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ERP correlates of masked affective priming with emoticons 😊

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ABSTRACT

Emoticons seem to enrich computer-mediated communication by improving enjoyment, perceived richness and usefulness of information (Huang, Yen, & Zhang, 2008). Despite their extensive use over the last decades, the way emoticons affect subsequent emotional/cognitive processing is not fully understood. Here we conducted a masked priming experiment that explored the time course of the masked affective priming effect while recording event-related potentials. Type of prime (emoticon vs. word) and prime valence (positive vs. negative) were manipulated to assess their influence in the processing of positive/negative target words. Results showed a masked affective priming effect in early (N2) and late temporal windows (LPC). This effect was observed in early components for negative target words and in later components for positive target words. Furthermore, it was restricted to those targets preceded by emoticon primes. Thus, the processing of emoticons seems to be privileged when compared with the words to which they refer.

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1. Introduction

In a transcript of Abraham Lincoln's speech from 1862, we can observe what is possibly the first use of an emoticon [;)].¹ Initially, emoticons were pictorial representations of facial expressions created by using punctuation marks and letters. More recently, and in contexts of Messenger-like applications, there has been an evolution to more human-like emoticons (e.g., 😊). The extensive use of emoticons starts with the current digital era, in which the communication mediated by computer has (to some extent) replaced face-to-face communication.

Emoticons seem to have a positive effect in enjoyment, personal interactions, perceived richness and usefulness of information, thus constituting a valuable addition to more traditional communication methods (see Huang et al., 2008). However, experimental research on how emoticons influence cognitive/affective processes is still scarce. Previous studies have revealed that emoticons activate brain areas related to the processing of affective valence – although not those related to the perception of human faces (Yuasa, Saito, & Mukawa, 2006). This finding suggests that emoticons are particularly useful to examine expressions of positive

and negative affect since they minimize the influence of feature confounds associated with real faces (see Jolij & Lamme, 2005). In addition, studies of affective blindsight with normal participants have revealed that the affective content of emoticons is automatically processed (Jolij & Lamme, 2005; see also White, 1995).

In the present paper, we examined the influence of briefly presented emoticons (e.g., the primes 😊 vs. 😞) on the processing of an affective target word [e.g., AZÚCAR (SUGAR)]. For comparison purposes, we also employed the words that those emoticons refer to [e.g., the primes *alegría* (happiness) vs. *rabia* (rage)] in order to compare the processing of emoticons to that of affective words. This was done by manipulating the affective/evaluative relationship between prime and target (positive prime–positive target vs. negative prime–positive target; positive prime–negative target vs. negative prime–negative target) in an affective categorization task (i.e., deciding whether a target word is positive or negative). Affective priming occurs when the response to a target stimulus differs depending on whether both prime and target are either affectively congruent or incongruent. In order to avoid any potential (non-automatic) strategies that may occur when using unmasked visible primes (see Bargh, 1996; Hermans, De Houwer, & Eelen, 2001; Kiefer & Brendel, 2006; Kinoshita & Norris, 2010; Perea, Duñabeitia, & Carreiras, 2008) and to track the earliest moments of processing, we used a sandwich-masked priming technique, in which a briefly presented prime is preceded and followed by a mask (e.g., see Draine & Greenwald, 1998). Importantly, we measured not only behavioral responses, but also Event Related

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¹ Retrieved from <http://cityroom.blogs.nytimes.com/2009/01/19/hfo-emoticon/>.

Potentials (ERPs). Bear in mind that ERP methodology allows us to analyze the temporal course of the masked affective priming effect with a resolution of milliseconds – in contrast, response times only provide a data point at the end of processing.

A common assumption is that masked affective priming can be observed independently of the type of prime (e.g., Draine & Greenwald, 1998; Hermans, Spruyt, De Houwer, & Eelen, 2003; Otten & Wentura, 1999). However, behavioral data are not particularly consistent. Using a categorization task, a number of studies have reported either a masked affective priming effect with words (e.g., Draine & Greenwald, 1998; Greenwald, Draine, & Abrams, 1996; Greenwald, Klinger, & Liu, 1989; Otten & Wentura, 1999), and pictures (e.g., Marcos & Redondo, 2005; Murphy & Zajonc, 1993; White, 1995), or a reverse masked affective priming (i.e., slower responses for congruent pairs relative to incongruent ones) with words (Banse, 2001; Glaser & Banaji, 1999) and with pictures (e.g., Banse, 2001; Hermans et al., 2003; Marcos & Redondo, 2005, with threat-irrelevant faces). Moreover, other studies have failed to find an affective priming effect (e.g., with these two types of representations, as Hermans, 1996, or with schematic faces, as Andrews, Lipp, Mallan, & König, 2011). Such inconsistencies can be explained in three ways: (a) due to the existence of differences in the way unawareness is operationalized (e.g., a forced choice discrimination task vs. participant's self-reports); (b) because of the existence of some methodological flaws, namely the use of semantic tasks before the masking task (see Hermans et al., 2003), or the use of the same masked primes as targets (see Greenwald et al., 1996; see also Kouider & Dehaene, 2007, for review); and (c) due to a scarce control of lexical variables that may affect visual word recognition (e.g., length, word class, word frequency, concreteness, imageability and level of arousal).

In the electrophysiological domain, few ERP studies have explored the temporal course of masked affective priming. Hsu, Hetrick, and Pessoa (2008) explored the influence of happy and fearful face primes on affective target words. The duration of the prime (30 vs. 90 ms) was manipulated while keeping the SOA constant (150 ms). A congruent effect was observed for fearful primes, but only in the high visibility condition (90 ms). Hsu and colleagues concluded that the affective priming effect found for negative primes was due to the visibility of the primes. The fact that only fearful faces promoted a priming effect is in line with previous findings showing a preferential detection and enhanced processing of negative stimuli (Dijksterhuis & Aarts, 2003; Marcos & Redondo, 2005; Raichle & Gusnard, 2005; Öhman, 2002, 2005). This affective congruity effect was observed in both behavioral and electrophysiological data, particularly at the level of the lateralized readiness potential (LRP: 600–700 ms), which is an ERP component that indexes motor preparation.

