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Affect Semantic Processing

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COGNITIVE BIASES IN DEPRESSION AFFECT SEMANTIC PROCESSING

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Abstract

Prior research has shown that depressed people have a cognitive bias for emotionally negative information. The present study investigates this phenomenon by comparing depressives to control subjects in a semantic processing paradigm involving emotional stimuli. The N400 component of the event-related brain potential was employed as a measure of semantic processing. As hypothesized, depressives' N400 differentiated positive and negative sentence endings. This effect was much smaller in controls. This physiological evidence that depressed patients process emotional sentences differently depending on the emotional valence supports the claim based on behavioral performance that depressives have a bias towards negative information.

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There is increasing evidence that language processing is sensitive to an individual's mood state: depressed patients have a strong bias for the perception and recall of negative information (for review see Blaney, 1986; Bower, 1981; Clark & Teasdale, 1982; Denny & Hunt, 1992; Teasdale & Russell, 1983). Both psychological and biological components of depression may play a role in this negative bias.

This negative bias is seen in a variety of situations and is strongest for self-referential information (Bower, Gilligan, & Monteiro, 1981; MacLeod & Mathews, 1991; Mathews & Bradley, 1983; Williams, Watts, MacLeod, & Mathews, 1988). For example, Teasdale and Fogarty (1979) used a mood induction procedure to put subjects in a happy or sad mood. They found that sad subjects retrieved sad memories faster than happy ones. The bias occurs both when the negative material is autobiographical and when it is experimentally controlled. Furthermore, this memory bias occurs with laboratory mood induction as well as in clinical depression and seems to remit following recovery from depression (Beck, 1976; MacLeod & Mathews, 1991). Lewinsohn, Steinmety, Larson, and

Franklin (1981) asserted after evaluation of a large sample of normal subjects that these negative attributions about the self and life events followed, rather than preceded, the depressed emotional state. Subjects who became depressed showed a negative bias in cognition, but this bias was not observed in their cognitive assessment prior to the onset of depression.

Depressed subjects have also been found to have memory deficits as measured by recall tasks (for review see Ellis & Ashbrook, 1987). There is evidence that memory impairment is related directly to depressed mood, rather than representing a stable trait in individuals prone to depressive disorders. First, similar deficits can be produced in typically nondepressed subjects by inducing a depressed mood (Ellis, Thomas, & Rodriguez, 1984). Second, the degree of memory impairment is often found to be correlated with the level of depressed mood across a patient population (Beck, 1976; Pettineti & Rosenberg, 1984; Weingartner, Miller, & Murphy, 1977). These studies provide evidence that memory bias is directly associated with depression such that as the depression increases, memory bias strengthens.

Bradley and Mathews (1983) compared recall of clinically depressed subjects and non-psychotic controls. They found that the depressed subjects recalled more negative than positive self-referential adjectives. This finding of a negative bias for self-referential information has been found in other studies as well (Bower & Gilligan, 1979; Roger, Kuiper, & Kirker, 1977). Similar work has found not only a bias for self-referential information but for statements about a friend or acquaintance (Kuiper & Rogers, 1979).

Theories about the Negative Processing Bias in Depression

Two theories have at their center the hypothesis that depressed subjects show processing advantages for material that shares the same emotional valence as their affective condition (depression). Beck (1976; Beck, Rush, Shaw, & Emery, 1979) made his proposal in order to accommodate thinking patterns reported by patients, while Bower (1981, 1987) based his model on laboratory mood inductions in nonpatients. Although the methodology is quite different in these two literatures, they have strikingly similar results.

Beck's cognitive theory proposes that a system

"filters" environmental information through pre-existing memory representations known as schemata, which in turn imposes their own structure on this new information. These schemata are stored knowledge that interact with encoding, comprehension, and/or retrieval of new information within their domain, by guiding attention, interpretation, and memory searches. Existing schemata will be used to process novel stimuli by guiding the intake of information, imposing structure, resolving ambiguities, and providing additional information. Ultimately, how this new information is stored in memory will be heavily influenced by the active schemata used during encoding. Beck suggests that individuals with mood disorders (depression) are characterized by distorted schemata that lead to processing biases. Thus, depressed patients easily pay more attention to negative affective information, leading them also to expect it more readily.

Beck (1976; Beck, Rush, Shaw, & Emery, 1979) assert that there are three critical concepts that explain the psychological substrates of depression. The first of these is that there is a "cognitive

triad", including negative views of the self, negative interpretations of ongoing experiences, and negative views about the future. The second and third concepts are apperception and cognitive errors, which reinforce the negative views of the triad. These three concepts prompt the person to misinterpret information incompatible with their negative beliefs, and thus, increase the number of negative thoughts.

Bower's cognitive model provides an alternative account, using standard notions within cognitive psychology, including a network structure and priming mechanisms (Bower, 1981; Gilligan & Bower, 1984). His model is one of interrelated nodes which contain information regarding specific semantic concepts or elements of events. The related nodes share associative connections. In order to retrieve needed information, nodes containing the relevant memories need to be activated beyond a critical threshold. This activation will cause spreading through the associative connections to partially activate nodes. These nodes are now "primed" and will be more readily available because they are partial activated.

Bower has extended this basic concept of nodes and

priming to mood states within the network by connecting "emotional nodes". He claims that the emotional node is activated when the subject enters a particular mood state. He further believes that nodes containing information causally related to the occurrence of any particular mood state will develop associative links with the corresponding emotion node. Therefore, nodes related to negatively valenced concepts and events will develop connections in associative memory with the "depression" node. In general, any mood state will share associative ties with those nodes in memory space that contain mood-congruent information. In this theory, just entering a particular mood state will activate the corresponding emotion node in memory space. This theory of depression related to mood-congruent material is well supported (MacLeod & Mathews, 1991; Mineka & Sutton, 1992; Lewinsohn et al., 1981; Williams et al., 1988).

