

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

**Will the Glass be Half Full or Half Empty?  
Brain Potentials and Emotional Expectations**

Eva M. Moreno<sup>a,\*</sup> & Carmelo Vázquez<sup>b</sup>

*<sup>a</sup>Human Brain Mapping Unit, Instituto Pluridisciplinar, Universidad Complutense de Madrid, Paseo Juan XXIII, 1, 28040 Madrid, Spain. [emmoreno@pluri.ucm.es](mailto:emmoreno@pluri.ucm.es)*

*<sup>b</sup>School of Psychology, Universidad Complutense de Madrid, Campus de Somosaguas, 28223 Madrid, Spain. [cvazquez@psi.ucm.es](mailto:cvazquez@psi.ucm.es)*

\* Corresponding author at: Human Brain Mapping Unit, Instituto Pluridisciplinar, Universidad Complutense de Madrid, Paseo Juan XXIII 1, 28040 Madrid, Spain. Tel.: +34 91 394 32 61; fax: +34 91 394 32 64

*E-mail address:* [emmoreno@pluri.ucm.es](mailto:emmoreno@pluri.ucm.es) (Eva M. Moreno).

**Keywords:** Event-related potentials (ERPs); language processing; N400; post-N400 frontal positivity; emotion regulation; expectations; optimism; pessimism.

## A B S T R A C T

1  
2  
3  
4  
5  
6 | Brainwave responses to words in context depend on semantic and world-knowledge  
7  
8 | expectations. Using the N400 component of event-related potentials as an index of word  
9  
10 | expectation, we explored brain responses to negatively and positively biased sentence  
11 | frames randomly presented with their emotionally-matched highly expected outcome or  
12 | with violations that included switches to unexpected emotionally-opposite outcomes or  
13 | nonsense. Nonsense elicited large N400 responses regardless of the bias of the  
14 | preceding sentence frame. Unexpected emotionally-opposite outcomes elicited smaller  
15 | than nonsense N400 responses and subsequent post-N400 frontal positivities, both  
16 | unaffected by sentence frame bias. Over a midline-posterior scalp region, expected  
17 | positive outcomes elicited larger N400 responses than negative ones, despite a high and  
18 | matched word probability. Our study reveals that brains respond to unexpected  
19 | emotional outcomes regardless of the direction of the emotional switch and hints at the  
20 | possibility that the strength of positive and negative expectations may be adjusted  
21 | before experiencing unexpected events.  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

Our species is endowed with both a tendency to expect positive outcomes for unknown future events, and a heightened sensitivity to negative outcomes (Cacioppo and Gardner, 1999; Vaish et al., 2008). People tend to have a stable, overall pessimistic or optimistic outlook in life (Scheier and Carver, 1985, 1987; Scheier et al, 1994). This appears to be crucial in determining affective responses, as *expectations* about what "might have been" play an important role in how people feel about what actually occurred. In fact, good and bad outcomes feel better or worse, respectively, when they are *unexpected* than when expected (Shepperd and McNulty, 2002). Interestingly, our tendency to make optimistic predictions about improbable bad outcomes (e.g. failing an exam) shift over time when feedback is anticipated in the near future, and when the outcome is uncontrollable (Carroll et al., 2006; Sweeny et al., 2006; Sweeny and Shepperd, 2007). Trying to avoid the disappointment of an unexpected bad outcome by anticipating troubles (Golub et al., 2009) or by using defensive pessimism strategies (Norem and Chang, 2002) may be adaptive. Nevertheless, the fact that most people exhibit positive illusions, including an unrealistic optimism about the future (Taylor and Brown, 1988), raises an intriguing question: can individuals avoid harboring good expectations even on the millisecond timescale of brainwave responses?

This question can be approached by analyzing the event-related potential (ERP), which allows examination of brain responses to expected and unexpected linguistic events with millisecond resolution. This technique has the additional advantage of not requiring overt responses or tasks beyond silently reading for comprehension. According to ERP studies, expectations in fact play an important role in language comprehension tasks. Thus, unexpected linguistic events such as a word that does not semantically fit in its sentence frame (e.g. the word 'city' in the sentence 'He shaved off

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56

*his mustache and 'city')* elicit greater negativity at around 400 ms post-word onset than does a predictable, appropriate word such as *'beard'* (Kutas and Hillyard, 1980a, 1980b). The amplitude of the N400 component of the ERP is sensitive to the nature of the semantic relationship between any actual word and the word(s) that can be *expected* to complete the given sentence frame (Federmeier and Kutas, 1999). The *expected* completion of a sentence frame contains those words with the highest Cloze Probability (CP) in that context. The CP of a word in a given context refers to the percentage of individuals that choose it to complete the given sentence frame in a paper-and-pencil sentence completion task (Taylor, 1953). Brainwave analyses then reveal that N400 is smallest following words with high CP; intermediate or large following words that are, respectively, related or unrelated to the highest-CP completion; and largest following nonsense words (Kutas, 1987; Kutas and Hillyard, 1984; Kutas et al., 1984). The fact that N400 depends on a word's semantic relationship to the expected completion indicates that individuals use knowledge stored in long-term memory to make online predictions about upcoming words (Federmeier and Kutas, 1999; Kutas and Federmeier, 2000). Other studies provide further evidence of an upcoming word prediction model (DeLong et al., 2005; Kutas et al., 2011; Van Berkum et al., 2005; Wicha et al., 2004). The N400 is also sensitive to violations of true facts from our world knowledge (Hagoort et al., 2004; Hald et al., 2007). For example, in the sentence *'The Dutch trains are white and very crowded'* the word *'white'* elicits an N400 response as it violates a known fact for Dutch speakers (i.e., Dutch trains are yellow). Interestingly, the N400 amplitude in response to a false statement is as large as the one in response to a nonsense word (e.g. *'sour'* in the previous example).

57  
58  
59  
60  
61  
62  
63  
64  
65

Although psycholinguistics research has mainly explored affectively neutral knowledge (Van Berkum et al., 2009), a large part of our world knowledge consists of

1 experiences about what outcomes go with what types of emotional events. Indeed,  
2 messages devoid of emotional meaning may be the exception rather than the rule in  
3  
4 everyday linguistic experience. One would be surprised to hear that after being left by  
5  
6 her boyfriend, a woman reacted by 'flirting' rather than by 'crying' or 'getting depressed.'  
7  
8 There is, in some sense, a world knowledge that has to do with emotional rather than  
9  
10 emotionally detached facts about the world. This knowledge reflects how likely we  
11  
12 think it is that sad or happy events lead to sad or happy consequences. In fact, this  
13  
14 orderly view of the emotional world is broken only under exceptional circumstances,  
15  
16  
17 such as severe traumatic experiences (Janoff-Bulman, 1989).  
18  
19  
20  
21  
22

23 Making strong predictions about upcoming words in a sentence, however, may  
24  
25 also carry a processing cost in situations in which those predictions prove false. An  
26  
27 increased post-N400 frontal positivity (pN400FP) is observed between 500-900 ms over  
28  
29 frontal electrode sites during the processing of unexpected word endings in highly  
30  
31 constraining contexts (Federmeier et al., 2007). A similar but longer lasting pN400FP  
32  
33 (500-1200 ms) has also recently been reported in response to strongly expected sentence  
34  
35 continuations that go unfulfilled (DeLong et al., 2011). Therefore, while a small N400  
36  
37 response indicates the benefit of a fulfilled word expectation, the pN400FP effect has  
38  
39 been proposed to reflect the consequences of processing a word that violates a  
40  
41 prediction (Federmeier et al., 2007). In contrast to the long history of studies on N400  
42  
43 effects (Kutas and Federmeier, 2011) the pN400FP effect has only recently been  
44  
45 regarded as a potential functionally independent ERP response linked to  
46  
47 disconfirmation of strongly made predictions (DeLong et al., 2011).  
48  
49  
50  
51  
52  
53

54 The outcome of an incoming emotional message may not be under control in a  
55  
56 passive reading task. Nevertheless, the brain may implement mechanisms to cope with  
57  
58 negative and positive outcomes from incoming messages. People might anticipate  
59  
60  
61  
62  
63  
64  
65

1 happy and sad endings based on their emotional world knowledge, though these may  
2 also involve certain adaptive strategies. Adopting an optimistic or pessimistic strategy  
3 will alter expectations and therefore the ease or difficulty of semantic processing in a  
4 language comprehension task. We should be able to detect these alterations as changes  
5 in brainwave signatures (i.e., N400 and pN400FP) in response to expected and  
6 unexpected good and bad outcomes. Thus, tracing brainwaves in language  
7 comprehension tasks can provide information on how we prepare ourselves to process  
8 emotionally loaded information.

9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19         Studies of the processing of single emotional words have reported an early ERP  
20 (200-300 ms) arousal effect (pleasant and unpleasant *versus* neutral words) over left  
21 occipito-temporal electrodes (Kissler et al., 2007). The word's valence discrimination is  
22 reported to occur later, with pleasant word stimuli eliciting both a smaller N400 and a  
23 larger late positivity response than unpleasant word stimuli (Herbert et al., 2008).  
24 However, a recent picture-word priming study found N400 to be insensitive to emotion  
25 (Kissler and Koessler, 2011). ERP studies investigating the time course of processing  
26 single affective stimuli have given mixed results that depend on the type of stimuli  
27 (pictures, faces, words) and the type of task, e.g. reading for comprehension,  
28 memorization, lexical decision-making, and evaluation of emotional content (Fischler  
29 and Bradley, 2006; Kissler et al., 2006).

30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46         Only a few studies have examined ERP responses to emotional words in whole-  
47 sentence contexts. The early posterior negativity found in single word studies was not  
48 found, whereas a posterior late positivity discriminated between negative and neutral  
49 words (Bayer et al., 2010). Other studies examining N400 effects found that the  
50 amplitude of the N400 did not differ between negative and positive words (Holt et al.,  
51 2008), or that it was larger for negative words than for positive and neutral words (De  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

Pascalis et al., 2009). In the latter study, the CP of target words, a strong determinant of N400 amplitude in sentence paradigms, was not reported. In the study by Holt et al. (2008), emotional and neutral words were all low-CP (2% on average) embedded in emotionally neutral contexts.

In tasks using emotional prosody (happy or sad intonation) to provide a context for subsequent processing of negative and positive words (e.g. 'success' or 'failure'), a larger N400 amplitude was found in response to words whose valence mismatched the prosody of the preceding sentence (Schirmer et al., 2002). A recent study also revealed that emotional prosodic expectancy violations elicit a right-lateralized, positive-going ERP effect, while combined semantic/prosodic expectancy violations elicit an early negativity ERP effect (Paulmann and Kotz, 2008).