In another study, Li, Zinbarg, Boehm, and Paller (2008) explored the effect of fearful vs. happy prime faces (presented for 30 ms) on surprise target faces. They reported that the prime's valence modulated early (P1: 60–140 ms) and late (P3a: 300–400 ms) electrophysiological components. Specifically, larger occipital P1 amplitude was observed for target faces when they were preceded by fearful primes than when they were preceded by happy primes. This result was interpreted as a facilitation of an early perceptual analysis by threat stimuli. Nevertheless, the authors also found enhanced P3 amplitudes for target faces following happy faces relative to fearful faces. They explained this finding by assuming that people tend to orient to positive stimuli once negative stimuli are evaluated as insignificant (e.g., see Cacioppo, Gardner, & Berntson, 1997, for evidence). Furthermore, using a similar procedure to that employed by Li et al., Gibbons (2009) explored the effect of word masked primes (presented for 17 ms) on picture targets, by manipulating not only the valence of the prime as in the Li et al. (2008) study, but also its level of arousal (high vs. low). Gibson

found that positive words with high arousal levels influenced late components [Late Positive Component (LPC) – measured from 500 to 650 ms]. However, he did fail to find modulations of threat stimuli in early ERP components. It is worth noticing the fact that the P3 component described by Li et al. is sometimes considered as part of the LPC (Liu, Jin, Wang, & Hu, 2010; Werheid, Alpay, Jentzsth, & Sommer, 2005). The LPC is thought to reflect the functional mobilization of attentional resources, stimuli evaluation processes, the activation of motivational brain systems by emotional stimuli, and the initial memory storage during the processing of affective information (Bradley & Lang, 2007; Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). Additionally, this component seems to be associated with the stimuli's arousal rather than with their valence (e.g., Carretié, Martín-Loeches, Hinojosa, & Mercado, 2001; Hinojosa, Carretié, Méndez-Bértolo, Míguez, & Pozo, 2009).

In summary, the present experiment was designed to shed some light on the temporal course of masked affective priming – in particular when using emoticon primes. We employed two types of primes (emoticons – 😊 vs. 😞 – and words – *alegría* [happiness] vs. *rabia* [rage]) to test their effects on the processing of negative and positive target words. The main questions under scrutiny were: (a) Is it possible to observe an affective priming effect of briefly presented emoticon and word primes on target words?; (b) at which stages of processing (early and/or late) is it possible to observe affective priming?; (c) how quickly can positive and negative information be differentiated?; and (d) are there any differences in affective priming in relation to the type of prime (emoticons vs. words)? If there is an automatic activation of affect from masked primes, then we expect to find an affective priming effect with both emoticons and words, especially at the (more sensitive) electrophysiological level. Emoticons were expected to modulate the early (P1) and late (P3, LPC) ERP components to a greater extent than emotional words. The rationale of the manipulation in the present experiment is that even though emotional pictures and words may receive comparable arousal ratings, pictures may lead to a more direct access to meaning representations than word stimuli (de Houwer & Hermans, 1994; Kouider & Dehaene, 2007). Furthermore, we expected to observe differences between negative and positive stimuli in both early and late components. Concerning the early P1 component, and due to the preferential detection of negative stimuli, stronger modulations were expected to be observed with this kind of stimuli (Dijksterhuis & Aarts, 2003; Dijksterhuis, Corneille, Aarts, Vermeulen, & Luminet, 2004). Moreover, this difference should be more evident in emoticons because the negative bias is more easily observed in pictures than in words (see Herbert, Kissler, Junghofer, Peyk, & Rockstroh, 2006; Kouider & Dehaene, 2007). For later ERP components (P3, LPC), we expected to find differences related to prime–target affective relationship (congruence vs. incongruence) in the amplitude of the LPC. If our hypothesis is correct, these differences should be preferentially observed for positive stimuli (see Gibbons, 2009; Li et al., 2008, for previous evidence).

2. Method

2.1. Participants

Eighteen Spanish undergraduate psychology students from the University of Santiago de Compostela, all of them right-handed (15 women, three men; $M = 22.82$ years, $SD = 2.61$) participated in this study in exchange for credit course. They were informed about the experiment and signed a consent form. All participants completed a socio-demographic questionnaire (e.g., gender, age, educational level), as well as the STAI (the Spanish adaptation of the State Trait Anxiety Inventory; Seisdedos, 1988) and the BDI

(the Spanish adaptation of Beck Depression Inventory; Beck, Rush, Shaw, & Emery, 1979) scales to assess their emotional states. None of the participants had anxiety or depression disorders. All of them were native speakers of Spanish and had either normal or corrected-to-normal vision.

2.2. Materials

120 target words from the Spanish Adaptation of Affective Norms for English Words (ANEW; Redondo, Fraga, Padrón, & Comesaña, 2007) were used: 60 pleasant ($M = 7.5$, $SD = 0.6$) and 60 unpleasant ($M = 2.2$, $SD = 0.6$) words. Within the first set, there were 24 adjectives and 36 nouns, and within the second set there were 26 adjectives and 34 nouns. The Spanish word count, B-Pal (Davis & Perea, 2005) was used in order to equate them all in arousal (6.5 and 6.7, respectively), length (7.6 and 7.3, respectively), frequency (14.2 and 11), orthographic neighborhood (1.2 and 1.1), concreteness (5.1 and 4.6), and imageability (5.3 and 4.7), and word class. Target words were presented in uppercase 14-pt Courier font and were preceded by two types of primes: (a) a pleasant (😊) or unpleasant (😡) emoticon; (b) a pleasant (*alegría* – happiness) or unpleasant (*rabia* – rage) word. Prime words were presented in lowercase 14-pt Courier font. The emoticons were presented in color with a white background. Their dimensions were $0.26^\circ \times 0.26^\circ$ in order to maintain the same characteristics they have in the Microsoft Messenger application.

It is worth noting that in order to select the stimuli that would function as primes, we conducted two previous pilot studies using a sample of 180 subjects (mean age = 22.17 years; $SD = 5.05$). In the first pilot study, the participants were asked to write down the word they associated with each emoticon. In the second study, they were asked to complete a questionnaire in which they evaluated the valence and arousal levels of each emoticon, using the Self-Assessment Manikin (SAM, Bradley & Lang, 1994). For the present study, we selected the most frequent words associated with these two emoticons while keeping, as far as possible, equivalent arousal levels (happiness to 😊 and rage to 😡, respectively). No differences were found between negative emoticons and negative words neither in valence (2.27 vs. 2.33, respectively) nor arousal (7.95 vs. 7.47, respectively). No differences between positive emoticons and positive words were found in valence (7.68 vs. 8.41, respectively).² However, for positive primes, the arousal scores between emoticons and words were different (4 vs. 7.7 respectively; $p < .05$), as well as between positive and negative emoticons (4 vs. 7.95 respectively; $p < .05$). In order to assure stimuli counterbalancing, the primes were rotated through the pleasant and unpleasant conditions so that each target word was primed by each of the four types of primes across the experiment. Four sets of materials were constructed so that each target word could only appear once in every one of the four different priming conditions. The target words in the experiment are presented in the Appendix A.