Bower further identifies three categories of this processing bias. First, mood should influence relative ability to retrieve emotionally valenced information from memory, with mood-congruent information being more accessible. Second, it should influence how readily

emotional stimuli are perceived and, therefore, the degree to which stimuli capture attention. A stimulus that is emotionally consistent with current mood should have a reduced threshold, and thus, a correspondingly increased ability to recruit selective attention. Third, comprehension processes, which involve imposing meaning on complex or ambiguous information, should also be biased by emotional state with mood-consistent interpretations being favored over alternatives inconsistent with affective states.

According to both theories of depression, an individual's affective state should be associated with pervasive biases, favoring emotionally congruent information throughout processing. Cognitive models of psychopathology are based on the assumption that individuals respond emotionally, not directly to external events, but to their internal representation of such events (MacLeod & Mathews, 1991). This leads to the possibility that mood-congruent information processing biases may play a functional role in the development and maintenance of emotional disorders, particularly depression.

Biological Manifestations of Biased Expectations in

Semantic Processing

More recent studies have used biological measures to investigate psychological phenomena. Event-related brain potentials (ERPs) are regarded as manifestations of brain activity that occur in preparation for, or in response to, discrete events, whether internal or external to the subject (Coles, Gratton, & Fabiani, 1990). These ERPs allow researchers to study ongoing cognitive processes that may not be directly observable with behavioral measures (Coles, 1989; Donchin, 1981; Fischler, Bloom, Childers, Roucos, & Perry, 1983). Distinct ERP waveforms have been associated with a variety of cognitive states and processes.

The N400 is a negative peak in the ERP which begins approximately 250 milliseconds (ms) after the onset of a stimulus and peaks roughly 400 ms after stimulus onset (Kutas & Hillyard, 1980a). It was first described by Kutas and Hillyard (1980a) when they recorded ERPs in a sentence-reading task where 25 percent of the sentences ended with a semantically incongruous (but syntactically correct) word (e.g., "He took a sip from the transmitter"). The incongruous words elicited an N400 component that was larger than

the one elicited by congruous words. Incongruous words that were semantically related to a proper word elicited an N400, but it was smaller than the N400 elicited by incongruous, unrelated words (e.g., "He took a sip from the waterfall"). This finding has been highly replicable (e.g., Curran, Tucker, Kutas, & Posner, submitted; Kutas, Lindamood, & Hillyard 1984; Kutas & Hillyard 1980b).

The N400 has been found to be rather robust when looking at words that are anomalous given the preceding text of a sentence. It has also been found when looking at expectancies of the subjects (Kutas & Hillyard, 1984; Kutas, Lindamood, & Hillyard 1984). These studies used Taylor's (1953) "cloze" probability as the measure of the degree to which a word was expected. In this procedure, subjects are presented passages of one or more sentences from which words have been omitted and the subjects' task is to fill in the words that seem most appropriate for the context. The more constraining the context is, the fewer possible words could fit into it. The frequency with which a particular word is filled in by subjects is defined as the word's cloze probability in that context. Kutas

and colleagues found the amplitude of the N400 to be inversely related to the subjects expectancy of the terminal word.

In a related experiment, Fischler, Childers, Achariyapaopan, and Perry (1985) also found an expectancy effect. Fischler and colleagues had subjects learn occupations of particular people. They were then asked to indicate whether sentences were true or false, based on these previous learned statements. These semantically congruent but false statements were associated with larger negativities than true statements. They attributed this larger negativity to the subject's expectancies. Since they learned "John/ is a / dentist", not "John/ is a / plumber", the second sentence proves unexpected; therefore, it elicited a large N400. This has been found in other studies examining true/false sentence (Boaz, Perry, Raney, Fischler, & Shuman, 1991; Fischler et al., 1983). In general, the N400 has been found to be elicited specifically to violations of the semantic expectancies of the subject.

Also influencing the amplitude of the N400 are word frequency and semantic priming (Holcomb, 1985;

Kutas & Hillyard, 1984; Kutas, Hillyard, & Gazzaniga, 1988; Van Petten & Kutas, 1990). The ability to recall previously learned information is an important feature of comprehension; people rely on prior knowledge to understand present context. The usefulness of recalled information is partially dependent on the swiftness with which it is remembered, which often depends on the type of information needed. According to Van Petten and Kutas (1990), the frequency of a word's occurrence in common usage and the relationship of a word to prior context (semantic priming) have proven to be two of the most powerful determinants of performance in recognition tasks. Semantic priming refers to the process wnere the response to a word is facilitated (quicker) when it follows either a related word (e.g., CAT-DOG) or it is highly expected (constrained) within a familiar sentence context (e.g., "He takes his coffee with cream and SUGAR"), compared to a word following either an unrelated word (i.e CAT-CAR) or a misleading sentences context (e.g., "Every Sunday morning people pray in their local SUGAR") (Kutas, 1985). Van Petten and Kutas also found that less frequent words are associated with larger N400s, but that this holds true

only for the words occurring early in the sentence. Frequency of a word had been related to the subject's expectancy. If a word is common, it more likely is expected which can cause a diminish ERP.

Kutas and Hillyard (1984) found that N400 amplitude to semantic anomalies is reduced if the word is semantically related to the expected completion, which can be interpreted as a priming effect on the last word. Fischler et al. (1983) also showed a priming effect when false statements with a high degree of semantic relation showed smaller ERPs than did true statements with words that were unrelated (e.g., "A robin is not a bird" prompted a smaller N400 than did "A robin is not a truck"). This gives evidence that priming reduces N400 amplitude.