Finally, some ERP studies have shown that an individual's current mood is crucial during information processing. Experimental mood inductions can make "happy" people more likely to accept some unexpected sentence endings (Federmeier et al., 2001) or make people in pessimistic moods more biased towards expectations of negative outcomes (Chung, et al., 1996). Our study does not externally induce a mood; rather, it explores brainwave responses to the processing of fulfilled and unfulfilled positive and negative expectations during a sentence comprehension task. We aim to relate our findings to potential strategies that we may use to prepare ourselves for pleasant 'surprises' and 'setbacks'. Thus, our experimental design included negatively and positively biased sentence frames with a highly expected congruent ending, a nonsense ending, or an ending that is less expected and emotionally opposite to the expected one. In ERP studies, syntactically anomalous words presented at sentence-ending positions have been reported to elicit an increased negativity over anterior electrode sites between 300 and 500 ms relative to when the same anomalies appear in

1 sentence-embedded positions (Osterhout, 1997). This effect has been considered to be  
2 driven by wrap-up processes that are potentially triggered at the end of sentences.  
3  
4 However, words in context also tend to elicit smaller N400 responses as their  
5  
6 predictability increases over the course of a sentence (Kutas and Federmeier, 2000). For  
7  
8 the purposes of our study it is critical to induce a strong negative or positive expectation  
9  
10 from the incoming message in order to be able to explore the response to its fulfillment  
11  
12 or its violation. Thus, target words in our study appear at a point in the sentence in  
13  
14 which ample semantic constraint has been built-up (i.e., sentence-final position), such  
15  
16 that expectations are most likely entrenched.  
17  
18  
19  
20

21  
22 We anticipate that N400 responses will be graded by expectancy, that is, by the  
23  
24 CP of the target word ending; N400 amplitudes will be largest in response to nonsense  
25  
26 endings, smaller in response to low-probability emotionally opposite endings, and  
27  
28 smallest in response to highly probable emotionally congruent endings. Thus, fulfilled  
29  
30 expectations will generate reduced N400 amplitudes, whereas unfulfilled expectations  
31  
32 will generate enhanced N400 responses followed by a pN400FP effect.  
33  
34  
35

36  
37 Despite the fact that expected negative and positive endings (fulfilled  
38  
39 expectations) are bound to elicit the smallest N400 amplitudes due to their good  
40  
41 emotionally semantic fit in context and their high CP value, brainwave differences  
42  
43 between them may arise. We are biologically prompted to quickly and effectively  
44  
45 identify and process aversive events (Baumeister, 2001; Vaish, et al., 2008); indeed, a  
46  
47 negativity bias has been reported in ERP studies using negatively and positively  
48  
49 valenced pictures (Carretie et al., 2001; Ito and Cacioppo, 2000; Ito et al., 1998). In a  
50  
51 sentence comprehension task, individuals may also be better at making accurate and fast  
52  
53 online predictions about upcoming negative endings than upcoming positive ones, even  
54  
55 if both endings have a similarly high CP value in a paper-and-pencil task. If we are  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

1 more prone to accurately predict negative outcomes, they may elicit a smaller N400  
2 than positive outcomes. At the same time, if we are able to avoid expectations of  
3 positive outcomes, they will elicit a larger N400 than negative ones. As mentioned  
4 earlier, a reduction in N400 amplitude in response to pleasant words has been suggested  
5 to index a natural bias towards positively valenced information in single-word  
6 processing paradigms (Herbert et al., 2008). However, since our experimental design  
7 forces individuals to process unfulfilled predictions by making possible both "happy"  
8 endings in negatively biased contexts and "sad" endings in positively biased ones, they  
9 may change the strength of their expectations under these unpredictable conditions, and  
10 they may make such adjustments differently, depending on whether the prediction is  
11 negatively or positively biased.  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27

## 28 **1. Methods**

### 29 *1.1. Participants*

30  
31  
32  
33  
34 Twenty-four native Spanish speakers (21 female<sup>1</sup>, mean age = 21.3 years, range  
35 = 19-26 years) volunteered to participate in the study in exchange for course credit. The  
36 study protocol was approved by the Ethics Committee of the University, and  
37 participants gave written informed consent. Twenty-three participants reported being  
38 right-handed and one ambidextrous. The average handedness score (Oldfield, 1971) was  
39 +75.7 (range, +20 to +100). All participants reported normal vision and none had a  
40 history of neurological or psychiatric disorders.  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52

### 53 *1.2. Psychological assessment*

---

54  
55  
56  
57  
58  
59 <sup>1</sup> A replication of the analyses, restricted to the subset of 21 females, did not significantly alter the  
60 direction of overall results.  
61  
62  
63  
64  
65

1 Participants scored higher in positive affect state (mean = 34.2, SD = 5.9) than in  
2 negative affect state (mean = 15.2, SD= 5.9) ( $t_{22} = 11.8; p = 0.001$ ), according to the  
3 Positive and Negative Affect Schedule (Watson et al., 1988). Their scores in the Beck  
4 Depression Inventory II (Beck et al., 1996) fell within the normal range (mean = 9.5,  
5 SD = 7.7) (Vázquez and Sanz, 1997). The Defensive Pessimism Questionnaire (DPQ) is  
6 a 12-item questionnaire that includes items such as "*I often start out expecting the*  
7 *worst, even though I will probably do OK*", and "*Considering what can go wrong helps*  
8 *me to prepare*" (Norem, 2001). Participants indicated the extent to which each item  
9 described them, from 1 (*not at all true of me*) to 7 (*very true of me*). Their mean score  
10 on the DPQ was 56.2 (SD = 9.5, range = 34-72).  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25

### 26 *1.3. Materials*

27  
28 In order to select CP-matched sentences for the ERP study, an initial set of  
29 experimental stimuli was created. It consisted of 420 sentence frames designed to bias  
30 strongly towards a positive or negative outcome. A norming procedure was conducted  
31 with 189 university students to determine the CP values of plausible word endings.  
32  
33 Students completed one of six lists (28-35 participants per list), each of which  
34 comprised 70 sentence frames. They were asked to read each one and write down the  
35 word they would generally expect to find completing the sentence fragment (Response  
36 1, R1). Following Federmeier's extension procedure, students were also instructed to  
37 give two additional plausible completions (R2 and R3) (Federmeier et al., 2007).  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50

51 A final set of 210 sentence frames was then selected for inclusion in the ERP  
52 experiment. Positively biased (105) and negatively biased (105) sentences were selected  
53 such that their endings were equally highly expected words. The mean CP values for the  
54 words as an R1 did not differ (73% on average;  $t_{208} = 0.69; p = 0.49$ ) (Table 1). During  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

1 the experiment we randomly presented each sentence with its highly expected ending  
2 (33.3% of the time, "expected ending" condition), with a nonsense ending (zero CP  
3 value, "nonsense" condition), or with a word that reversed the sentence's intended  
4 emotional valence ("emotionally opposite" condition). Table 2 shows examples of  
5 sentences and their endings. Emotionally opposite word endings were, when possible,  
6 drawn from our subjects' R2 or R3 responses and never had more than a 10% CP as an  
7 R1 (average CP of 0.8% as an R1). Three experimental lists were constructed such that  
8 each ending was assigned to a list in order to avoid sentence repetition effects; the  
9 frequency of use (Sebastián-Gallés, 2000), length, and CP of ending words were  
10 matched within and across lists (Table 3). Each list was randomly assigned to 8  
11 participants per list. Sentences were randomized within each list such that there were no  
12 more than 5 consecutive positively or negatively biased sentences.  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30

#### 31 *1.4. Experimental Procedure*

32  
33 Participants were fitted with encephalogram (EEG) electrodes and they filled out  
34 handedness, vision and health questionnaires. They were seated approximately 100 cm  
35 in front of a 17" computer monitor. The session began with a short set of practice  
36 sentences to acclimate the participants to the reading task. Sentences were always  
37 presented one word at a time, in the center of the screen in black, lower-case Arial font  
38 (maximum letter height, 1.27 cm) on a white background. Each word was presented for  
39 200 ms, with the exception of the final word, which was presented for 500 ms. The  
40 interstimulus interval was 300 ms. A "Press to continue" message in blue font followed  
41 each sentence. Participants were asked to blink if needed and then press a button to  
42 initiate the next sentence. They were also instructed to read each sentence for  
43 comprehension, since they would be asked questions about them at the end of the  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

1 recording session. Lists were divided into 5 blocks of 42 sentences each. The  
 2 participants proceeded from one block to the next at their own pace.  
 3

4 At the end of the recording session, participants completed a 42-sentence  
 5 recognition test; six of these sentences had never been seen before (lure sentences), and  
 6 six came from each of the positively or negatively biased sentences with the expected,  
 7 emotionally opposite, or nonsense endings described above. All sentences were  
 8 presented with the actual ending that participants had already seen, as well as two other  
 9 endings that they had not seen before and that were drawn from the other experimental  
 10 lists. Their task was to mark from among the three provided endings the one that they  
 11 had seen during the reading task. Participants were generally accurate in recognizing  
 12 previously seen endings: there were 73.5% hits, 24.5% false alarms, and 1.9%  
 13 omissions, including the results with the lure sentences.<sup>2</sup> The percentage of hits was  
 14 subjected to repeated-measures ANOVA with two levels of Emotional frame (positively  
 15 or negatively biased) and three levels of Expectancy (expected, emotionally opposite,  
 16 nonsense). A main effect of Emotional Frame was not present [ $F(1,23) = 0.026$ ;  $p =$   
 17  $0.873$ ] indicating that participants accurately recognized endings of negatively and  
 18 positively biased sentences to the same extent (71.7% and 71.3%, respectively). There  
 19 was a main effect of Expectancy [ $F(2,46) = 3.865$ ;  $p = 0.032$ ]. Post- hoc Bonferroni-  
 20 corrected  $t$  tests revealed that there was only a marginally significant difference ( $p =$   
 21  $0.06$ ) between hits in sentences that had been presented with a nonsense ending (64.9%)  
 22 and hits in sentences with a highly expected word ending (78.5%).  
 23  
 24  
 25  
 26  
 27  
 28  
 29  
 30  
 31  
 32  
 33  
 34  
 35  
 36  
 37  
 38  
 39  
 40  
 41  
 42  
 43  
 44  
 45  
 46  
 47  
 48  
 49  
 50  
 51  
 52  
 53  
 54  
 55  
 56  
 57  
 58

59 After the recognition test, participants completed a set of psychological  
 60 measures, which included the Defensive Pessimism Questionnaire (DPQ), the Positive  
 61  
 62  
 63  
 64  
 65

---

<sup>2</sup> One participant was excluded from further ERP analysis as she correctly recognized only 47.6% of endings.

1 and Negative Affect Schedule (PANAS), the Beck Depression Inventory II (BDI-II), the  
2 Patient Health Questionnaire Depression Module (PHQ-9) and the Life Orientation Test  
3 Revised (LOT-R). Only the data from the DPQ were used in the analysis presented  
4 here. Scores on the PANAS and the BDI-II tests are reported in the Psychological  
5 Assessment section to provide some general features of our participant sample.  
6  
7  
8  
9

### 10 11 12 13 14 *1.5. EEG Recording and Analyses*

15  
16 EEGs were recorded from 31 tin electrodes mounted in an electrode cap  
17 (Electro-Cap International, Eaton, Ohio, USA). Electrode impedances were kept below  
18 5 K $\Omega$ . Electrodes were referenced online to the left mastoid, amplified with Brain Amps  
19 amplifiers (Brain Products, Munich, Germany) at a sampling rate of 250 Hz with a  
20 bandpass of 0.01-40 Hz, and re-referenced off-line to the mastoid average<sup>3</sup>. Bipolar  
21 horizontal and vertical electrooculograms (EOGs) were recorded for artifact rejection  
22 and correction purposes, using the method of Gratton et al. (1983). Data were processed  
23 using BrainVision Analyzer software (Brain Products, Munich). After visual inspection  
24 of individual data files, the following artifact threshold criteria were set: maximal  
25 allowed voltage step, 50  $\mu$ V; minimal and maximal allowed amplitude,  $\pm$  100  $\mu$ V;  
26 lowest allowed activity (max-min), 5  $\mu$ V for a 1500 ms interval length. Once any  
27 threshold was met in the continuous EEG file, data recorded at that point were marked  
28 and discarded, together with data recorded during the 200 ms before and after the  
29 detected artifact. This was done to avoid including any residual artifacts in subsequent  
30 computations of ERP averages. EEG raw data from all subjects were scanned and  
31 marked using the same artifact rejection criteria. As a result, 12% of trials were  
32 discarded and an average of 30.8 trials remained per experimental condition.  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57