2.3. Procedure

Participants were tested individually in a quiet room with dim lighting. Before starting the experiment, participants read the target words randomly organized in a list. This was done to minimize potentially confounding repetition effects associated with repeatedly seeing the stimuli throughout the experiment. Stimuli were repeated three times in three separate blocks to assure stable electrophysiological data. This procedure was important because

² The noun *alegría* (happiness) is not included in the Spanish adaptation of ANEW. Instead, we have considered the mean valence and arousal values for *alegre* (happy), as other related nouns and adjectives contained in the database have similar mean values (see, for instance, *agresión-agresivo* or *enfado-enfadado*).

repetition effects seem to modulate brain waveforms by increasing the amplitude of several components after stimuli's first presentation, but not after successive presentations (see Hinojosa et al., 2009). Moreover, it is worth noting that the repetition effect with emotional stimuli seems to be homogeneously distributed among affective stimuli's categories (Olofsson & Polich, 2007).

Stimuli were then presented in three separated blocks by using the Presentation software (Neurobehavioral Systems, Inc.) on a 15" monitor set with a 60 Hz refresh rate. The order of presentation per block was counterbalanced across participants. In each trial, a forward mask consisting of a row of hash marks (#'s) was presented for 500 ms in the center of the screen in lowercase 14-pt. Courier font. The number of hash marks was equal to the number of letters of the largest target word. Then, the prime (which was presented and stayed in the center of the screen for 50 ms) was immediately followed by a second mask presented for 16.67 ms. Target stimuli were presented after this second mask. Both prime and target were presented in the same screen location as the forward mask. The target remained in the screen until the participant response or after 2500 ms. The intertrial interval was 2500 ms (see Fig. 1). Participants were instructed to press one of two buttons in the keyboard to indicate whether the uppercase item was a positive or a negative word, and were instructed to make a decision as quickly and as accurately as possible. The "positive" and "negative" buttons were counterbalanced across participants. They were not informed of the presence of either the lowercase words or the emoticons. Prior to the 120 experimental trials, they were shown a total of eight practice trials (with the same manipulation as in the experimental trials). At the end of the experiment, the participants were presented with a response sheet that included the selected emoticons as well as a list of other emoticons, and they were asked whether or not they had seen something else than the words. They were also asked to identify those emoticons that they thought they had seen. A similar procedure was followed with the prime words. Participants who reported having seen any emoticons or word primes were replaced by other participants from the same population, and their data were not analyzed (four out of 18 participants). Moreover, participants who claimed to have seen "something" but were not able to identify any specific emoticon or word primes were also replaced. This subjective measure of awareness was chosen because it provides an index that reflects the impact of the prime on behavior and brain processing (Hsu et al., 2008). The entire experimental session lasted for about 30 min.

2.4. EEG data acquisition

Electroencephalographic activity was recorded with a NeuroscanTM system, with 30 electrodes (Fp1, Fpz, Fp2, Fz, F3, F4, F7, F8, FCz, FC3, FC4, FT7, FT8, C3, Cz, C4, CP3, CPz, CP4, T3, T4, TP7, TP8, P3, Pz, P4, P7, P8, O1, and O2) inserted in a cap with a nose reference and frontopolar ground—in accordance with the International 10–20 System. The EEG signal was passed through a 0.1–50 Hz (24 dB/octave slope) analog bandpass filter, and amplified at 22.5 K before being sampled at 500 Hz. Simultaneously with EEG recordings, ocular movements (EOG) were recorded by two electrodes located supra- and infra-orbitally to the right eye (vertical EOG) and by two additional electrodes at the lateral angle of each eye (horizontal EOG). All impedances were kept below 10 kΩ s. After signal storage, ocular artifacts were corrected offline using the algorithm proposed by Gratton, Coles, and Donchin (1983).

Individual ERP epochs were constructed starting 200 ms before prime onset and ending at 1500 ms after the stimulus onset. The epochs were segmented based on the prime rather than the target stimuli, in order to obtain a task-free EEG activity in the baseline,

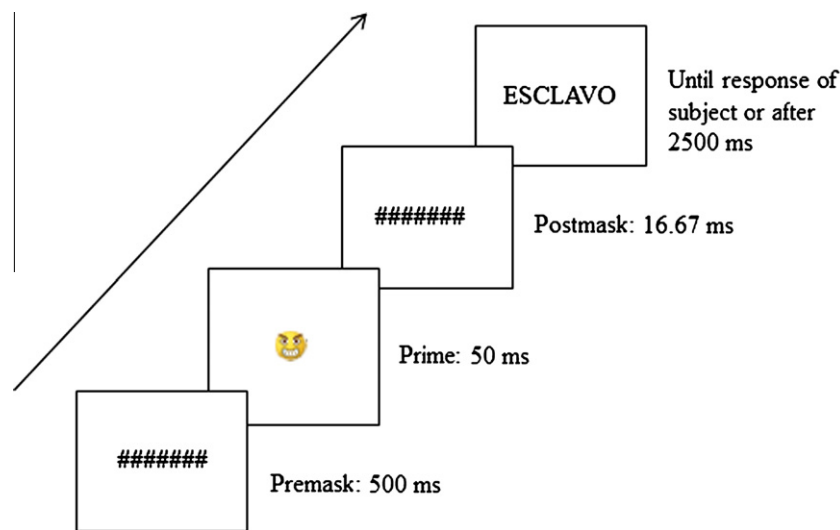


Fig. 1. A typical trial -here using an emoticon as a prime.

and therefore to avoid interpreting modulations that were related to the presentation of two different types of primes (emoticons vs. words) as target-related effects. The signal was passed through a 0.1–20 Hz (24 dB/octave slope) digital band-pass filter. Epochs with signals exceeding $\pm 100 \mu\text{V}$ were automatically rejected, and all remaining epochs were individually inspected to identify those still showing artifacts. Epochs with artifacts were also excluded from subsequent averaging. Separate averages were calculated for each type of condition, after subtraction of the 200 ms pre-stimulus baseline.

2.5. Data analysis

For ERP recordings, eight averaged ERP waveforms were obtained for each participant, consisting of the different combinations of stimuli (Pleasant Emoticon Prime–Pleasant Word Target; Pleasant Emoticon Prime–Unpleasant Word Target; Unpleasant Emoticon Prime–Unpleasant Word Target; Unpleasant Emoticon Prime–Pleasant Word Target; Pleasant Word Prime–Pleasant Word Target; Pleasant Word Prime–Unpleasant Word Target; Unpleasant Word Prime–Unpleasant Word Target; Unpleasant Word Prime–Pleasant Word Target). After a careful inspection of grand average waveforms, four components were selected for analysis: P1, N1, N2, LPC. Therefore, we measured mean amplitude in four intervals: 100–150 ms (P1), 150–200 ms (N1), 250–350 (N2), and 450–600 (LPC). Nine regions of interest were computed out of the 30 recorded electrodes, each containing the mean amplitudes at a group of electrode sites. These regions were: Left Anterior (LA): F7, F3, FC3; Medial Anterior (MA): Fp1, Fz, Fp2; Right Anterior (RA): FC4, F4, F8; Left Central (LC): FT7, T3, C3; Medial Central (MC): FCz, Cz, CPz; Right Central (RC): C4, T4, FT8; Left Posterior (LP): CP3, P7, P3; Medial Posterior (MP): Pz, O1, O2; and Right Posterior (RP): P4, P8, CP4.