The N400 seems most sensitive to congruence between the word and the expectation of the subject. Fischler, Bloom, Childers, Achariyapaopan, and Perry (1984) found a bias for self-referential statements in an ERP study. They recorded ERPs (N400) to true and false self-referential statements. Statements were either categorized as strong (e.g., "My name is...") or weak (e.g., "My shoe size is..."). Both strong and

weak false sentences elicited an N400, but the N400 was significantly larger for the strong, rather that the weak, false statements. This finding supports the belief that the more relevant the information is to the subject the larger the effect on the ERP.

A more recent study was aimed at examining semantic processing and expectancy of subjects with an induced mood (Chung, Tucker, West, Potts, & Liotti, submitted). An optimistic or pessimistic mood was induced, and subjects were then read stories in which the last word was either positive, negative, or incongruent with their mood. Chung et al. found that the semantic expectancy was biased by the subjects' mood state; pessimistic subjects had larger N400s to the unexpected positive ending than did optimistic subjects. This gives some support to the proposal of mood-congruent biases in depression.

The Experimental Problem

As reviewed above, there is very considerable evidence of (a) a negative processing bias in depression and (b) an enhancement of N400 for unexpected relative to expected sentence endings. The recent Chung et al. study was the first to bring

together these two literatures, using induced moods in nonpatients.

The present study attempted to test the same general hypothesis using diagnosed psychiatric inpatients and self-referential, valenced sentence endings. The N400s of depressives and controls were compared while reading sentences which ended in one of three categories of mood-congruent and mood-incongruent words - positive, neutral, and negative. Given depressives' processing bias, it was hypothesized that depressives would produce larger N400s to positive than to negative words, with neutral words intermediate. There was no reason to anticipate such a difference for controls. Thus, a second hypothesis was that the word valence effect on N400 would be confined to depressives. Finally, it was hypothesized that in a separate condition involving standard N400-eliciting sentences which did not employ self-referential valence words both depressives and controls would show the standard N400 enhancement to incongruous endings.

Method

Subjects

Four depressed inpatients, ages 18-65, were recruited on a local psychiatric inpatient unit. Subjects were diagnosed by an advanced doctoral student in clinical psychology using the Structural Clinical Interview for the DSM-III-R, patient edition (SCID-P; Spitzer, Williams, Gibbon, & First, 1990). In order to determine the endogenous/nonendogenous status of the patients, questions from the Schedule for Affective Disorders and Schizophrenia-Lifetime Edition (SADS-L; Endicott & Spitzer, 1978) were added. Four subjects consented out of six subjects invited to participate. Subjects were tested in a lab adjacent to the unit. Patients were not paid for their participation.

Nonpatient controls were recruited from the local community by newspaper ads. Controls were screened using the SCID-NP (non-patient version) as having no Axis I diagnoses and were paid $5/hour to participate. Three subjects out of seven who completed the interview were invited to participate. An attempt was made to match patient and control groups on age, gender, and education (see Table 1).

Apparatus and Physiological Recording

Subjects were seated in a comfortable chair with a room divider, curtain, and Sonex sound-absorbing material separating them from the recording equipment. They were monitored with an unobtrusive video camera, which they were informed of. A computer-controlled video screen was positioned 70 cm in front of the subject.

Stimulus presentation and physiological data processing were controlled by a PDP-11/23 based PEARL II-C microcomputer (Heffley, Foote, Mui, & Donchin, 1985). EEG recordings were amplified using a Grass Model 12 polygraph with a gain of 10K and half-amplitude frequency cutoffs of .1 and 30 Hz. A 60 Hz notch filter was also used. Signals were digitally sampled at 125 Hz for 1400 ms beginning 200 ms prior to the onset of the last word in each sentence.

The electroencephalogram (EEG) was recorded from several International 10-20 System sites (Jasper, 1958): Fz, Cz, Pz, F3, C3, P3, F4, C4, and P4, all referenced to left mastoid. EEG activity recorded from the right mastoid (A2-A1) was used subsequently to compute an average mastoid reference (Miller,

Lutzenberger, & Elbert, 1991). Beckman miniature Ag-AgCl electrodes were used for EEG recording, using Grass EC2 electrode paste. Vertical EOG was recorded from electrodes above and below the left eye. Horizontal EOG was recorded from electrodes at the outer canthus of each eye. A ground electrode was placed on the forehead. Impedances were kept below 10 Kohms.

Procedure

An initial interview screened prospective control subjects for handedness, prior brain injury, and prior psychiatric illness. Eligible subjects then participated in an individual lab tour and provided written consent prior to testing. Patients and nonpatient controls participated in the diagnostic interviews prior to testing. No subjects reported uncorrected visual problems.

At the beginning of the laboratory session, subjects were given a brief lab tour and were provided with an explanation of the study and the physiological recording procedures. After obtaining consent, subjects filled out questionnaires, including the Beck Depression Inventory (BDI; Beck, Rush, Shaw & Emery,

1979), the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970), the Edinburgh Handedness Inventory (Oldfield, 1971), and the Chimeric Face Booklet Ratings (Levy, Heller, Banich, & Burton, 1983) during electrode application.

Following electrode application and polygraph calibration, subjects completed a separate ERP protocol not reported here, were given a rest period, and then were instructed about the present task. (A copy of the instructions is in the appendix). Subjects were instructed to relax and focus on the screen in front of them. They were told that they would see words appear briefly on the screen one at a time and that the words formed sentences. They were asked to read the sentences silently and to try and identify with the sentences. They were told that they would be asked questions about the sentences at the end of the session. These questions were used to encourage the subjects to read all of the sentences presented to them.

Thirty different self-referential sentence stems were constructed. Each stem was used three times completed with a positive, negative and neutral

adjective ending. These were presented in a 90-trial block. In addition, a second block of 30 congruent and 30 incongruent sentences used in previous N400 studies was shown in order to evaluate the N400 amplitude capability of the subject. Interstimulus interval was 400 ms: each word appeared on the screen for 200 ms, with 200 ms of blank screen between each word. An intertrial interval of 2600 ms occurred between the offset of the last word and the onset of the next sentence.