58  
59 <sup>3</sup> Electrode sites were Fp1/z/2, F7/3/z/4/8, FT7/8, FC3/z/4, T7/8, C3/z/4, TP7/8, CP3/z/4, P7/3/z/4/8,  
60 O1/z/2.  
61  
62  
63  
64  
65

1 A Butterworth zero phase filter was applied to the EEG data (low cutoff at 0.1  
 2 Hz, time constant = 1.6 s, 24 dB/oct; high cutoff at 20 Hz, 24 dB/oct). The continuous  
 3 EEG was segmented into 1000-ms epochs starting 100 ms before the onset of the target  
 4 word ending. Artifact-free average waveforms were calculated for each word ending  
 5 (expected, nonsense, emotionally opposite) in positively and negatively biased sentence  
 6 frames after subtraction of the pre-stimulus baseline.  
 7  
 8  
 9  
 10  
 11  
 12  
 13

## 14 **2. Results**

### 15 *2.1. N400 effects*

16  
 17  
 18  
 19  
 20  
 21  
 22  
 23 In negatively and positively biased sentences, nonsense endings elicited the  
 24 largest N400 responses, highly expected endings the smallest, and emotionally opposite  
 25 endings intermediate responses (Fig. 1A). A repeated-measures ANOVA was carried  
 26 out with two levels of Emotional Frame (negatively and positively biased), three levels  
 27 of Expectation (expected, emotionally opposite, nonsense) and ten levels of scalp  
 28 Region of Interest (ROIs)<sup>4</sup>. The analysis revealed main effects of both Expectation  
 29 [ $F(2,46) = 54.751$ ;  $p=0.001$ ] and ROI [ $F(9,207) = 8.201$ ;  $p=0.001$ ], as well as an  
 30 interaction of Expectation by ROI [ $F(18,414) = 21.761$ ;  $p=0.001$ ]<sup>5</sup>. Paired comparisons  
 31 using Bonferroni-corrected *t*-tests confirmed that nonsense endings elicited larger  
 32 negative-going potentials than emotionally opposite endings, and that both of these  
 33 unexpected endings elicited larger negative-going potentials than highly expected  
 34 endings [means: nonsense (0.3  $\mu$ V) < emotionally opposite (1.7  $\mu$ V) < highly expected  
 35  
 36  
 37  
 38  
 39  
 40  
 41  
 42  
 43  
 44  
 45  
 46  
 47  
 48  
 49  
 50  
 51  
 52

---

53 <sup>4</sup> ROIs location and electrodes included: (1) left fronto-lateral (Fp1, F7, FT7); (2) left fronto-medial (F3,  
 54 FC3, C3); (3) midline frontal (Fpz, Fz, FCz); (4) right fronto-medial (F4, FC4, C4); (5) right fronto-  
 55 lateral (Fp2, F8, FT8); (6) left posterior-lateral (T7, TP7, P7); (7) left posterior-medial (CP3, P3, O1); (8)  
 56 midline posterior (Cz, CPz, Pz); (9) right posterior-medial (CP4, P4, O2) and (10) right posterior lateral  
 57 (T8, TP8, P8).

58 <sup>5</sup> Analyses were restricted to the 250-550 ms window to avoid overlap with prior P2 deflections and later  
 59 post-N400 frontal positivity (pN400FP). The Greenhouse-Geisser correction was applied to this and all  
 60 subsequent analyses in all F tests with more than one degree of freedom in the numerator.  
 61  
 62  
 63  
 64  
 65

1 (3.1  $\mu\text{V}$ ); all  $p$ s < 0.001). Follow-up ANOVAS on each ROI revealed this to be the  
2 pattern at all regions except for the left and right fronto-lateral ROIs, where there was  
3 only an incongruity effect, i.e. nonsense endings differed from emotionally opposite and  
4 highly expected endings, but the latter two did not differ from each other.  
5  
6  
7  
8  
9

10 Of critical interest for the present study was whether CP-matched word endings,  
11 would elicit N400 responses of different amplitude as a function of the emotional bias  
12 of the preceding sentence frame. Thus, ANOVAs were also conducted for each  
13 expectation condition. Nonsense and emotionally opposite experimental conditions  
14 showed no significant effects of the type of Emotional Frame at any scalp ROI. Thus,  
15 nonsense endings elicited a similarly large N400 response regardless of whether they  
16 were preceded by positively or negatively biased frames (Fig. 1Bb). Similarly,  
17 emotionally opposite endings elicited medium-sized N400 responses regardless of  
18 emotional frame at all scalp ROIs (Fig. 1Bc). In contrast, the ANOVA on the response  
19 to highly expected endings revealed an Emotional Frame effect in the midline posterior  
20 region (ROI # 8), which included electrodes Cz, CPz, and Pz [ $F(1,23) = 4.374, p =$   
21  $0.048$ ]. Highly expected *positive* endings elicited a larger negative-going potential than  
22 highly expected *negative* endings (4.2  $\mu\text{V}$  vs. 5.2  $\mu\text{V}$ , respectively), even though they  
23 were both embedded in emotionally-matched sentence frames. This effect was localized  
24 to that ROI and was not statistically significant at any other scalp region. Only the left  
25 posterior-medial region (ROI # 7) approached significance ( $p=0.07$ ). Thus, despite  
26 sharing a high CP value and a sentence frame providing an emotionally matching  
27 contextual constraint, the positive expected outcomes elicited a slightly larger N400  
28 response than did the negative expected ones in the midline posterior scalp region (Fig.  
29 1Ba).  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

## 2.2. *Post-N400 effects*

Between 600-900 ms, a larger frontal positivity was elicited by emotionally opposite endings than by expected and nonsense endings (Fig. 1A). A repeated-measures ANOVA on a frontal ROI<sup>6</sup> revealed main effects of both Expectation [ $F(2,46) = 5.120; p=0.01$ ] and Electrode [ $F(5,115) = 6.207; p=0.001$ ], as well as the interactions Expectation by Electrode [ $F(10,230) = 4.319; p=0.002$ ] and Emotion by Electrode [ $F(5,115) = 3.893; p=0.013$ ]. Paired-sample two-tailed  $t$ -tests on amplitude measures in this ROI revealed that the response to emotionally opposite endings differed in size from that of expected endings in both negatively ( $t_{23} = -3.192; p = 0.004$ ) and positively biased frames ( $t_{23} = -2.140; p = 0.04$ ). The effect appeared to be slightly larger for negatively than for positively biased sentences, but these amplitude differences did not reach statistical significance ( $t_{23} = -1.641; p = 0.11$ ). Moreover, nonsense endings did not differ from expected endings in pN400FP amplitude (negatively biased sentences,  $t_{23} = -0.403, p = 0.69$ ; positively biased sentences,  $t_{23} = -0.728, p = 0.44$ ).

## 2.3. *Defensive Pessimism and ERP effects*

An inter-subject variable, high versus low score on the DPQ, was added to the repeated-measures ANOVA analyses described above. The participants' median-split score was 55 (range = 34-72), with 10 participants scoring 56-72 (high defensive pessimist group, HDP), and 11 participants scoring 34-53 (low defensive pessimist group, LDP)<sup>7</sup>.

The HDP group showed a similar response to all ending types until approximately 200 ms (Fig. 2A). Then, a three-way split occurred in the N400 region

<sup>6</sup> The frontal ROI included electrodes F3, Fz, F4, FC3, FCz, and FC4.

<sup>7</sup> Three participants scoring 55 were left out for the purposes of the present analysis.

1 for each type of ending. The size of the N400 ERP component followed the trend  
2 nonsense > emotionally opposite > expected, as described earlier with regard to the  
3  
4 entire sample of 24 participants. In contrast, the LDP group seemed to show early  
5  
6 brainwave modulations before 200 ms. However, earlier deflections around the P2 peak  
7  
8 may be driven by a developing N400 effect. Thus, we continued to focus our analyses  
9  
10 on the amplitude measured within the N400 time-window.  
11  
12  
13

14  
15  
16       Between 200 and 800 ms, the HDP group showed a larger and sustained  
17  
18 negative-going voltage in response to expected endings that was larger than that of the  
19  
20 LDP group (Fig. 2Ba). ANOVAs restricted to the N400 time-window of analysis (250-  
21  
22 550 ms) over a centro-parietal electrode region<sup>8</sup> revealed a main effect of DP [ $F(1,19)$ ;  
23  
24  $p=0.039$ ]. Unpaired-sample two-tailed  $t$ -tests revealed that amplitude measures  
25  
26 significantly differed between groups both for positively biased expected endings ( $t_{19} =$   
27  
28 2.958;  $p = 0.008$ ) and negatively biased ones ( $t_{19} = 2.586$ ;  $p = 0.018$ ). These results may  
29  
30 suggest that the HDP group generally seemed to avoid holding expectations. Pearson  $r$   
31  
32 coefficient analyses showed significant correlations between the DP score and the  
33  
34 voltage measured between 250-550 ms in response to highly expected word outcomes at  
35  
36 specific centroparietal electrodes (i.e.,  $r = -.477$ ,  $p = 0.029$  at CP4;  $r = -.461$ ,  $p = 0.035$   
37  
38 at Pz). Higher scores on the DP questionnaire predicted more negative-going brainwave  
39  
40 responses (i.e., smaller positive voltage). In the same time-window, the groups did not  
41  
42 differ in the response to nonsense or emotionally opposite endings (Fig. 2Bb and 2Bc).  
43  
44 Only the N400 response to “happy” endings that were preceded by negatively biased  
45  
46 sentence frames appeared to be larger in the HDP than the LDP group (Fig. 2Bc).  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

However, this effect was not statistically significant ( $p = 0.09$ ).

---

<sup>8</sup> This region included electrodes FCz, C3, Cz, C4, CPz and Pz.

## 2.4. Summary of Results

N400 amplitudes were graded by Expectation (Expected < Emotionally Opposite < Nonsense) and showed no main effects of Emotional frame. Between 250-550 ms, a similar triphasic pattern of ERP deflections was observed for the two types of emotionally biased sentences. Emotional frame did, however, have an influence on N400 size when the response to highly expected word outcomes was examined in isolation. Positive expected outcomes elicited larger N400 amplitudes than did negative ones in a midline posterior scalp region, suggesting that the semantic integration/prediction of word endings was easier in the case of negative expectations than positive ones or that the positive predictions were easier to withhold. Subsequent to the N400 effect (between 600-900 ms), positivity over frontal electrode sites (pN400FP) was larger in response to emotionally opposite endings than to expected and nonsense ones, indicating that unfulfilled emotional expectations were more difficult to process than fulfilled or nonsense ones, regardless of the preceding emotional frame. Further analyses seem to indicate that individual differences in personal strategies (i.e., defensive pessimism) may be linked to specific patterns of brainwave responses. However, these results should only be considered exploratory, since the sample size within each group was quite limited.