To analyze the factors affecting the mean amplitude of the four different ERP time intervals chosen for analysis in the response categories and at the different electrode positions, repeated measure analysis of variances (ANOVAs) were computed with: (a) five within-subject factors: Prime type (Emoticon vs. Word) \times Prime Valence (Positive vs. Negative) \times Target Valence (Positive vs. Negative) \times Laterality (Left, Medial, Right) \times Caudality (Anterior, Central, Posterior). The Greenhouse–Geisser correction was applied to degrees of freedom in all cases in which the condition of sphericity was not met. *Post hoc* tests were conducted for signifi-

cant main and interaction effects, using pairwise comparisons, with Bonferroni correction. Differences in results were considered significant if $p < .05$.

For the behavioral data, error trials and those trials with reaction times (RTs) shorter than 300 ms or longer than 1500 ms were not included in the data analysis. The final sample was of 16 participants due to a technical failure in data recording for two participants. Repeated-measure ANOVAs for RTs and for error percentage were conducted based on a 2 (Type of prime: Emoticon vs. Word) \times 2 (Prime Valence: Positive vs. Negative) \times 2 Target Valence (Positive vs. Negative) design. All factors were manipulated as within-subjects.

3. Results

3.1. Electrophysiological data

There were 4608 epochs (36 averages per each of the eight stimulus types in 16 participants out of 18 – two subjects were not included in the analysis because of missing data) and 11.5% of epochs were eliminated for incorrect or delayed responses. The grand averages for the different conditions and the scalp maps are shown in Figs. 2 and 3, respectively.

Since our aim was to examine whether masked priming could be observed with emoticons and with affective prime words, and for simplicity of presentation, only effects concerning the critical variables (Type of prime, Prime valence and Target valence) are presented.

3.1.1. P1 (100–150 ms)

For P1, the repeated measures ANOVA (Type of prime \times Prime's valence \times Target's valence \times Caudality \times Laterality) revealed a significant Prime valence \times Caudality interaction effect, $F(2,34) = 24.58$, $\epsilon = 0.756$, $p < .05$. For both primes, P1 amplitudes were larger from anterior to posterior electrode sites. For positive primes, P1 amplitudes were larger in anterior relative to central ($p < .01$) and posterior electrode sites ($p < .001$). For negative primes, the same differences reached significance (both $ps < .01$). The ANOVA also revealed a significant interaction between target valence and laterality, $F(2,34) = 3.27$, $p = .05$: pairwise comparisons revealed that the P1 amplitudes were larger in medial than in right electrode sites for both positive and negative targets ($p < .01$ and $p < .05$, respectively).

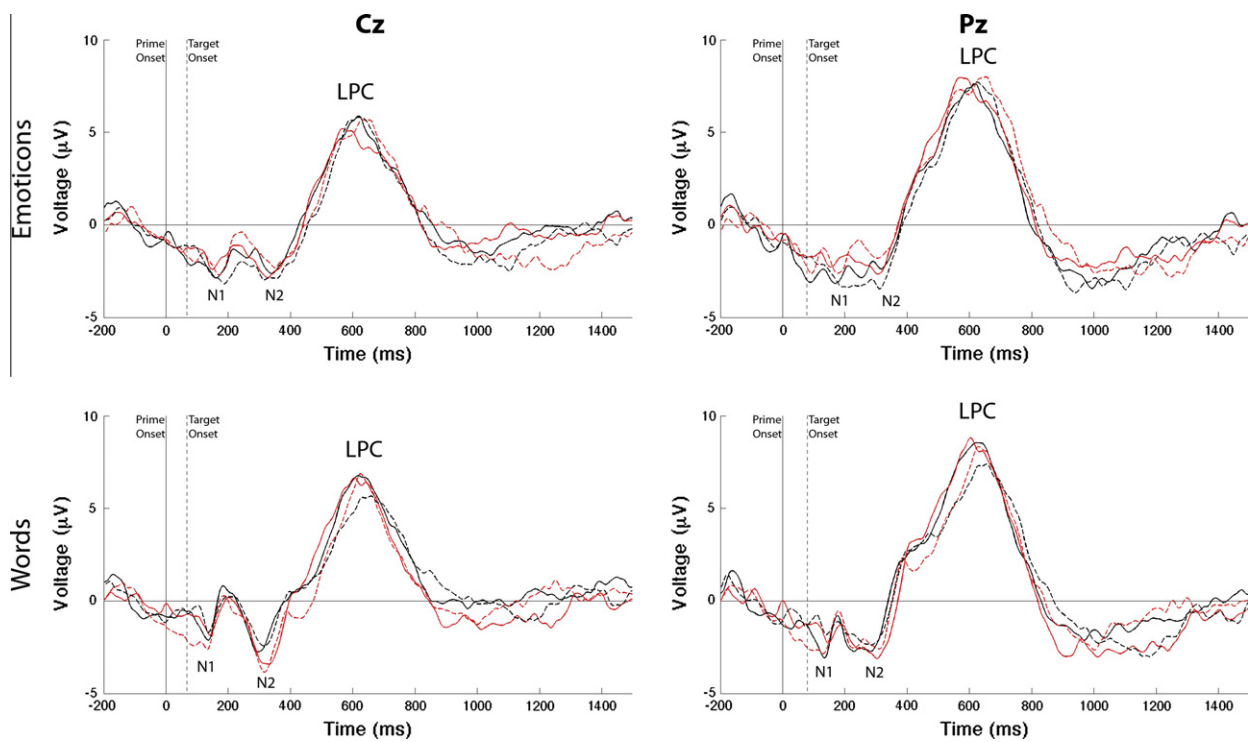


Fig. 2. Grand Average waveforms at Cz and Pz. The Figure shows the Grand Averages at Cz and Pz for type of prime (emoticons and words) for congruent (black line) conditions and incongruent (red line) conditions by positive target (continuous line) and negative target (dashed line) separately. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