Stimulus Development and Pilot Studies

Emotion Sentences. A stimulus list was developed in conjunction with another experimenter using these emotional adjectives in a different study. The stimulus list was developed from several studies which used emotional adjectives (Anderson, 1968; Bellezza, Greenwald, & Banaji 1986; Goldberg, 1977) and supplemented by the present experimenters. A list of approximately 470 words was divided into one of five categories according to valence and arousal: positive valence and low arousal, positive valence and high arousal, neutral valence and arousal, negative valence and low arousal, or negative valence and high arousal.

From this list, 310 words which fit criteria based on Goldberg's (1977) arousal and happiness scale and/or were chosen by two of three independent raters as fairly good descriptors of each category were chosen to be rated during a mass testing of 146 undergraduate students. Students rated each word on five-point scales of happy/sad, arousing/calm, and dominant/passive. Words were then chosen which were suitably matched on these ratings as well as on length and frequency of the word across each condition (positive, negative, and neutral) (see Table 2). One-way ANOVAs and Newman-Keuls analyses were conducted for valence, arousal, length, and frequency of the words. Valence ratings for types of words (positive, neutral, and negative) were found to be significantly different, $F(4,85)=346.58$, $p<.001$. Experimenters tried to select words with three distinct levels of arousal ratings (high arousal, neutral arousal, and low arousal) but were not highly successful. The decision was made to maximize the valence dimension at the expense of perfectly matching the arousal ratings. For this reason, three different levels of arousal were not developed, rather two levels were developed (high and

low arousal). High and low arousal types were statistically different, $F(4,85)=152.28$, $p<.001$. The high arousal type was also different from the neutral, but the low arousal condition was not significantly different from the neutral arousal type. The means for the positive valence and low arousal, for negative valence and low arousal, and for neutral valence and arousal were 17.46, 16.133, and 15.36 respectively. Length and frequency of the words were equal across stimulus type. Mean lengths of the final words chosen (for the five different word types) varied between 6.7 to 8.7 letters, and were not statistically significant, $F(4,85)=1.66$, $p<.17$. Because of the variability in frequency between the positive and negative words (some positive words had much higher frequency), words with zero frequency and a frequency over 100 were not chosen for this study. Although the words had a rather wide range of frequencies, from 1 to 64 occurrences per one million written English words (Francis & Kucera, 1982), the means were not statistically different, $F(4,85)=.14$, $p<.97$. In the final set of words, there were 30 positive valence words (15 high and 15 low arousal), 30 negative valence words (15 high and 15 low

arousal), 30 negative valence words (15 high and 15 low arousal), and 30 of neutral valence (all low arousal).

The emotion sentences were chosen because of their state rather than trait quality and for their unconstrained (low cloze probability) nature. Final words (see Table 3) were originally randomly chosen. In order to avoid obtaining an N400 to an anomalous sentence ending, rather than to violation of emotional expectancy, sentences that did not make sense were altered so that all sentence endings would be congruent. Order of sentence type was random within the constraints that (a) no more than four of the same valence endings occurred in a run and (b) 10 of each type occurred within each 30 trials.

Standard Sentences. A second block of sentences was a replication of traditional N400 paradigms, using non-emotional sentences with congruent and incongruent sentence endings. There were 30 congruent and 30 incongruent sentences. Sentences were obtained from Kutas from previous N400 studies. Order of sentences type was random within the constraints that no more than four of the same sentence type occurred in a run. All sentences were between 6-8 words in length. All of

the final sentences are provided in Table 4.

Data Reduction

Sentence type was categorized according to the word which ended the sentence: positive, neutral, or negative valence, or congruent or incongruent meaning. Average ERP waveforms were computed for each word type and for each group (depressives or controls). For depressives, 4 subjects' data contributed to the waveforms for the emotion sentences. Data for one of the 4 were not available for the congruent/incongruent condition because he declined to continue the experiment. Average waveforms for controls had 3 subjects in each condition. Because of time constraints, the proposed eye movement correction procedure was not run on these data. Instead, trials were discarded if vertical eye movement during the 200 ms period prestimulus to 800 ms poststimulus was greater than a range of 200 uvolts or if the waveform for Pz or VEM channels contained an off-scale value. Table 5 presents the number of trials included in each average waveform.

Results for the Pz site will be discussed here. Of midline sites, P300 tends to be maximal at Pz, and

N400 tends to be maximal at Cz or Pz. Reported findings are based on a visual inspection of the group-average waveforms following application of a 51 weight, 0-7 Hz digital filter (Cook, 1981; Cook & Miller, 1992). Scoring of components in individual subject waveforms was not undertaken, given the small number of subjects. Questionnaire and performance data have also not yet been analyzed.

Results

Replication Block

Figure 1 illustrates that a clear N400 was obtained for controls in the replication block. The N400 peaked right at 400 ms. As expected, N400 was more negative for the incongruent sentence condition (about 2 uvolts) than for congruent sentences (about 5 uvolts). Controls also exhibited a fairly large P200 wave for both the congruent and incongruent conditions, 7 uvolts and 5 uvolts, respectively.

This pattern of a larger N400 to the incongruent sentences was not observed for the depressed subjects. As seen in Figure 2, no clear N400 was apparent for either the congruent or incongruent sentences. What was noticeable was that there was a difference in the two waveforms around the latency of the expected N400: the incongruent wave was more negative than the congruent sentence wave. It is also striking that depressives had a much smaller P200 wave for both the congruent and incongruent conditions, about 3.5 uvolts and 2 uvolts, respectively.

Thus, in the N400 replication block, using classic stimuli provided by Kutas, controls showed the typical

N400 effect for incongruence, indicating a basically sound experimental procedure. However, depressives showed little, if any, N400 and only indirect evidence of an N400 incongruence effect. Given our reliance on ERP superaverages, the lack of an N400 might result if depressives have greater latency jitter in their ERPs, but thi is only a speculation. Alternatively, it may be that depressives simply lack an N400.