## 3. Discussion

In line with previous ERP studies, N400 responses were greatest in response to nonsense endings (e.g. spending restless nights '*being born*' after being left by a boyfriend), intermediate in response to less likely but still plausible endings (*flirting*),

1 and lowest in response to highly expected CP endings ('*crying*'). In our study the word  
2 '*flirting*', in addition to being a low-CP ending (0.8% as an R1), also critically violated  
3 the expectation of an emotional outcome ('*crying*'). Thus, violations of emotionally  
4 loaded expectations gave rise to an N400 effect: i.e. N400 was larger for endings  
5 emotionally opposite to the highly expected emotional outcome. This effect may be due  
6 solely to the low CP of the word or to both the low CP and the fact that an emotional  
7 switch was concurrently taking place when that target word appeared. Interestingly, the  
8 size of the N400 response to endings that violated expectations either emotionally or  
9 semantically was larger for the nonsense than for the emotional opposites, but it was  
10 unaffected by whether the context biased our participants towards a negative or positive  
11 expectation. According to our N400 results, less plausible emotionally opposite endings  
12 were always easier to integrate or were more predictable in their context than nonsense  
13 endings, regardless of whether participants had strongly been biased towards expecting  
14 a "good" or "bad" outcome.

15 Surprisingly, although highly expected outcomes elicited the smallest N400  
16 responses, as expected based on the N400 literature, emotional frame modulated  
17 responses to this kind of outcome, but not responses to the other outcomes. Thus,  
18 although positive and negative expected outcomes had a similarly high paper-and-pencil  
19 CP value as well as a preceding emotionally-matched frame, the positive outcomes  
20 elicited a larger negative-going voltage than negative ones, as measured at a midline  
21 posterior region in the N400 time-window. We regard this effect as preliminary due to  
22 its limited scalp location and its weak statistical significance. Nonetheless, the  
23 integrative and the predictive views of the N400 component may suggest a different  
24 interpretation of this result. According to the integration view, N400 amplitude variation  
25 would indicate our participants were forced to devote fewer resources to integrating the

1 negative words than the positive ones into their context, even though both were highly  
2 expected based on paper-and-pencil offline measures. According to the prediction view,  
3  
4 readers were better at using negative contexts than positive ones to generate  
5  
6 expectations for an outcome word. Our data do not allow us to determine whether  
7  
8 people are better at successfully integrating/predicting negative outcomes than positive  
9  
10 ones, or they are reluctant to make predictions of "happy" outcomes, or both. Future  
11  
12 studies should seek to discern between these alternative interpretations.  
13  
14  
15

16  
17 In our experimental design, the emotionality of the target word and the  
18  
19 emotionality of the sentence frame always agreed for highly expected endings and  
20  
21 always disagreed for emotionally opposite endings. However, the CP value of all target  
22  
23 endings was matched across emotionality in both high and low CP conditions.  
24  
25

26 Differences in the relative sizes of N400 and pN400FP responses may be attributed to  
27  
28 the emotionality of the frame in which high and low CP endings occurred. Nonetheless,  
29  
30 negative and positive emotional frames may also behave as better primers of their  
31  
32 respective negative or positive endings, and this alternative low-level account of N400  
33  
34 effects must also be considered (see Kutas et al., 2011 and Van Berkum, et al., 2005 on  
35  
36 the integrative/predictive views of N400 effects).  
37  
38  
39  
40

41 At present, only a few studies have used a whole-sentence comprehension  
42  
43 paradigm to explore the mechanisms underlying the processing of emotionally  
44  
45 evocative language (De Pascalis, et al., 2009; Holt et al., 2008; Bayer et al., 2010).  
46  
47 Results from the two of these studies in which N400 effects were explored, contrast  
48  
49 with the ones obtained in the present work. Those studies found that N400 was  
50  
51 modulated by arousal but not by emotional valence (Holt et al., 2008); or that it was  
52  
53 larger for negative than for positive and neutral words (De Pascalis, et al., 2009). These  
54  
55 contrasting results may arise from significant methodological differences across studies.  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

1 In the study by De Pascalis et al. (2009), word CP was not accounted for. Thus, N400  
2 effects may have arisen due to a lower word CP for negative relative to positive/neutral  
3 words. In the study by Holt et al. (2008), word CP was low for sentence-embedded  
4 targets (2% on average). Critically, and in contrast to our study, their contexts were  
5 emotionally neutral, which may have led to an N400 effect for any emotional target,  
6 whether positive or negative, but not for neutral targets. Moreover, their offline-  
7 measured word CP was slightly larger for positive (3.5%) than negative (1.4%) and  
8 neutral targets (1.1%). This behavioral result fits with theoretical models that postulate  
9 that, by default, people tend to be optimistic about upcoming events (Taylor and Brown,  
10 1988), as well as with single-word ERP studies reporting smaller N400 responses to  
11 positive than neutral words (Herbert, et al., 2008). Our ERP study ensured a high and  
12 matched CP value across negative and positive sentence frames by performing an initial  
13 word CP norming study that aimed to select matched sentences for the brainwave study.  
14 In our ERP scenario, in which positive and negative expectations were equally strongly  
15 biased but were randomly violated, we found a local increase in N400 in response to  
16 highly expected positive word endings compared to highly expected negative ones. We  
17 speculate that participants in our study were particularly reluctant to make predictions of  
18 "happy" outcomes under such unpredictable conditions. According to social psychology  
19 studies, positive predictions tend to shift away from being *positive* as feedback  
20 information is soon becoming available and when the outcome is uncontrollable  
21 (Carroll, et al., 2006).  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51

52 Our group analyses also preliminarily suggest that *defensive pessimism* strategies  
53 might induce people to avoid holding expectations in emotional contexts. However, we  
54 did not obtain separate estimates of word ending CPs for high versus low defensive  
55 pessimists. Future studies are needed to explore more thoroughly individual differences  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

1 in ERP response patterns under evocative language processing tasks. In the current  
2 study individual affect ratings of target words and their preceding emotional frames was  
3  
4 not measured. Sentence frames were designed simply to bias towards a good or a bad  
5  
6 outcome (e.g. dying, falling from heights, laughing, having fun). In future studies  
7  
8 emotionality rating levels might reveal better defined ERP effects and also clarify  
9  
10 potential individual differences in brainwave responses.  
11  
12  
13

14  
15 As previous ERP studies indicate, pN400FP effects index the cost associated  
16  
17 with the processing of an unfulfilled expectation in a highly constrained context  
18  
19 (DeLong, et al., 2011; Federmeier, et al., 2007). Our results show that, indeed,  
20  
21 processing an emotionally unexpected word in a highly constrained context does incur a  
22  
23 cost. However, since the pN400FP effect may reflect the need to inhibit or revise a  
24  
25 strong expectation (Federmeier et al., 2007), our results suggest that such revision may  
26  
27 have been unnecessary for sentences in which an emotionally loaded expectation did not  
28  
29 make sense at all (i.e., nonsense condition). Moreover, a larger pN400FP in response to  
30  
31 emotionally opposite outcomes under the influence of negative expectations than under  
32  
33 the influence of positive expectations may indicate that negative predictions were more  
34  
35 strongly entrenched than positive ones. Our results point in that direction, but we failed  
36  
37 to find statistically significant amplitude differences over the frontal scalp region.  
38  
39 Perhaps the proposed partial temporal overlap between frontal pN400FP and posterior  
40  
41 N400 effects (DeLong et al., 2011) may be present in our data.  
42  
43  
44  
45  
46  
47  
48  
49  
50

51 In conclusion, in time-constrained scenarios in which biased negative and  
52  
53 positive expectations may or may not be fulfilled quickly at random, brainwave  
54  
55 responses reveal no difference in N400 amplitude depending on whether the emotional  
56  
57 violation represents an `emotional setback´ (i.e. worse than expected) or a `pleasant  
58  
59  
60  
61  
62  
63  
64  
65

1 surprise' (i.e. better than expected). These expectations do, however, incur a processing  
2 cost, as indexed by the subsequent pN400FP effect. Again, however, the direction of the  
3 emotional switch does not seem to make a difference. Nonsense endings pose a  
4 difficulty for integration/prediction, as indexed by an enhanced N400 response, but the  
5 pN400FP that indexes the need of a revision of a strongly held prediction was not  
6 present. Finally, an interesting result was obtained when ERPs to highly expected  
7 outcomes was explored. In this condition, negative and positive word endings shared an  
8 equally high CP value as well as an emotionally-matched preceding sentence frame.  
9 The N400 amplitude under these conditions was consequently reduced relative to the  
10 other conditions. However, results obtained at a focal midline posterior scalp region  
11 suggest that the negative and the positive highly expected outcomes might have been  
12 processed differently. In light of our results, we can only speculate that relevant  
13 phenomena described in the social psychology literature (e.g. the proximity of real  
14 feedback and lack of control over the outcome) may play a critical role in our online  
15 language comprehension task. Since bad outcomes feel worse when unexpected than  
16 when expected, nature may have endowed us with the ability to make accurate  
17 predictions of negative outcomes to avoid the 'extra' pain when such an outcome is  
18 unexpected. In addition, since good outcomes feel better when unexpected than when  
19 expected, we seem to be good at avoiding harboring positive expectations in order to  
20 maximize the good feeling that results when they end up coming true. Recent studies on  
21 hedonic adaptation (Diener et al., 2006) suggest that people adapt quickly to the  
22 presence of positive events because they tend to become "unsurprising" (Koo et al.,  
23 2008). In our study, the larger N400s for highly expected positive outcomes might  
24 indicate that our participants still managed to find those outcomes 'surprising', at least  
25 more so than the negative ones.  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

1 Our study illustrates how brainwave measurements obtained during a language  
2 comprehension task might provide information about how individuals cope with  
3  
4 emotionally loaded incoming information. Our results provide preliminary evidence that  
5  
6 in time-constrained affective scenarios, humans may selectively adjust the strength of  
7  
8 their positive and negative expectations before a verbal input comes in.  
9  
10  
11  
12  
13  
14  
15  
16  
17

### 18 *Acknowledgements*

19  
20 This original research has not been published elsewhere and was supported by Spanish  
21  
22 Ministry of Science and Innovation grant PSI2008-04961 to EMM and grants PSI2008-  
23  
24 02889-E and SEJ-PSI2009-13922 to CV. We thank Carmen Gómez-Nuñez, María  
25  
26 Provencio, and Claudia Del Pozo-Moreno for their help during data collection,  
27  
28 Armando Chapin Rodríguez for manuscript editing, and all the participants in our study  
29  
30  
31 for their cooperation.  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