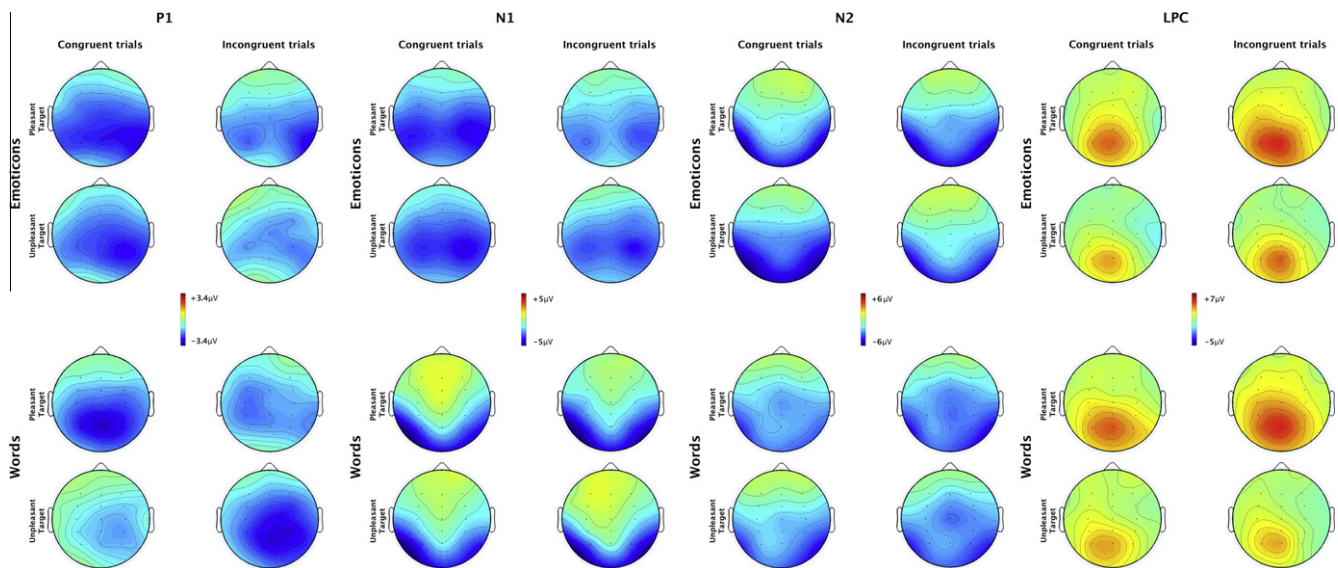


Fig. 3. Topographic maps for the analyzed ERP components (P1, N1, N2, LPC).

3.1.2. N1 (150–200 ms)

For the N1 component, the ANOVA revealed a significant effect of Type of prime: emoticon primes led to larger amplitudes than word primes, $F(1,17) = 7.53, p < .01$. The ANOVA also revealed a significant interaction between Type of prime and Caudality, $F(2,34) = 24.58, \epsilon = 0.562, p < .001$: emoticon primes led to larger amplitudes than word primes at anterior ($p < .001$) and central ($p < .001$) electrode sites, but not at posterior electrode sites ($p = 0.64$).

3.1.3. N2 (250–350 ms)

The ANOVA revealed a significant Type of prime \times Caudality interaction: $F(2,34) = 5.08, \epsilon = 0.585, p < .01$: emoticon primes pro-

duced larger amplitudes than word primes at posterior electrode sites ($p < .05$), but not at anterior or central sites. The ANOVA also revealed a significant interaction between Type of prime, Prime valence, and Target valence, $F(1,17) = 7.21, p < 0.05$. Simple effect tests revealed that for emoticon primes, congruent negative pairs (NN; i.e., a negative emoticon paired with a negative target word) showed larger N2 amplitudes than incongruent ones (PN; i.e., a positive emoticon paired with a negative target word) ($p < .05$). That is, a masked affective priming effect was observed for negative word targets preceded by emoticons. In contrast, there were no signs of a masked priming effect for positive target words preceded by a positive vs. a negative emoticon prime ($p = .55$). When the

Table 1

Mean RTs (in ms – in bold), standard deviations (in parentheses), and percentage of errors per valence target (positive vs. negative) as a function of the type of prime (emoticon vs. word).

Valence target Primes	Positive	Negative
😊	701(114) 2.6 (3.3)	722 (116) 4.2 (8.5)
😡	696 (100) 4.3 (5.6)	720 (115) 6.1 (8.6)
alegría	729 (118) 4.2 (5.6)	742 (115) 3.1 (5.5)
rabia	730 (115) 5.4 (11.9)	740 (94) 4.2 (5.8)

primes were words, no priming effects were found neither to negative target words ($p = .56$), nor to positive target ones ($p = .38$).

3.1.4. Late Positive Component: LPC (450–600 ms)

The ANOVA revealed an effect of Target's valence, $F(1,17) = 8.24$, $p < .01$: positive target words showed larger amplitudes than negative target words. The interaction between Type of prime, Prime's valence, and Target's valence was also significant, $F(1,17) = 4.63$, $p < .05$. More critically, the four-way Type of prime \times Prime valence \times Target valence \times Caudality interaction was also significant, $F(2,34) = 9.74$, $p < .001$. This interaction reflected larger amplitudes for positive targets preceded by negative emoticons (NP) than for positive targets preceded by positive emoticons (PP) (i.e., a masked affective priming for positive targets) at posterior electrode sites ($p < 0.02$), but not at central ($p = 0.63$) or anterior ($p = 0.16$) electrode sites. The interaction also reflected larger LPC amplitudes for negative target words preceded by positive emoticon primes (PN) relative to negative target words preceded by positive word primes (PN) ($p < 0.05$). Finally, positive targets showed larger amplitudes than negative targets when they were preceded by negative emoticons at anterior ($p < 0.01$), central ($p < .01$), and posterior ($p < .02$) electrode sites.

3.2. Behavioral data

The mean RTs and the number of errors per condition are shown in Table 1. The ANOVA for the latency data showed a main effect of Type of prime, $F(1,15) = 16.53$, $p < 0.001$: responses for targets preceded by an emoticon prime were 25 ms faster than responses preceded by a word prime. The main effect of Target valence was also significant, $F(1,15) = 5.58$, $p < 0.05$: positive targets elicited a response 17 ms faster than negative ones. The other effects did not approach significance.

The ANOVA on the error data failed to show any significant effects.

4. Discussion

In the present experiment, we examined the temporal course of affective priming on target words by using emoticons (😊 vs. 😡) vs. affective words (rage vs. happiness) as primes. Participants were asked to perform an evaluative categorization task with positive vs. negative target words carefully controlled for the relevant lexical factors. We found a masked affective priming effect with emoticon primes (N2, LPC components), but not with word primes. This finding supports the notion that the processing of emoticons is privileged relative to the words to which they refer. Importantly, the results were modulated not only by type of prime but also by the valence of the target: masked affective priming occurred in early components for negative target words, while they occurred in later components for positive target words. In addition, masked

priming effects were not observed in the RT data, thus providing a new demonstration that ERP waveforms provide a more sensitive measure than RTs in masked priming experiments (see Carreiras, Perea, Vergara, & Pollatsek, 2009, for a similar dissociation between RTs and ERP data in the context of masked phonological priming). This is consistent with a recent behavioral study with masked schematic faces that also failed to show a priming effect (Andrews et al., 2011).