Emotion Block

Figure 3 shows the waveforms for the three types of emotion sentences in controls. As with the congruent/incongruent sentences, a large P200 component is noticeable. This P200 was largest for the negative (9 uvolts) and smallest for the neutral (5 uvolts) endings, while positive endings were intermediate (6.5 uvolts). Indeed, P200 was not particularly distinct for the latter two sentence types.

In contrast to the clear N400 which controls produced in the replication block, their N400 was not prominent in the emotion block. Figure 3 shows a small negative displacement around 400 ms for neutral stimuli and no clear N400 for the positive and negative stimuli. Rather than valence, ERP components were

sensitive to the arousal dimension, with more positivity throughout the trial for positive and negative stimuli than for neutral.

The emotion sentences for the depressives produced generally flatter waveforms than for the controls (see Figure 4). P200 was virtually absent, in contrast to Figure 3 for controls. The ERPs for the positive and neutral sentences both showed what might be seen as a small N400 at about 500 ms and generally were indistinguishable. The negative sentences, on the other hand, produced no apparent N400 but what could be interpreted as a late P300 at approximately 600 ms.

Thus, in the emotion block, controls showed almost no N400, except for a small negative peak about 400 ms for the neutral stimuli. In contrast, the depressives showed a possible small N400 to both the positive and neutral sentences and a possible late P300 to the negative words. As in the replication block, controls produced a very prominent P200, compared to depressives' essentially absent P200.

Discussion

Results for control subjects in the present study achieved a partial replication of traditional N400 studies with unselected subjects. Findings also suggested that depression is associated with differentiated processing of emotionally valenced sentences.

Replication Block

The congruent/incongruent block for the controls replicated the robust finding in the literature of N400 enhancement for anomalous sentences. Although depressives did not produce a clear N400 to the incongruent sentences, it is important to note that differential processing did occur. The waveforms for congruent and incongruent sentences were similar until approximately 175 msec after stimulus onset. Then, the incongruent condition remained more negative through the anticipated N400 period (300 - 600 ms) until approximately 550 msec, when it again became very similar to the congruent condition. Nevertheless, it is unclear why the depressives would fail to show a clear N400 component waveshape in the replication block.

Also surprising is the considerable difference in the P200 wave between the two groups in all sentence types. Little is known about the P200. It is often associated with the N100 as the N1-P2 complex and usually thought to be associated with attention and perception (Hillyard, 1984; Sandman & Walker, 1985). Miller and Yee (1988) found the P200 to be sensitive to subjects' fear level and valence of the attended stimuli. The N1-P2 complex is elicited by a wide range of stimuli, and the psychological significance and specificity of P200 has yet to be determined. There is not enough data to support a specific psychological link to the P200. Regardless of exactly what mechanism the P200 reflects, it is interesting that such a substantial difference occurred between the amplitude of controls' and depressives' P200.

Emotion Block

Interpretation of the waveforms is more ambiguous for the emotion sentences than for the congruent/incongruent sentences. Once again, the controls showed a large P200 for all three sentence types. Although the positivity was largest and clearest for the negative sentence endings for

controls, it was largest for the positive sentences for depressives.

Overall, the positive and neutral sentences had very similar waveforms (in both amplitude and latency) for depressives. The negative sentence type, on the other hand, had a different waveform, which suggests that it was being processed differently than the other two sentence types.

The positive and neutral sentence endings elicited a small N400. We had hypothesized that for depressives the negativity would be greatest for the positive sentences and smallest for the negative sentences. Results support this, although the neutral endings elicited as large an N400 as the positive endings. This could have been because creating neutral sentences was difficult, and many of them were somewhat awkward or unlikely. For example, "During this last month I felt neutral". This is a grammatically correct but rather awkward sentence that one is unlikely to use in describing their emotional state. It is possible that the relatively incongruent nature of the sentence elicited an N400, independent of its emotional valence.

It was hypothesized that the N400 would not occur

in response to the negative sentence ending for depressives because it is congruent with their mood state. Results for this small group of subjects confirmed that the negative sentence endings did not produce an N400. This would suggest that the negative information was expected by the depressives.

Negative sentence endings for depressed subjects did produce an apparent P300. P300 has been linked to memory updating, stimulus evaluation and categorization, task relevance, and the subjective rather than objective probability of events (Coles, Gratton, & Fabiani, 1990; Donchin & Coles, 1988; Johnson, 1993). P300 has also been found to have a longer latency in depressives (Henriques & Davidson, 1989).

A common paradigm used in P300 tasks is the "oddball" paradigm, where the subject hears tones and must count the infrequent tone (Donchin, 1979). The P300 is elicited when subjects hear this infrequent, task relevant tone (Duncan-Johnson & Donchin, 1977). It has also been found to be elicited to the subjective probability of a task. Johnson and Donchin (1978) presented subjects with three different tones of equal

probability of occurring (33% each). Subjects were then asked to count one of the three tones. Subjects could have performed this task in two ways. They could have approached the task as having three different tones or they could have categorize the tones into target versus nontarget groups. Subjects did in fact categorize the three tones into target and nontarget tones. The P300s elicited by the target or infrequent (33%) tone had a greater amplitude than that of the nontarget (67%) tones. This demonstrated that the amplitude of the P300 depends on the subjective probability of the category to which the stimulus is classified in rather than on the probability of the physical stimulus (actual tone). The amplitude is inversely related to the probability of the stimulus and thus, depends on the cognitive expectancy which the subject develops in relative frequency of events in the environment.

Perhaps because the positive and neutral endings elicited the same component with approximately the same amplitude, and the negative endings elicited a different component all together, the depressives categorized the positive and neutral differently than

the negative and thus processing them differently as well.