## References

- 1  
2  
3  
4 Baumeister, R. F., Bratslavsky, E., Finkenauer, C., Vohs, K.D. 2001. Bad is stronger  
5 than good. *Review of General Psychology*, 5(4), 323-370.
- 6 Bayer, M., Sommer, W., Schacht, A. 2010. Reading emotional words within sentences:  
7 the impact of arousal and valence on event-related potentials. *International*  
8 *Journal of Psychophysiology*, 78(3), 299-307.
- 9  
10 Beck, A. T., Steer, R. A., Brown, G. K. 1996. BDI-II : Beck depression inventory :  
11 manual (2nd ed ed.). San Antonio (Tex.) [etc.]: Psychological Corp. : Harcourt  
12 Brace.
- 13 Cacioppo, J. T., Gardner, W. L. 1999. Emotion. *Annual Review of Psychology*, 50,  
14 191-214.
- 15 Carretie, L., Mercado, F., Tapia, M., Hinojosa, J. A. 2001. Emotion, attention, and the  
16 'negativity bias', studied through event-related potentials. *International Journal*  
17 *of Psychophysiology*, 41(1), 75-85.
- 18 Carroll, P., Sweeny, K., Shepperd, J. A. 2006. Forsaking optimism. *Review of General*  
19 *Psychology*, 10(1), 56-73.
- 20 Chung, G., Tucker, D. M., West, P., Potts, G. F., Liotti, M., Luu, P., Hartry, A.L. 1996.  
21 Emotional expectancy: brain electrical activity associated with an emotional bias  
22 in interpreting life events. *Psychophysiology*, 33(3), 218-233.
- 23 De Pascalis, V., Arwari, B., D'Antuono, L., Cacace, I. 2009. Impulsivity and  
24 semantic/emotional processing: an examination of the N400 wave. *Clinical*  
25 *Neurophysiology*, 120(1), 85-92.
- 26 Delong, K. A., Urbach, T. P., Groppe, D. M., Kutas, M. 2011. Overlapping dual ERP  
27 responses to low cloze probability sentence continuations. *Psychophysiology*.  
28  
29 DeLong, K. A., Urbach, T. P., Kutas, M. 2005. Probabilistic word pre-activation during  
30 language comprehension inferred from electrical brain activity. *Nature*  
31 *Neuroscience*, 8(8), 1117-1121.
- 32 Diener, E., Lucas, R. E., Scollon, C. N. 2006. Beyond the hedonic treadmill: revising  
33 the adaptation theory of well-being. *American Psychologist*, 61(4), 305-314.
- 34 Federmeier, K. D. 2007. Thinking ahead: the role and roots of prediction in language  
35 comprehension. *Psychophysiology*, 44(4), 491-505.
- 36 Federmeier, K. D., Kirson, D. A., Moreno, E. M., Kutas, M. 2001. Effects of transient,  
37 mild mood states on semantic memory organization and use: an event-related  
38 potential investigation in humans. *Neuroscience Letters*, 305(3), 149-152.
- 39 Federmeier, K. D., Kutas, M. 1999. A rose by any other name: Long-term memory  
40 structure and sentence processing. *Journal of Memory and Language*, 41(4),  
41 469-495.
- 42 Federmeier, K. D., Wlotko, E. W., De Ochoa-Dewald, E., Kutas, M. 2007. Multiple  
43 effects of sentential constraint on word processing. *Brain Research*, 1146, 75-84.
- 44 Fischler, I., Bradley, M. 2006. Event-related potential studies of language and emotion:  
45 words, phrases, and task effects. *Understanding Emotions*, 156, 185-203.
- 46 Golub, S. A., Gilbert, D. T., Wilson, T. D. 2009. Anticipating one's troubles: the costs  
47 and benefits of negative expectations. *Emotion*, 9(2), 277-281.
- 48 Gratton, G., Coles, M. G., Donchin, E. 1983. A new method for off-line removal of  
49 ocular artifact. *Electroencephalography and Clinical Neurophysiology*, 55(4),  
50 468-484.
- 51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

- 1 Hagoort, P., Hald, L., Bastiaansen, M., Petersson, K. M. 2004. Integration of word  
2 meaning and world knowledge in language comprehension. *Science*, 304(5669),  
3 438-441.
- 4 Hald, L. A., Steenbeek-Planting, E. G., Hagoort, P. 2007. The interaction of discourse  
5 context and world knowledge in online sentence comprehension. Evidence from  
6 the N400. *Brain Research*, 1146, 210-218.
- 7 Herbert, C., Junghofer, M., Kissler, J. 2008. Event related potentials to emotional  
8 adjectives during reading. *Psychophysiology*, 45(3), 487-498.
- 9 Holt, D. J., Lynn, S. K., Kuperberg, G.R. 2008. Neurophysiological correlates of  
10 comprehending emotional meaning in context. *Journal of Cognitive*  
11 *Neuroscience*, 21(11), 2245-2262.
- 12 Ito, T. A., Cacioppo, J. T. 2000. Electrophysiological evidence of implicit and explicit  
13 categorization processes. *Journal of Experimental Social Psychology*, 36(6),  
14 660-676.
- 15 Ito, T. A., Larsen, J. T., Smith, N. K., Cacioppo, J. T. 1998. Negative information  
16 weighs more heavily on the brain: the negativity bias in evaluative  
17 categorizations. *Journal of Personality and Social Psychology*, 75(4), 887-900.
- 18 Janoff-Bulman, R. 1989. Assumptive worlds and the stress of traumatic events:  
19 applications of the schema construct. *Social Cognition*, 7(Special Issue: Social  
20 Cognition and Stress), p. 113-136.
- 21 Kissler, J., Assadollahi, R., Herbert, C. 2006. Emotional and semantic networks in  
22 visual word processing: insights from ERP studies. *Understanding Emotions*,  
23 156, 147-183.
- 24 Kissler, J., Herbert, C., Peyk, P., Junghofer, M. 2007. Buzzwords: early cortical  
25 responses to emotional words during reading. *Psychological Science*, 18(6),  
26 475-480.
- 27 Kissler, J., Koessler, S. 2011. Emotionally positive stimuli facilitate lexical decisions-an  
28 ERP study. *Biological Psychology*, 86(3), 254-264.
- 29 Koo, M., Algoe, S. B., Wilson, T. D., Gilbert, D. T. 2008. It's a wonderful life: mentally  
30 subtracting positive events improves people's affective states, contrary to their  
31 affective forecasts. *Journal of Personality and Social Psychology*, 95(5), 1217-  
32 1224.
- 33 Kutas, M. 1987. Event-related brain potentials (ERPs) elicited during rapid serial visual  
34 presentation of congruous and incongruous sentences. *Electroencephalography*  
35 *and Clinical Neurophysiology Supplement*, 40, 406-411.
- 36 Kutas, M., DeLong, K.A., Smith, N. J. 2011. A Look around at What Lies Ahead:  
37 Prediction and Predictability in Language Processing. In M. Bar (Ed.),  
38 *Predictions in the Brain: Using Our Past to Generate a Future* (pp. 190-207):  
39 Oxford University Press.
- 40 Kutas, M., Federmeier, K. D. 2000. Electrophysiology reveals semantic memory use in  
41 language comprehension. *Trends in Cognitive Sciences*, 4(12), 463-470.
- 42 Kutas, M., Federmeier, K. D. 2011. Thirty years and counting: finding meaning in the  
43 N400 component of the event-related brain potential (ERP). *Annual Review of*  
44 *Psychology*, 62, 621-647.
- 45 Kutas, M., Hillyard, S. A. 1980a. Event-related brain potentials to semantically  
46 inappropriate and surprisingly large words. *Biological Psychology*, 11(2), 99-  
47 116.
- 48 Kutas, M., Hillyard, S. A. 1980b. Reading senseless sentences: brain potentials reflect  
49 semantic incongruity. *Science*, 207(4427), 203-205.
- 50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

- 1 Kutas, M., Hillyard, S. A. 1984. Brain potentials during reading reflect word expectancy  
2 and semantic association. *Nature*, 307(5947), 161-163.
- 3 Kutas, M., Lindamood, T.E., Hillyard, S.A. (Ed.). 1984. *Word expectancy and event-*  
4 *related brain potentials during sentence processing*. Hillsdale, NJ: Erlbaum.
- 5 Norem, J. K. (Ed.). 2001. *The positive power of negative thinking*. NY: NY: Basic  
6 Books.
- 7 Norem, J. K., Chang, E. C. 2002. The positive psychology of negative thinking. *Journal*  
8 *of Clinical Psychology*, 58(9), 993-1001.
- 9 Oldfield, R. C. 1971. The assessment and analysis of handedness: the Edinburgh  
10 inventory. *Neuropsychologia*, 9(1), 97-113.
- 11 Osterhout, L. 1997. On the brain response to syntactic anomalies: manipulations of  
12 word position and word class reveal individual differences. *Brain and Language*,  
13 59(3), 494-522.
- 14 Paulmann, S., Kotz, S. A. 2008. An ERP investigation on the temporal dynamics of  
15 emotional prosody and emotional semantics in pseudo- and lexical-sentence  
16 context. *Brain and Language*, 105(1), 59-69.
- 17 Scheier, M. F., Carver, C. S. 1985. Optimism, coping, and health: assessment and  
18 implications of generalized outcome expectancies. *Health Psychology*, 4(3),  
19 219-247.
- 20 Scheier, M. F., Carver, C. S. 1987. Dispositional Optimism and Physical Well-Being -  
21 the Influence of Generalized Outcome Expectancies on Health. *Journal of*  
22 *Personality*, 55(2), 169-210.
- 23 Scheier, M. F., Carver, C. S., Bridges, M. W. 1994. Distinguishing optimism from  
24 neuroticism (and trait anxiety, self-mastery, and self-esteem): a reevaluation of  
25 the Life Orientation Test. *Journal of Personality and Social Psychology*, 67(6),  
26 1063-1078.
- 27 Schirmer, A., Kotz, S. A., Friederici, A. D. 2002. Sex differentiates the role of  
28 emotional prosody during word processing. *Brain Research Cognitive Brain*  
29 *Research*, 14(2), 228-233.
- 30 Sebastián-Gallés, N., Martí, M.A., Carreiras, M., Cuetos F. 2000. *Lexesp: Una base de*  
31 *datos informatizada del español*. Barcelona, Spain: Edicions de la Universitat de  
32 Barcelona.
- 33 Shepperd, J. A., McNulty, J. K. 2002. The affective consequences of expected and  
34 unexpected outcomes. *Psychological Science*, 13(1), 85-88.
- 35 Sweeny, K., Carroll, P. J., Shepperd, J. A. 2006. Is optimism always best?: Future  
36 outlooks and preparedness. *Current Directions in Psychological Science*, 15(6),  
37 302-306.
- 38 Sweeny, K., Shepperd, J. A. 2007. Do people brace sensibly? Risk judgments and event  
39 likelihood. *Personality and Social Psychology Bulletin*, 33(8), 1064-1075.
- 40 Taylor, S. E., Brown, J. D. 1988. Illusion and well-being: a social psychological  
41 perspective on mental health. *Psychological Bulletin*, 103(2), 193-210.
- 42 Taylor, W. L. 1953. "Cloze procedure": A new tool for measuring readability.  
43 *Journalism Quarterly*, 30, 415-433.
- 44 Vaish, A., Grossmann, T., Woodward, A. 2008. Not all emotions are created equal: the  
45 negativity bias in social-emotional development. *Psychological Bulletin*, 134(3),  
46 383-403.
- 47 Van Berkum, J. J., Brown, C. M., Zwitserlood, P., Kooijman, V., Hagoort, P. 2005.  
48 Anticipating upcoming words in discourse: evidence from ERPs and reading  
49 times. *Journal of Experimental Psychology: Learning, Memory, and Cognition*,  
50 31(3), 443-467.
- 51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

- 1 Van Berkum, J. J. A., Holleman, B., Nieuwland, M., Otten, M., Murre, J. 2009. Right or  
 2 Wrong? The Brain's Fast Response to Morally Objectionable Statements.  
 3 Psychological Science, 20(9), 1092-1099.  
 4 Vázquez, C., Sanz, J. 1997. Fiabilidad y valores normativos de la versión española del  
 5 Inventario para la Depresión de Beck de 1978. Clínica y Salud, 8, 403-422.  
 6 Watson, D., Clark, L. A., Tellegen, A. 1988. Development and validation of brief  
 7 measures of positive and negative affect: the PANAS scales. Journal of  
 8 Personality and Social Psychology, 54(6), 1063-1070.  
 9 Wicha, N. Y. Y., Moreno, E. M., Kutas, M. 2004. Anticipating words and their gender:  
 10 An event-related brain potential study of semantic integration, gender  
 11 expectancy, and gender agreement in Spanish sentence reading. Journal of  
 12 Cognitive Neuroscience, 16(7), 1272-1288.  
 13  
 14

## 15 Tables

16  
 17  
 18 **Table 1**

19 Cloze probabilities, frequency of use, and number of letters of expected, emotionally opposite, and  
 20 nonsense word endings for negatively and positively biased sentence frames.