4.1. Early electrophysiological correlates of masked affective priming

At a very early temporal window (P1), we failed to find any relevant significant effect of affective priming. As mentioned in the Introduction, Li et al. (2008) observed larger P1 amplitudes for neutral faces following threat masked primes when compared with happy ones (suggesting a preferential detection of negative stimuli). Similarly, using unmasked primes, Werheid et al. (2005) found an early affective priming effect between 100 and 200 ms after target onset. This effect reflected a decrease of the positive potential in response to congruent relative to incongruent primed targets. Werheid et al. interpreted this result as reflecting the facilitation of a very early stage of face processing, arguing that the processing of facial affect content starts before face identification. Since P1 modulations have been associated with the detection of expression-specific facial configurations (Werheid et al., 2005), and they have been observed in ERP studies that used faces as primes, one reasonable explanation is that the early positivity in affective processing is specifically associated to the processing of human faces, but not of emoticons.

At 150–200 ms after prime onset (N1), we observed a differential processing of the target words depending on whether they were preceded by an emoticon or a word – while there were no signs of a masked affective priming effect in this component. Emoticons were associated with larger negative amplitudes than their corresponding affective prime words irrespective of their valence. The N1 component has been considered an index of a discrimination process within the focus of attention (see Vogel & Luck, 2000, for a review). It may reflect differences in low-level features over visual processed cortical areas (e.g., Eddy, Schmid, & Holcomb, 2006). Thus, it is not surprising that the amplitudes for this component were larger for different representations (emoticons preceding target words) relative to the same representations (words as primes and targets). The larger amplitude associated with emoticons relative to word primes is consistent with previous studies proposing a differential processing of pictures and words (see Herbert et al., 2006; Liu et al., 2010; Zhang, Lawson, Guo, & Jiang, 2006). As Herbert et al. (2006) indicated, "...visually presented words generally constitute less arousing stimuli than complex colored pictures..." (p. 204)".

Finally, and more importantly, masked affective priming was observed between 200 and 350 ms after prime onset (N2), to negative target words preceded by emoticon primes – congruent pairs showed larger amplitudes than incongruent pairs. Consistent with our hypothesis, the effect of emoticon primes reflects an earlier access to their affective content compared to the affective content of prime words. We acknowledge that the color could have contributed to the advantage of emoticon processing. In fact, previous electrophysiological studies showed that stimulus color facilitates the emergence of valence effects (e.g., Cano, Class, & Polich, 2009). The fact that only the effect of priming was observed with negative emoticons seems to sustain previous studies in which (e.g., Olofsson & Polich, 2007; Rozenkrants, Olofsson, & Polich, 2008) the modulations observed in early components were associated with valence rather than arousal. These findings are in line with the claim of a preferential detection and enhanced processing of negative stimuli (Dijksterhuis & Aarts, 2003; Marcos & Redondo, 2005;

Raichle & Gusnard, 2005; Öhman, 2002, 2005). Thus, at an early stage (N2), it is possible to observe a masked affective priming effect elicited by negative emoticon primes (but not by word primes) – which indicates that emoticons seem to show a processing advantage when compared to affective words.

4.2. Late electrophysiological correlates of masked affective priming

Effects of masked affective priming were also observed at 450–600 ms temporal windows after prime onset (LPC). In this temporal window, incongruent conditions showed larger amplitudes than their congruent counterparts. As with the N2 component, the effect was observed for emoticon primes, but not for word primes. The difference with respect to the N2 component is that the effect in the LPC component occurred mostly for positive words and it was widely distributed across electrode sites – a similar effect occurred for negative words but it was restricted to posterior electrodes. This finding is in line with the results of masked priming electrophysiological experiments that reported modulations in late temporal windows for positive stimuli (Gibbons, 2009; Li et al., 2008).

Importantly, the above-mentioned dissociation of masked affective priming for negative words (N2) and positive words (LPC) supports the idea that there is a differential processing of negative and positive stimuli, possibly due to differential activation in brain structures (see Cacioppo, Crites, Berntson, & Coles, 1993; Ito, Larsen, Smith, & Cacioppo, 1998; LeDoux, 1996; Öhman & Wiens, 2001). Taking into account the temporal proximity between the two priming effects observed for negative and positive primes and given the existing association between LPC and attention orienting (Cuthbert et al., 2000; Li et al., 2008), masked emoticon primes might have reoriented the attention to positive words, after negative ones were evaluated as threat insignificant (Cacioppo et al., 1997). It is worth noting here that the presence of a masked affective priming effect in later intervals than in the studies of Li et al. (2008), and Gibbons (2009) can be due to methodological differences (different SOA, duration of the prime and the use of prime-locked instead of target-locked averaged waveforms).

A somewhat unexpected finding in the present experiment was the failure to observe a masked affective priming effect with word primes – both with behavioral and electrophysiological measures. Even though we acknowledge that it may be difficult to make strong conclusions from accepting a null hypothesis, it is important to keep in mind that the masked affective priming effect with words as primes and targets is a controversial phenomenon. Indeed, as reviewed in the Introduction, the empirical evidence is somehow mixed. This is somewhat parallel to the behavioral literature on masked semantic priming (with non-associative pairs), in which it has been claimed that the obtained semantic priming with word primes is caused by “conscious leakage on some percentage of trials” (see Holcomb, Reeder, Misra, & Grainger, 2005, p. 170). More research is necessary to examine in further detail the intricacies of masked affective priming with word primes.

Finally, one potential limitation of the present study is that we did not include a neutral priming condition acting as a baseline. Nonetheless, the issue of the choice of a “perfect” baseline in priming studies is tricky literature (e.g., see the influential paper by Jonides & Mack, 1984), and this is particularly relevant in the case of “neutral” emoticon primes (i.e., a simple circle would not work as an appropriate neutral prime). A more promising option is to use a within-condition baseline on the basis of changes in the prime duration of the masked primes (see Jacobs, Grainger, & Ferrand, 1995; see also Perea, Moret-Tatay, & Carreiras, 2011). This is an important issue for additional research.

4.3. Conclusions

To sum up, to our knowledge, the present experiment provides the first demonstration that masked affective priming occurs with emoticon primes. The effect of priming was observed at early (N2) and late (LPC) electrophysiological components. Importantly, differences between negative and positive stimuli were observed at 200 ms post-prime presentation, thus revealing an automatic processing of valence. Thus, the present findings are consistent with the idea that the affective evaluation of emoticons is an automatic process (Jolij & Lamme, 2005; White, 1995). This preferential and enhanced processing can have a positive effect on the communication mediated by computers by allowing a faster and more stable access to affective processing. We must bear in mind that emoticons are used as nonverbal cues to convey emotions and to help to interpret the written message. In this way, the communication mediated by computer between individuals is closer to that of face-to face communication. Future research should further explore the affective processing induced by emoticons across a range of paradigms – including the monitoring of eye movements during reading and its interplay with electrophysiological measures, in order to generalize the results obtained in the present study.