If the subjects were, as suggested above, grouping the positi and neutral sentence types together, then this becomes a traditional P300 study with frequent and infrequent stimulus categories. Accordingly, the interpretation would be that the depressives were singling out the negative items as the infrequent stimuli and processing them differently, and therefore eliciting a P300. With the bias that depressives have for negative information, it may be that the negative endings were more relevant than the mood-incongruent endings and thus are processed differently.

Taken as a whole, it appears that the controls process both the emotion and anomalous sentences differently from how the depressives process them. Furthermore, depressives do not seem to process negative stimuli as they do positive and neutral stimuli. These data show support for the view that depressives attend selectively to negative information.

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Appendix

Directions

A. We will show you a series of words one at a time on the screen. These words will make sentences. There will be a period at the end of the last word in each sentence. We want you to read the sentences silently to yourself. Try to imagine how you would complete each sentence. At the end of the block you will be asked some questions about the sentences you read. Try to keep your eyes on the screen and try not to move around or blink too much. If you need to blink try to at the beginning or middle of the sentence. Do you have any questions? Okay, I will let you know before we begin.

B. For the next block of sentences, we want you to do the same as you just did, read the sentences silently to yourself. The sentences will appear as a series of words like you just saw, only this time they will be a different type of sentences. Any questions? Okay, I will let you know before we begin.

Table I

Demographics of patients and controls

	Depressives	Controls
Ages	34, 40, 43, 46	21, 22, 43
Gender	M, F, M, F	M, F, M
Education (years)	12, *, 14, **	16, 16, 14

* dropped out of HS at 10th or 11th grade
** currently working on master's degree

Table 2

Means and Standard deviations of the 3 Word Types

Word Category	Valence	Arousal	Length	Frequency
Positive Valence, Low Arousal	1.88 (.12)	3.36 (.37)	8.40 (2.32)	17.47 (12.21)
Positive Valence, High Arousal	1.70 (.19)	1.84 (.24)	8.73 (2.09)	14.33 (12.79)
Neutral Valence, Neutral Arousal	2.96 (.37)	3.26 (.16)	8.03 (2.17)	15.37 (17.97)
Negative Valence, Low Arousal	4.19 (.18)	3.34 (.37)	6.69 (2.30)	16.13 (11.38)
Negative Valence, High Arousal	4.20 (.14)	1.98 (.15)	8.07 (1.58)	14.07 (12.02)

Note. Standard deviations are in parentheses.

Valence scale 1=very positive
5=very negative

Arousal scale 1=very aroused
5=very calm

Table 3

List of Emotional Adjectives used in physiology study

positive valence, low arousal	**Neutral**	**negative valence, low arousal**
	acceptable	
carefree	amiable	bored
comfortable	average	defeated
considerate	centered	depressed
dependable	commonplace	desolate
harmonious	decent	drained
peaceful	even	dreary
pleasant	everyday	dull
pleased	impartial	gloomy
reliable	impassive	helpless
satisfied	indifferent	hopeless
secure	listless	inadequate
sincere	mediocre	lonely
understanding	medium	pessimistic
valued	neutral	sad
wise	objective	weak
	ok	
positive valence, high arousal	passable	**negative valence, high arousal**
	poised	
	presentable	
	rational	
adventurous	routine	angry
affectionate	so-so	annoyed
animated	temperate	desperate
courageous	tolerable	distressed
creative	typical	disturbed
ecstatic	unadorned	frightened
enthusiastic	unchanging	furious
excited	uniform	horrified
lively	unremarkable	hostile
magnificent		irritable
outgoing		obnoxious
spirited		ruthless
splendid		tense
vivacious		tormented
witty		troubled

Table 4

Final sentences used for block 1 (emotion sentences)

Today I can be described as satisfied.
Lately when I finish something I feel ok.
I feel as though I am tolerable.
Presently I have a tendency to feel tormented.
Today my mood tends to be understanding.
Recently I seem to have become affectionate.
Tomorrow I would like to feel indifferent.
Recently my thoughts tend to be animated.
Lately I have felt completely rational.
During this last month I felt ruthless.
Yesterday I seemed to feel lonely.
Now I think others see me as mediocre.
My family now sees me as being unadorned.
Today I think I am irritable.
My thoughts and ideas are adventurous.
I think my future will be passable.
Lately I have often felt centered.
On days like today I feel horrified.
At midday I tend to feel poised.
Tomorrow I probably will feel drained.
Lately with others I tend to be objective.
My friends might say I am pleased.
As I ate today I felt hostile.
I woke up today and felt peaceful.
These days I feel my life is reliable.
Yesterday when I woke up I felt troubled.
Lately with my friends I seem comfortable.
This past week I have been depressed.
I think my life is valued.
This afternoon I am feeling desperate.
Lately I have often felt pleasant.
Tomorrow I probably will be presentable.
Today I think I am amiable.
Lately with others I tend to be creative.
Now I think others see me as harmonious.
Lately I have felt completely carefree.
My friends might say I am sad.
I think my life is inadequate.
As I ate today I felt average.
I feel as though I am vivacious.
Presently I have a tendency to feel listless.
On days like today I feel decent.

