRI responses by load at fixation during task-irrelevant stimulation in the peripheral visual field. *Cerebral Cortex*, *15*, 770–786.

Siddle, D., Stephenson, D., & Spinks, J. A. (1983). Elicitation and habituation of the orienting response. In D. Siddle (Ed.), *Orienting and habituation: Perspectives in human research* (pp. 109–182). Chichester: Wiley.

Siegle, G. J., Ingram, R. E., & Matt, G. E. (2002). Affective interference: An explanation for negative attention biases in dysphoria? *Cognitive Therapy and Research*, *26*, 73–87.

Smith, C. A., & Ellsworth, P. C. (1985). Patterns of cognitive appraisal in emotion. *Journal of Personality and Social Psychology*, *48*, 813–838.

Sokolov, E. N. (1963). *Perception and the conditioned reflex*. New York: Pergamon Press.

Vanderploeg, R. D., Brown, W. S., & Marsh, J. T. (1987). Judgments of emotion in words and faces: ERP correlates. *International Journal of Psychophysiology*, *5*, 193–205.

Vuilleumier, P., Armony, J. L., Driver, J., & Dolan, R. J. (2001). Effects of attention and emotion on face processing in the human brain: An event-related fMRI study. *Neuron*, *30*, 829–841.

Whalen, P. J., Bush, G., Shin, L. M., & Rauch, S. L. (2006). The emotional counting stroop: A task for assessing emotional interference during brain imaging. *Nature Protocols*, *1*, 293–296.

Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional Stroop task and psychopathology. *Psychological Bulletin*, *120*, 3–24.

(Received March 27, 2007; Accepted August 30, 2007)