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Appendix A

A.1. Positive target words

hogar, palacio, juguete, honesto, adinerado, valiente, guapo, millonario, mágico, excitado, romántico, soleado, logro, bailarín, afortunado, enérgico, azúcar, sociable, amado, generoso, juventud, adorable, satisfecho, simpático, licenciado, eufórico, caricia, enamorado, abrazo, vencedor, veloz, atrevido, festivo, cariñoso, diversión, afecto, orgasmo, optimismo, genial, maravilla, obsequio, chocolate, júbilo, admirado, incentivo, trofeo, sexy, canción, tarta, erótico, fantasía, ídolo, navidad, invitación, beso, encanto, comedia, ingenio, tesoro, lotería, guiño, circo, guardería, chiste, perfección.

A.2. Negative target words

indefenso, infiel, pistola, culpable, falso, insolente, esclavo, tenso, serpiente, traidor, celos, ansioso, demonio, violento, violación, agobiado, burla, raptó, sucio, herido, sospechoso, arrogante, corrupto, asediado, insulto, sangriento, nervioso, grosero, tortura, entierro, maltrato, bestia, peste, desastre, veneno, homicida, ladrón, intruso, huracán, tanque, asustado, homicida, ladrón, intruso, huracán, tanque, asustado, miedoso, aborto, accidente, agonía, daño, ambulancia, araña, ataúd, asqueroso, estrés, bomba, atrocidad, chantaje, chillido, pobreza, caos, cuchillo, infección, pánico.

References

- Andrews, V., Lipp, O. V., Mallan, K. M., & König, S. (2011). No evidence for subliminal affective priming with emotional facial expression primes. *Motivation and Emotion*, 35, 33–43.
- Banase, R. (2001). Affective priming with liked and disliked persons: Prime visibility determines congruency and incongruency effects. *Cognition and Emotion*, 15, 501–520.
- Bargh, J. A. (1996). Automaticity in social psychology. In E. T. Higgins & A. W. Kruglanski (Eds.), *Social psychology, Handbook of basic principles* (pp. 169–183). New York: Guilford Press.