Recently my thoughts tend to be distressed.
My family now sees me as being wise.
Yesterday when I woke up I felt medium.
At midday I tend to feel outgoing.
This afternoon I am feeling acceptable.
During this last month I felt neutral.
Tomorrow I would like to feel excited.
Yesterday I seemed to feel impartial.
Recently I seem to have become obnoxious.
Lately with my friends I seem helpless.
I woke up today and felt bored.
Today I can be described as dull.
I think my future will be secure.
This past week I have been uniform.
These days I feel my life is hopeless.
Lately when I finish something I feel enthusiastic.
Today my mood tends to be pessimistic.
My thoughts and ideas are angry.
Today I can be described as unchanging.
This afternoon I am feeling magnificent.
Lately if I see my friends I seem routine.
I feel as though I am frightened.
Recently my thoughts tend to be unremarkable.
Now I think others see me as desolate.
Yesterday I seemed to feel dependable.
Today I think I am lively.
Lately I have felt completely defeated.
As I ate today I felt splendid.
Yesterday when I woke up I felt courageous.
This past week I have been considerate.
Recently I seem to have become impassive.
My family now sees me as being weak.
Tomorrow I would like to feel tense.
During this last month I felt ecstatic.
My thoughts and ideas are everyday.
These days I feel my life is commonplace.
Lately with others I tend to be disturbed.
I think my life is typical.
On days like today I feel spirited.
Lately when I finish something I feel annoyed.
My friends might say I am temperate.
I think my future will be gloomy.
Presently I have a tendency to feel witty.
At midday I tend to feel furious.
Tomorrow I probably will feel sincere.

Today my mood tends to be even.
Lately I have often felt dreary.
I woke up today and felt so-so.

Congruent sentences used in block 2:

Dick waited and read a book.
Joe had to fill his truck with gas.
The child learned to count to ten.
Mary's vest was made of very fine silk.
Fred put the worm on a hook.
Lois is taller than most girls.
Kelly rested under a tree in the shade.
Mickey ordered a salad and a sirloin steak.
The Smiths had never visited that place.
Ron wondered if the storm would be over.
Peter won the cross country race.
The florist sent a single red rose.
The cigar burned a hole in the couch.
Sharon liked to sleep under the stars.
Suzy liked to play with her toy dolls.
Jeff was sent to bed without dinner.
Rob disliked having to commute to the city.
The mail should get here soon.
The child soared even higher on the swing.
Starting a business demands a lot of money.
It was clear that his thumb was broken.
You can't take the test without a pencil.
The rabbit hid in the tall grass.
The grocer surveyed his stock before going home.
Kathrine was stung by a bee.
We used to get company every night.
Betsy couldn't tell what she was doing.
Terry wiped the bowls with a towel.
My aunt adores reading the daily paper.
The little girl was afraid of the dark.

Incongruent sentences used in block 2:

Too many men are out of dusk.
The pill contained a powerful group.
One of the scouts got area.
Surgery was needed to repair his failing agree.
At night they often took a short spend.
Harriet sang while my brother played the clothes.
The earth is shaped like a develop.
Paul has always wanted to be a chain.
The actor was praised for being very teach.
Seals can swim better than they can nameless.
The pamphlet was missing its listen.
Dan caught the ball with his catsup.
My father and mother are getting eventually.
The kids were given hamburgers for maid.
Helen liked to season her food with mature.
Getting the shot didn't really valve.
In the park the hippie touched the calorie.
The sun turned his hair seafood.
Plants will not grow in dry rode.
Some of the ashes dropped on the find.
When the shooting started they ran for lady.
Before jogging it's a good idea to subtract.
David frowned and sat down at the untie.
Scott licked the bottom of the studio.
Most students prefer to work during the knocked.
The ache she felt was all in her practice.
Sally took short trips during the client.
Motorcycles can emit a lot of sentence.
Matt was wild when he was steal.
A future energy source is the caller.

Table 5

Number of trials per waveform

Stimulus type	Depressives	Controls
Positive	97/120	58/90
Neutral	98/120	55/90
Negative	100/120	48/90
Congruent	67/90 *	34/90
Incongruent	64/90 *	52/90

* One subject declined to continue the experiment after block 1, so data for his block 2 are not available.

Note: The first number represents the actual number of trials that went into computing the waveform (that were not rejected because of eye movement).

The second number represents the total number of trials given to all of the subjects.