Type of word ending		Sentence Frame Type					
		Negatively Biased (n = 105)			Positively Biased (n = 105)		
		Mean	Range	SD	Mean	Range	SD
No. of subjects in norming study (per sentence)		31	27-33	2.2	32	28-33	2
Cloze probability <sup>a</sup>	% Expected (R1)	73.6	50-100	14.1	72.2	50-100	14.2
	% Expected (R2)	10.8	0-31	6.7	10.8	0-38	7.3
	% Expected (R3)	3.5	0-18	3.4	4.3	0-14	3.6
	% Expected (R1-R2-R3)	87.1	62-100	9.8	86.7	61-100	10.4
	% Emotionally Opposite (R1)	0.7	0-10	1.9	0.9	0-10	2
	% Emotionally Opposite (R2)	3.5	0-39	5.9	3.5	0-30	5.1
	% Emotionally Opposite (R3)	3.2	0-18	4	3.2	0-27	4.1
Frequency of use	Expected	181	0-1535	280	215	0-3744	493
	Emotionally Opposite	205	0-3744	517	195	1-3249	459
	Nonsense	205	0-1923	358	206	0-2634	398
No. of Letters	Expected	6.7	3-10	1.6	6.9	3-11	1.9
	Emotionally Opposite	7.2	3-12	2.1	6.9	3-12	2
	Nonsense	7	3-11	1.8	6.9	3-11	1.7

39  
 40 <sup>a</sup> Cloze probability values are reported separately based on whether participants in the norming study gave  
 41 them as an R1, R2, or R3 response, or as any of them (R1-R2-R3). Nonsense completions were never  
 42 reported by our participants and therefore always had a CP value of zero.  
 43  
 44  
 45  
 46  
 47  
 48  
 49  
 50  
 51  
 52  
 53  
 54  
 55  
 56  
 57  
 58  
 59  
 60  
 61  
 62  
 63  
 64  
 65

**Table 2**

Examples of sentence frames and target word endings in the event-related potentials (ERP) experiment

Sentence frame <sup>a</sup>	Expected	CP as R1 <sup>b</sup> (%)	Ending type			
			Emotionally opposite	CP as R1, R2, or R3 <sup>b</sup> (%)	Nonsense	
Negatively Biased	En el borde del acantilado, alguien vino por detrás y le... <i>At the edge of the cliff, someone came from behind and [him]...</i>	...empujó. ... <i>pushed.</i>	78.8	...rescató. ... <i>rescued.</i>	6.1	...inventó. ... <i>invented.</i>
	Aquello era tan repugnante que me hizo... <i>That was so disgusting that it made me...</i>	...vomitar. ... <i>throw up.</i>	78.8	...reír. ... <i>laugh.</i>	9.1	...brotar. ... <i>sprout.</i>
	Abrió el cajón donde normalmente guardo el dinero y estaba... <i>I opened up the drawer where I usually keep the money and it was...</i>	...vacío. ... <i>empty.</i>	72.7	...allí. ... <i>there.</i>	24.2	...hablando. ... <i>talking.</i>
	Mi jefe estaba descontento conmigo y un buen día me... <i>My boss was unhappy with me and one fine day [me]...</i>	...despidió. ... <i>fired.</i>	69.7	...felicitó. ... <i>complimented.</i>	12.1	...abrochó. ... <i>buttoned up.</i>
	Siempre que tienes una emergencia la línea está... <i>Whenever you have an emergency the line is...</i>	...ocupada. ... <i>busy.</i>	60.6	...disponible. ... <i>available.</i>	6.1	...chapoteando. ... <i>splashing.</i>
	Un paciente de psiquiatría abrió una ventana y se... <i>A psychiatric patient opened up a window and [himself]...</i>	...tiró. ... <i>threw out.</i>	51.5	...asomó. ... <i>leant out.</i>	18.2	...parpadeó. ... <i>blinked.</i>
Positively Biased	Después de 10 años de matrimonio, todavía seguían estando muy... <i>After 10 years of marriage, they still remained very much...</i>	...enamorados. ... <i>in love.</i>	72.7	...mal. ... <i>badly.</i>	3	...soleados. ... <i>sunny.</i>
	El público se puso inmediatamente en pie y le... <i>The audience immediately stood up and [him]...</i>	...aplaudió. ... <i>applauded.</i>	75	...gritó. ... <i>shouted at.</i>	17.9	...podó. ... <i>pruned.</i>
	Esos detalles conmigo demostraban lo mucho que me... <i>Those little thoughtful details revealed how much [he/she] [me]...</i>	...quería. ... <i>loved.</i>	69.7	...envidiaba. ... <i>envied.</i>	6.1	...resumía. ... <i>summarized.</i>
	Cuando le vio regresar sano y salvo se... <i>When [he/she] saw him coming back safe and sound [he/she]...</i>	...alegró. ... <i>[was] happy.</i>	63.6	...enfadó. ... <i>[got] angry.</i>	12.1	...regó. ... <i>[got] watered.</i>
	Aquella brisa marina en el rostro era muy... <i>That sea breeze on [my/his/her/our/their] face was very...</i>	...agradable. ... <i>nice.</i>	57.6	...molesta. ... <i>annoying.</i>	9.1	...social. ... <i>social.</i>
	Comprando las cosas para la fiesta también nos... <i>While buying things for the party we also...</i>	...divertimos. ... <i>[had] fun.</i>	53.1	...perdimos. ... <i>[got] lost.</i>	18.8	...decoramos. ... <i>[got] decorated.</i>

<sup>a</sup> An approximate translation into English is offered in italics. Personal pronouns precede verbs in Spanish. Thus, in our translation the pronoun is inserted in the sentence frame prior to the ending target word to indicate that it was provided in Spanish before the verb came up at the screen.

<sup>b</sup> Based on our norming study (see Method). For expected endings we report their CP as a first response (R1), since it indicates the strength of the expectation. For emotionally opposite endings, we report their Cloze probability as either R1, R2 or R3, since this indicates the likelihood that the word will enter the reader's mind, even if it is not his or her first choice. Nonsense endings were never reported by our participants and therefore always had a CP value of zero.

**Table 3**

Cloze probability, frequency of use, and number of letters in target word endings arranged by sentence frame type within each list

List	Ending type	Sentence bias <sup>a</sup>	Cloze probability of target word endings in their sentence frame				Word frequency	No. of letters
			% as R1	% as R2	% as R3	% as R1-2-3		
1	Expected	N	70.1	12.5	3.5	86.0	117.7	7.1
		P	69.5	10.0	4.2	83.3	110.2	7.5
	Emotionally opposite	N	0.6	2.1	2.7	5.4	268.0	7.7
		P	0.6	3.1	3.3	6.9	309.8	6.6
	Nonsense	N	0	0	0	0	233.3	6.7
		P	0	0	0	0	184.5	6.7
2	Expected	N	74.2	10.2	3.3	87.1	165.5	6.6
		P	71.6	13.5	4.9	88.4	220.5	6.6
	Emotionally opposite	N	0.7	3.1	2.5	6.4	98.4	7.2
		P	0.6	3.9	3.0	7.6	136.1	7.3
	Nonsense	N	0	0	0	0	187.1	7.3
		P	0	0	0	0	321.9	7.1
3	Expected	N	76.5	9.6	3.8	88.2	259.7	6.5
		P	75.7	9.1	3.8	88.5	313.8	6.9
	Emotionally opposite	N	0.9	5.4	4.3	10.5	248.0	6.7
		P	1.5	3.4	3.3	8.3	140.4	7.0
	Nonsense	N	0	0	0	0	194.6	6.9
		P	0	0	0	0	112.5	6.8

<sup>a</sup>N, negatively biased; P, positively biased

## Figure Captions

**Figure 1. Panel A.** Brain activity of participants ( $N = 24$ ) at 12 electrode channels in response to expected, emotionally opposite, and nonsense endings when they were embedded in negatively (a) or positively (b) biased sentence frames. The N400 component is indicated with an arrow and labelled at a centroparietal midline electrode (CPz). The post-N400 frontal positivity (pN400FP) is labelled at a frontal midline electrode (Fz). In Figures 1 and 2, voltage (in microvolts) is displayed with negative voltage above the x-axis, and time (in milliseconds) is shown relative to the onset of the critical ending word at time 0. A three-way split depending on the type of ending can be observed in the amplitude of the N400 response. The N400 was smallest for expected endings (black), slightly larger for emotionally opposite endings (red) and largest for nonsense endings (green). In contrast, the pN400FP was larger for emotionally opposite endings (red) and similar for expected (black) and nonsense (green) endings. **Panel B.** Brain activity at the CPz electrode is shown in response to highly expected (a), nonsense (b) and emotionally opposite (c) endings as a function of whether they were embedded in negatively (black) or positively (red) biased sentence frames. The N400 was similar for nonsense (b) and emotionally opposite (c) endings regardless of emotional frame. In contrast, the amplitude of the N400 ERP component was larger and more sustained for highly expected positive outcomes than for highly expected negative ones (a).

**Figure 2. Panel A.** Brainwave responses at a centro-parietal midline electrode channel (CPz) are shown for participants scoring high (HDP,  $N = 10$ , left) and low (LDP,  $N = 11$ , right) in the Defensive Pessimism Questionnaire. When processing each type of ending, the LDP group (right) began to show brainwave differences around the P2 peak (marked as "P2"), earlier than the HPD group (left). Subsequently, N400 responses in the two groups showed a similar triphasic pattern, although their relative amplitudes differed under some conditions, as shown in Panel B. **Panel B.** Brain responses of HDP and LDP participants are shown for highly expected (a), nonsense (b), and emotionally opposite (c) endings. The top row shows the combined ERP activity across all sentence types. The second row shows responses in negatively biased sentences; the third row, in positively biased sentences. For expected endings (a), the N400 response of HDPs (red) was always larger than that of LDPs (black), regardless of whether the sentence was biased towards a positive or a negative outcome (second and third rows). In contrast, the N400 response did not differ overall between the two groups in response to nonsense (b) or to emotionally opposite endings (c). N400 amplitude was slightly lower for LDPs than for HPDs for 'happy' endings in negatively biased sentences (indicated in the third column, third row), but this difference was only marginally significant.