- Beck, A. T., Rush, A. J., Shaw, B. F., & Emery, G. (1979). *Cognitive therapy of depression*. New York: Guilford Press (Spanish translation in Bilbao: Desclée de Brower, 1983).
- Bradley, M. M., & Lang, P. J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behavioral Therapy and Experimental Psychiatry*, 25, 49–59.
- Bradley, M. M., & Lang, P. J. (2007). Emotion and motivation. In J. T. Cacioppo, L. G. Tassinary, & G. Berntson (Eds.), *Handbook of psychophysiology* (2nd ed., pp. 581–607). New York: Cambridge University Press.
- Cacioppo, J. T., Crites, S. L., Jr., Berntson, G. G., & Coles, M. G. H. (1993). If attitudes affect how stimuli are processed, should they not affect the event-related brain potential? *Psychological Science*, 4, 108–112.
- Cacioppo, J. T., Gardner, W. L., & Berntson, G. G. (1997). Beyond bipolar conceptualizations and measures: The case of attitudes and evaluative space. *Personality and Social Psychology Review*, 1, 3–23.
- Cano, M. E., Class, Q. A., & Polich, J. (2009). Affective valence, stimulus attributes, and P300: Color vs. black/white and normal vs. scrambled images. *International Journal of Psychophysiology*, 71(1), 17–24.
- Carreiras, M., Perea, M., Vergara, M., & Pollatsek, A. (2009). The time course of orthography and phonology: ERP correlates of masked priming effects in Spanish. *Psychophysiology*, 46, 1113–1122.
- Carretié, L., Martín-Loeches, M., Hinojosa, J. A., & Mercado, F. (2001). Attention and emotion interaction studied through event related potentials. *Journal of Cognitive Neuroscience*, 13, 1109–1128.
- Cuthbert, B. N., Schupp, H. T., Bradley, M. M., Birbaumer, N., & Lang, P. J. (2000). Brain potentials in affective picture processing: Covariation with automatic arousal and affective report. *Biological Psychology*, 52, 95–111.
- Davis, C., & Perea, M. (2005). BuscaPalabras: A program for deriving orthographic and phonological neighborhood statistics and other psycholinguistic indices in Spanish. *Behavior Research Methods*, 37, 665–671.
- De Houwer, J., & Hermans, D. (1994). Differences in the affective processing of words and pictures. *Cognition and Emotion*, 8, 1–20.
- Dijksterhuis, Ap., & Aarts, H. (2003). On wildebeests and humans: The preferential detection of negative stimuli. *Psychological Science*, 14, 14–18.
- Dijksterhuis, Ap., Corneille, O., Aarts, H., Vermeulen, N., & Luminet, O. (2004). Yes, there is a preferential detection of negative stimuli. A response to Labiouse. *Psychological Science*, 15(8), 571–572.
- Draine, S. C., & Greenwald, A. G. (1998). Replicable unconscious semantic priming. *Journal of Experimental Psychology: General*, 127, 286–303.
- Eddy, M., Schmid, A., & Holcomb, P. J. (2006). Masked repetition priming and event-related brain potentials: A new approach for tracking the time-course of object perception. *Psychophysiology*, 43, 564–568.
- Gibbons, H. (2009). Evaluate priming from subliminal emotional words: Insights from event-related potentials and individual differences related to anxiety. *Consciousness and Cognition*, 18, 383–400.
- Glaser, J., & Banaji, M. R. (1999). When fair is foul and foul is fair: Reverse priming in automatic evaluation. *Journal of Personality and Social Psychology*, 77, 669–687.
- Gratton, G., Coles, M. G. H., & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography and Clinical Neurophysiology*, 55, 468–484.
- Greenwald, A. G., Draine, S. C., & Abrams, R. L. (1996). Three cognitive markers of unconscious semantic activation. *Science*, 273, 1699–1702.
- Greenwald, A. G., Klinger, M. R., & Liu, T. J. (1989). Unconscious processing of dichoptically masked words. *Memory and Cognition*, 17, 35–47.
- 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.
- Hermans, D. (1996). *Automatische stimulusvaluatie: Een experimentele analyse van de voorwaarden voor evaluatieve stimulusdiscriminatie aan de hand van het affectieve-primingparadigma* [Automatic stimulus evaluation. An experimental analysis of the preconditions for evaluative stimulus discrimination using an affective priming paradigm]. Unpublished doctoral dissertation, University of Leuven, Belgium.
- Hermans, D., De Houwer, J., & Eelen, P. (2001). A time course analysis of the affective priming effect. *Cognition and Emotion*, 15, 143–165.
- Hermans, D., Spruyt, A., De Houwer, J., & Eelen (2003). Affective priming with subliminally presented pictures. *Canadian Journal of Experimental Psychology*, 57, 97–114.
- Hinojosa, J. A., Carretié, L., Méndez-Bértolo, C., Míguez, A., & Pozo, M. A. (2009). Arousal contributions to affective priming: Electrophysiological correlates. *Emotion*, 9, 164–171.
- Holcomb, P. H., Reder, L., Misra, M., & Grainger, J. (2005). The effects of prime visibility on ERP measures of masked priming. *Cognitive Brain Research*, 24, 155–172.
- Hsu, S. M., Hetrick, W. P., & Pessoa, L. (2008). Depth of facial expression processing depends on stimulus visibility: Behavioral and electrophysiological evidence of priming effects. *Cognitive, Affective, & Behavioral Neuroscience*, 8(3), 282–292.
- Huang, A. H., Yen, D. C., & Zhang, X. (2008). Exploring the effects of emoticons. *Information & Management*, 45(7), 466–473.
- Ito, T. A., Larsen, J. T., Smith, N. K., & Cacioppo, J. T. (1998). Negative information weighs more heavily on the brain: The negativity bias in evaluative categorizations. *Journal of Personality and Social Psychology*, 75, 887–900.
- Jacobs, A. M., Grainger, J., & Ferrand, L. (1995). The incremental priming technique: A method for determining within-condition priming effects. *Perception & Psychophysics*, 57, 1101–1110.
- Jolij, J., & Lamme, V. A. F. (2005). Repression of unconscious information by conscious processing: Evidence from affective blindsight induced by transcranial magnetic stimulation. *PNAS*, 102(30), 10747–10751.
- Jonides, J., & Mack, R. (1984). On the cost and benefit of cost and benefit. *Psychological Bulletin*, 96, 29–44.
- Kiefer, M., & Brendel, D. (2006). Attentional modulation of unconscious “automatic” processes: Evidence from event-related potentials in a masked priming paradigm. *Journal of Cognitive Neuroscience*, 18, 184–198.
- Kinoshita, S., & Norris, D. (2010). Masked priming effect reflects evidence accumulated by the prime. *The Quarterly Journal of Experimental Psychology*, 63(1), 194–204.
- Kouider, S., & Dehaene, S. (2007). Levels of processing during non-conscious perception: A critical review. *Philosophical Transactions of the Royal Society of London B*, 362, 857–875.
- Ledoux, J. E. (1996). *The emotional brain*. New York: Simon & Schuster.
- Li, W., Zinbarg, R. E., Boehm, S. G., & Paller, K. A. (2008). Neural and behavioral evidence for affective priming from unconsciously perceived emotional facial expressions and the influence of trait anxiety. *Journal of Cognitive Neuroscience*, 20, 1–13.
- Liu, B., Jin, Z., Wang, Z., & Hu, Y. (2010). The interaction between pictures and words: Evidence from positivity offset and negativity bias. *Experimental Brain Research*, 201, 141–153.
- Marcos, J. L., & Redondo, J. (2005). Facilitation and interference of the automatic information processing on a reaction task to threat-relevant stimuli. *Psicothema*, 17(002), 332–337.
- Murphy, S. T., & Zajonc, R. B. (1993). Affect, cognition, and awareness: Affective priming with optimal and suboptimal stimulus exposures. *Journal of Personality & Social Psychology*, 64(5), 723–739.
- Öhman, A. (2002). Automaticity and the amygdala: Nonconscious responses to emotional faces. *Current Directions in Psychological Sciences*, 11(2), 62–66.
- Öhman, A. (2005). The role of the amygdala in human fear: Automatic detection of threat. *Psychoneuroendocrinology*, 30(10), 953–958.
- Öhman, A., & Wiens, S. (2001). The concept of an evolved fear module as a challenge to cognitive theories of anxiety. Paper presented at *Feeling and Emotions: The Amsterdam Symposium*, Amsterdam.
- Olofsson, J. K., & Polich, J. (2007). Affective visual event-related potentials: Arousal, repetition, and time-on-task. *Biological Psychology*, 75, 101–108.
- Otten, S., & Wentura, D. (1999). About the impact of automaticity in the minimal group paradigm: Evidence from affective priming tasks. *European Journal of Social Psychology*, 29, 1049–1071.
- Perea, M., Duñabeitia, J. A., & Carreiras, M. (2008). Masked associative/semantic priming effects across languages with highly proficient bilinguals. *Journal of Memory and Language*, 58, 916–930.
- Perea, M., Moret-Tatay, C., & Carreiras, M. (2011). Facilitation vs. inhibition in the masked priming same-different matching task. *Quarterly Journal of Experimental Psychology*, 64, 2065–2079.
- Raichle, M. E., & Gusnard, D. A. (2005). Intrinsic brain activity sets the stage for expression of motivated behavior. *Journal of Comparative Neurology*, 493, 167–176.
- Redondo, J., Fraga, I., Padrón, I., & Comesaña, M. (2007). The Spanish adaptation of ANEW (Affective Norms for English Words). *Behavior Research Methods*, 39, 600–605.
- Rozenkrants, B., Olofsson, J. K., & Polich, J. (2008). Affective visual event-related potentials: Arousal, valence, and repetition effects for normal and distorted pictures. *International Journal of Psychophysiology*, 67, 114–123.
- Seisdedos, N. (1988). *Adaptación Española del STAI, Cuestionario de ansiedad estado-rasgo* [Spanish adaptation of the STAI, State-Trait Anxiety Inventory]. Madrid: Tea Ediciones.
- Vogel, E. K., & Luck, S. J. (2000). The visual N1 component as an index of a discrimination process. *Psychophysiology*, 37, 190–203.
- Werheid, K., Alpay, G., Jentzsch, I., & Sommer, W. (2005). Priming emotional facial expressions as evidenced by event-related brain potentials. *International Journal of Psychophysiology*, 55, 209–219.
- White, M. (1995). Preattentive analysis of facial expressions of emotion. *Cognition and Emotion*, 9, 439–460.
- Yuasa, M., Saito, K., & Mukawa, N. (2006). Emoticons convey emotions without cognition of faces: An fMRI Study. *Conference on human factors in, computing systems*, 1565–1570.
- Zhang, Q., Lawson, A., Guo, C., & Jiang, Y. (2006). Electrophysiological correlates of visual affective priming. *Brain Research Bulletin*, 71, 316–323.