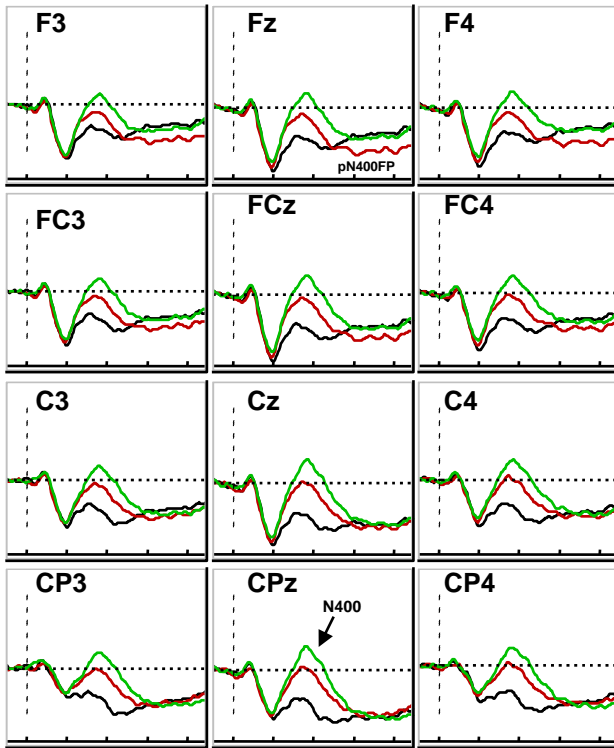
## Figure Captions (Black and White version)

**Figure 1. Panel A.** Brain activity of participants ( $N = 24$ ) at 12 electrode channels in response to expected, emotionally opposite, and nonsense endings when they were embedded in negatively (a) or positively (b) biased sentence frames. The N400 component is indicated with an arrow and labelled at a centroparietal midline electrode (CPz). The post-N400 frontal positivity (pN400FP) is labelled at a frontal midline electrode (Fz). In Figures 1 and 2, voltage (in microvolts) is displayed with negative voltage above the x-axis, and time (in milliseconds) is shown relative to the onset of the critical ending word at time 0. A three-way split depending on the type of ending can be observed in the amplitude of the N400 response. The N400 was smallest for highly expected endings (black), slightly larger for emotionally opposite endings (dark gray) and largest for nonsense endings (light gray). In contrast, the pN400FP was larger for emotionally opposite endings (dark gray) and similar for expected (black) and nonsense (light gray) endings. **Panel B.** Brain activity at the CPz electrode is shown in response to highly expected (a), nonsense (b) and emotionally opposite (c) endings as a function of whether they were embedded in negatively (gray) or positively (black) biased sentence frames. The N400 was similar for nonsense (b) and emotionally opposite (c) endings regardless of emotional frame. In contrast, the amplitude of the N400 ERP component was larger and more sustained for highly expected positive outcomes than for highly expected negative ones (a).

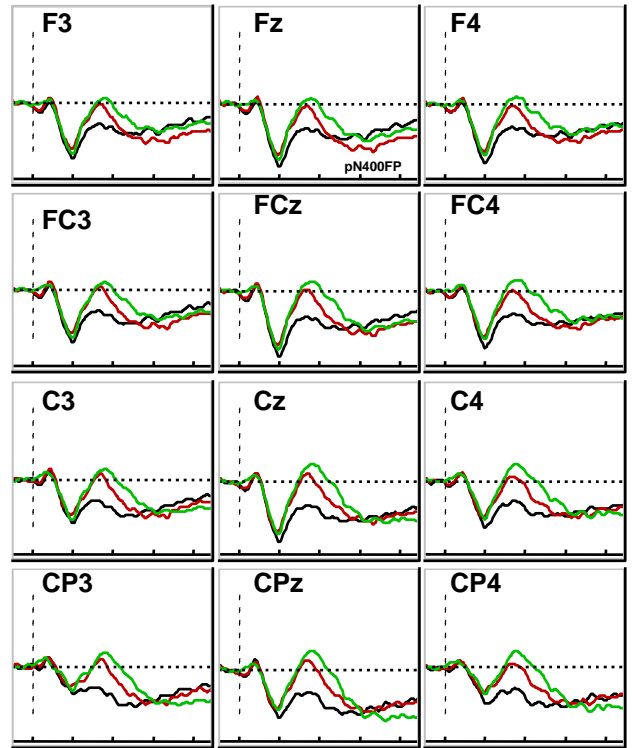
**Figure 2. Panel A.** Brainwave responses at a centro-parietal midline electrode channel (CPz) are shown for participants scoring high (HDP,  $N = 10$ , left) and low (LDP,  $N = 11$ , right) in the Defensive Pessimism Questionnaire. When processing each type of ending, the LDP group (right) began to show brainwave differences around the P2 peak (marked as "P2"), earlier than the HPD group (left). Subsequently, N400 responses in the two groups showed a similar triphasic pattern, although their relative amplitudes differed under some conditions, as shown in Panel B. **Panel B.** Brain responses of HDP and LDP participants are shown for highly expected (a), nonsense (b), and emotionally opposite (c) endings. The top row shows the combined ERP activity across all sentence types. The second row shows responses in negatively biased sentences; the third row, in positively biased sentences. For expected endings (a), the N400 response of HDPs (black) was always larger than that of LDPs (gray), regardless of whether the sentence was biased towards a positive or a negative outcome (second and third rows). In contrast, the N400 response did not differ overall between the two groups in response to nonsense (b) or to emotionally opposite endings (c). N400 amplitude was slightly lower for LDPs than for HPDs for 'happy' endings in negatively biased sentences (indicated in the third column, third row), but this difference was only marginally significant.

A

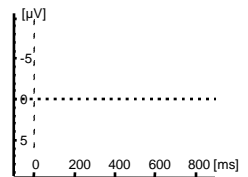
a Negatively Biased



b Positively Biased

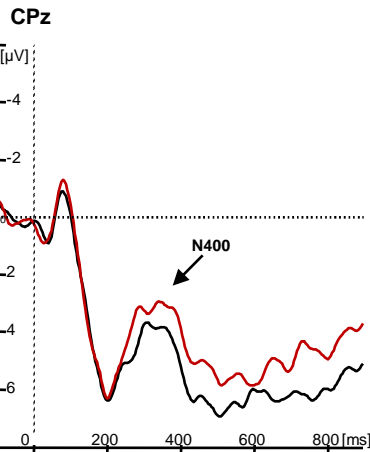


— Nonsense  
— Emotionally Opposite  
— Highly Expected

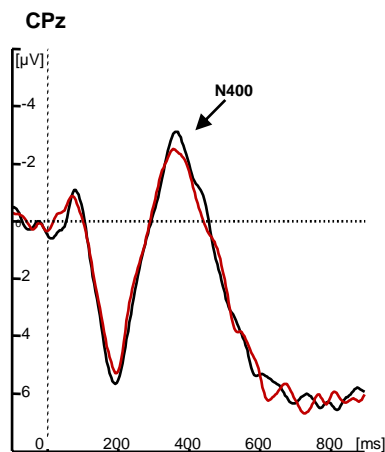


B

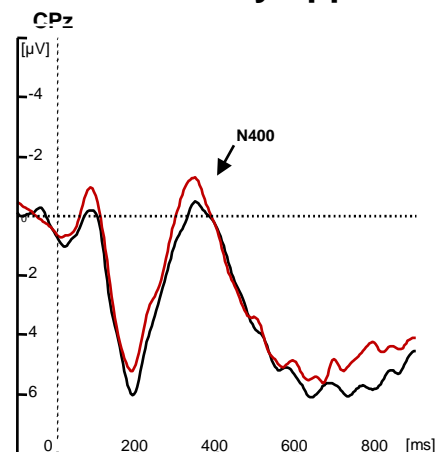
a Highly expected



b Nonsense



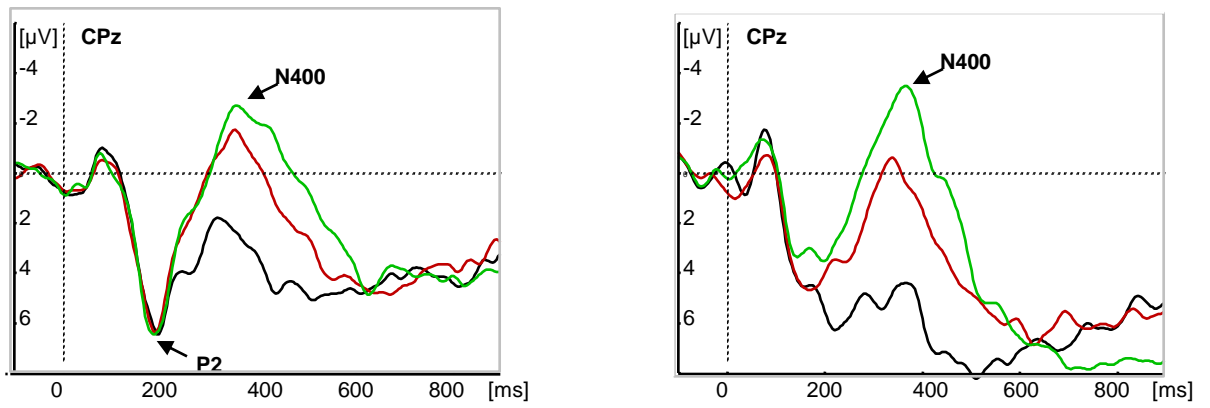
c Emotionally opposite



— Positively Biased Sentences  
— Negatively Biased Sentences

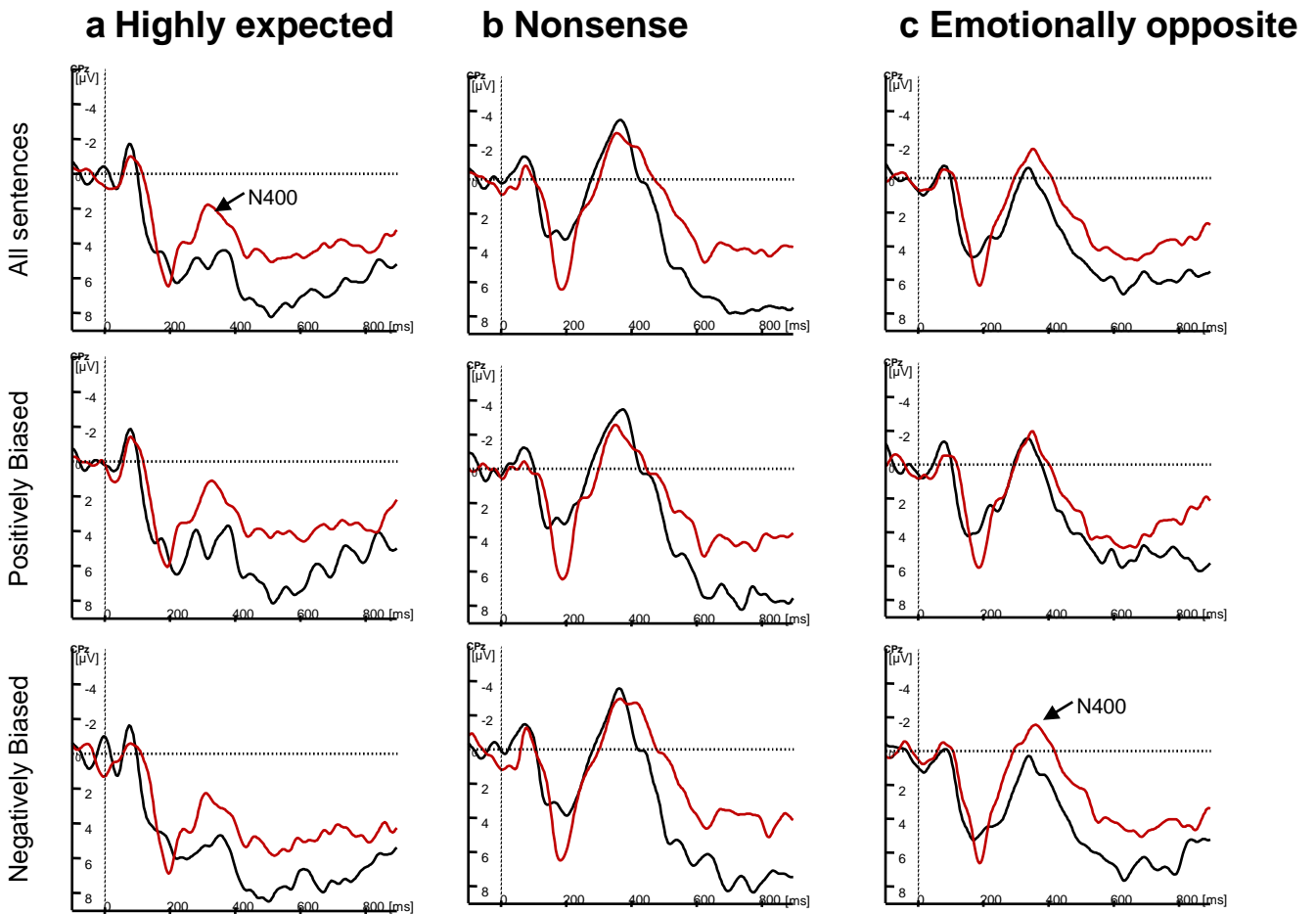
Figure 1

**A** High Defensive Pessimists (HDPs)      Low Defensive Pessimists (LDPs)



— Nonsense  
— Emotionally Opposite  
— Highly Expected

**B**

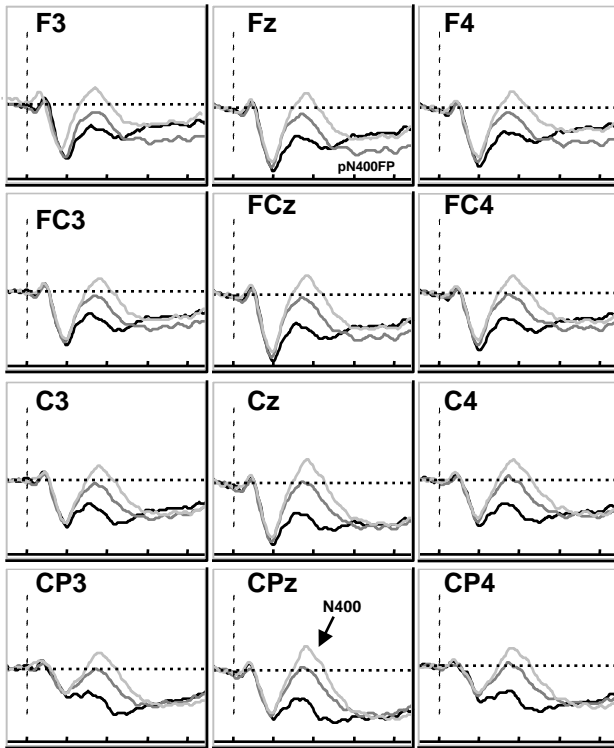


— High Defensive Pessimists (N=10)  
— Low Defensive Pessimists (N=11)

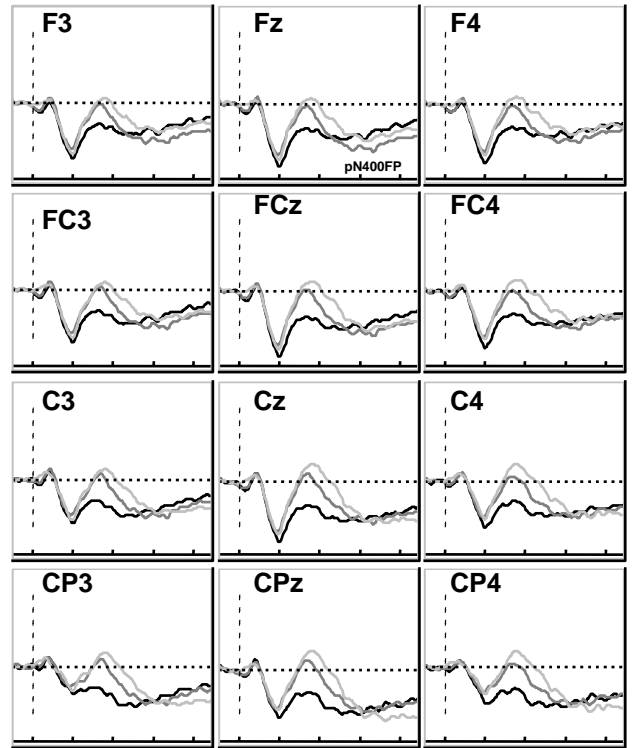
**Figure 2**

A

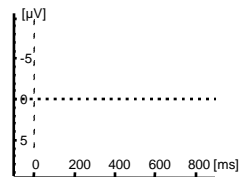
a Negatively Biased



b Positively Biased



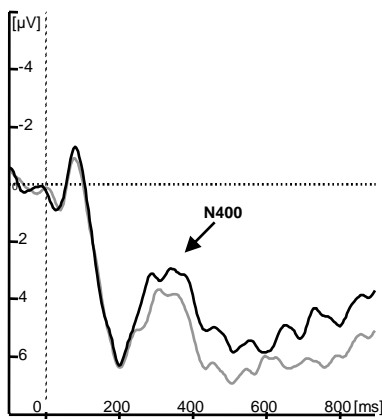
— Nonsense  
 — Emotionally Opposite  
 — Highly Expected



B

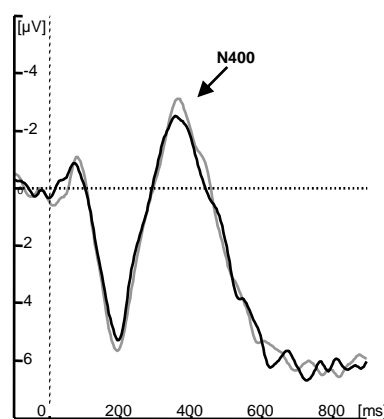
a Highly expected

CPz



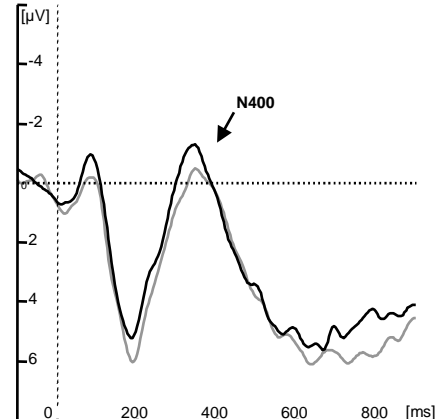
b Nonsense

CPz



c Emotionally opposite

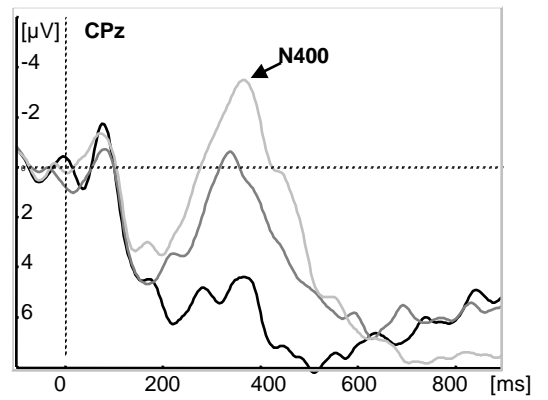
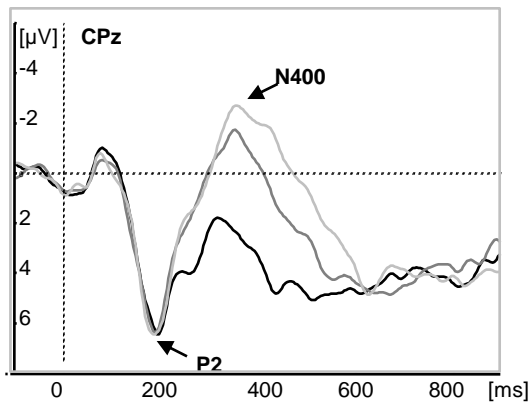
CPz



— Positively Biased Sentences  
 — Negatively Biased Sentences

Figure 1

**A** High Defensive Pessimists (HDPs)      Low Defensive Pessimists (LDPs)



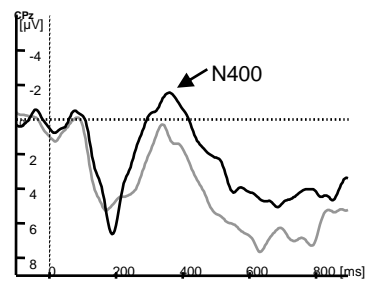
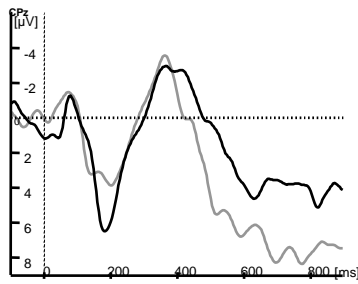
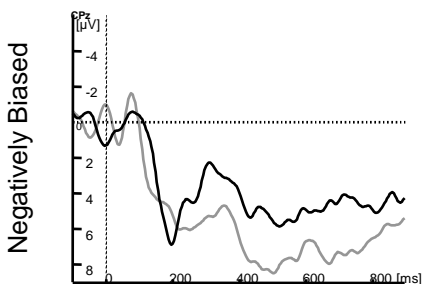
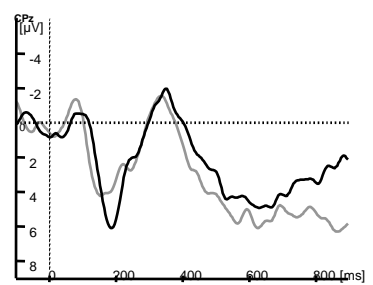
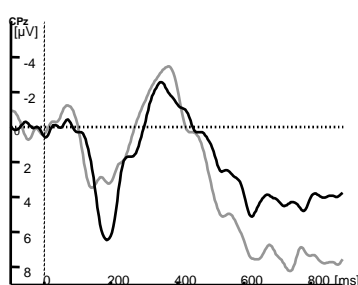
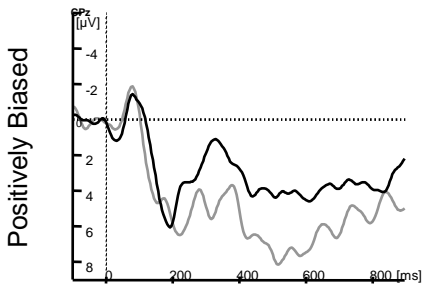
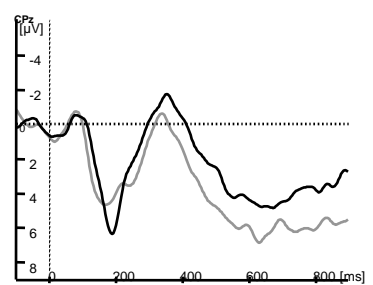
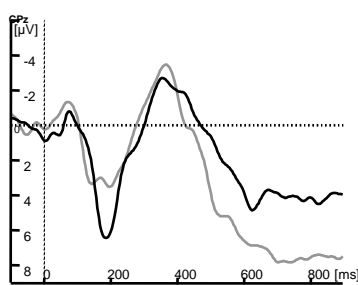
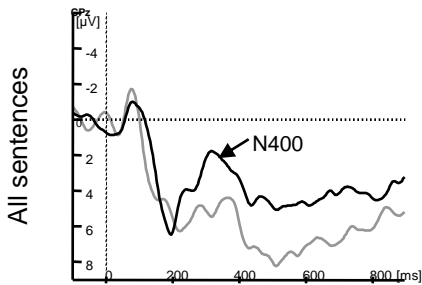
**B**

— Nonsense  
 - - - Emotionally Opposite  
 — Highly Expected

**a Highly expected**

**b Nonsense**

**c Emotionally opposite**



— High Defensive Pessimists (N=10)  
 - - - Low Defensive Pessimists (N=11)

**Figure 2**

Research Highlights:

- High cloze words elicit larger N400s in positive than negative emotional contexts
- Emotionally opposite words elicit post-N400 effects regardless of emotional bias
- Defensive Pessimists show large N400 responses to expected endings
- Strength of expectations alters in time-constrained affective scenarios
- Human language processing favors pleasant surprises minimizing emotional setbacks