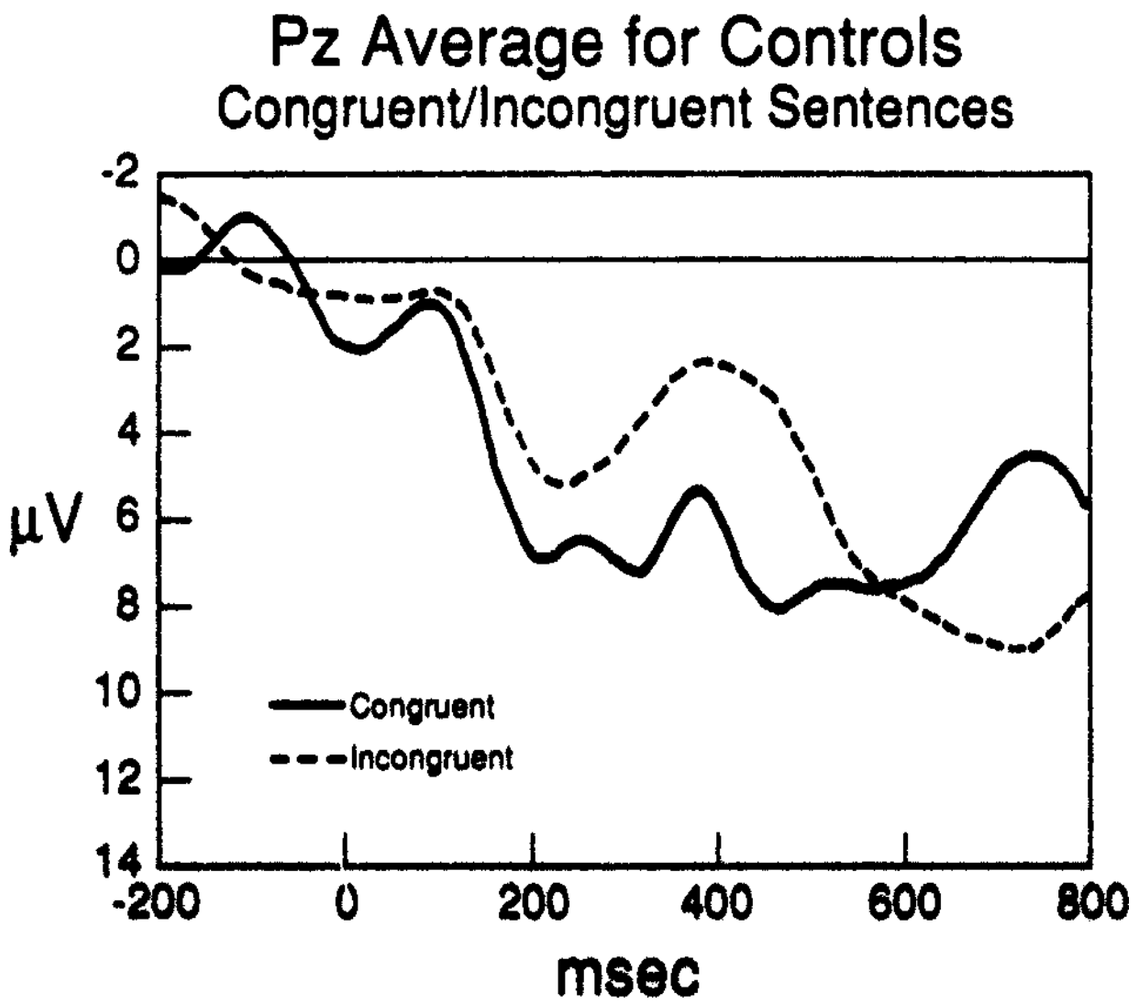
Figure Captions

Figure 1. Average waveforms at Pz for controls during the congruent/incongruent sentence condition.

Figure 2. Average waveforms at Pz for depressives during the congruent/incongruent sentence condition.

Figure 3. Average waveforms at Pz for controls during the emotion sentence condition (positive/neutral/negative).

Figure 4. Average waveforms at Pz for depressives during the emotion sentence condition (positive/neutral/negative).


Pz Average for Controls
Congruent/Incongruent Sentences
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Congruent
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Figure 1.

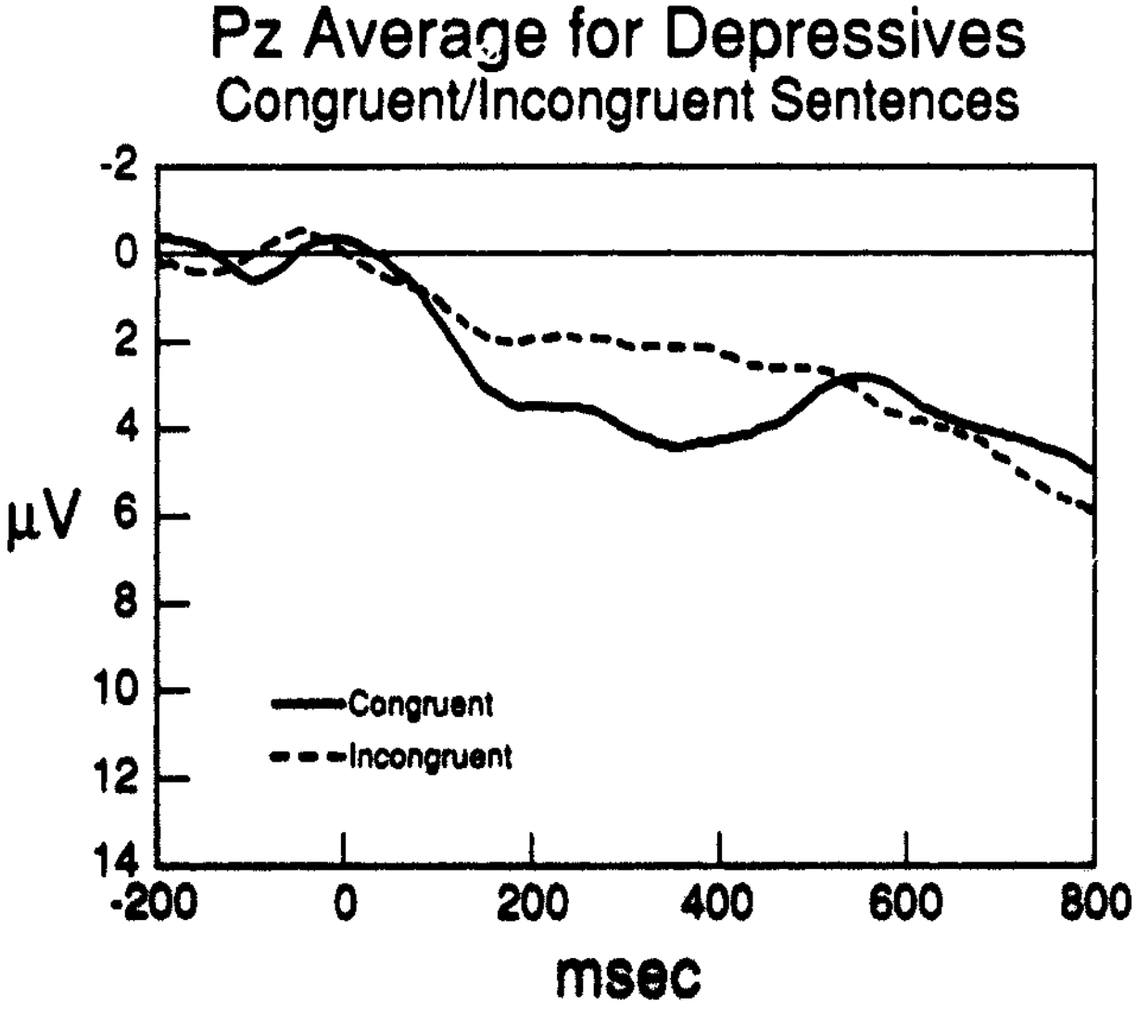
Pz Average for Depressives
Congruent/Incongruent Sentences
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Figure 2.

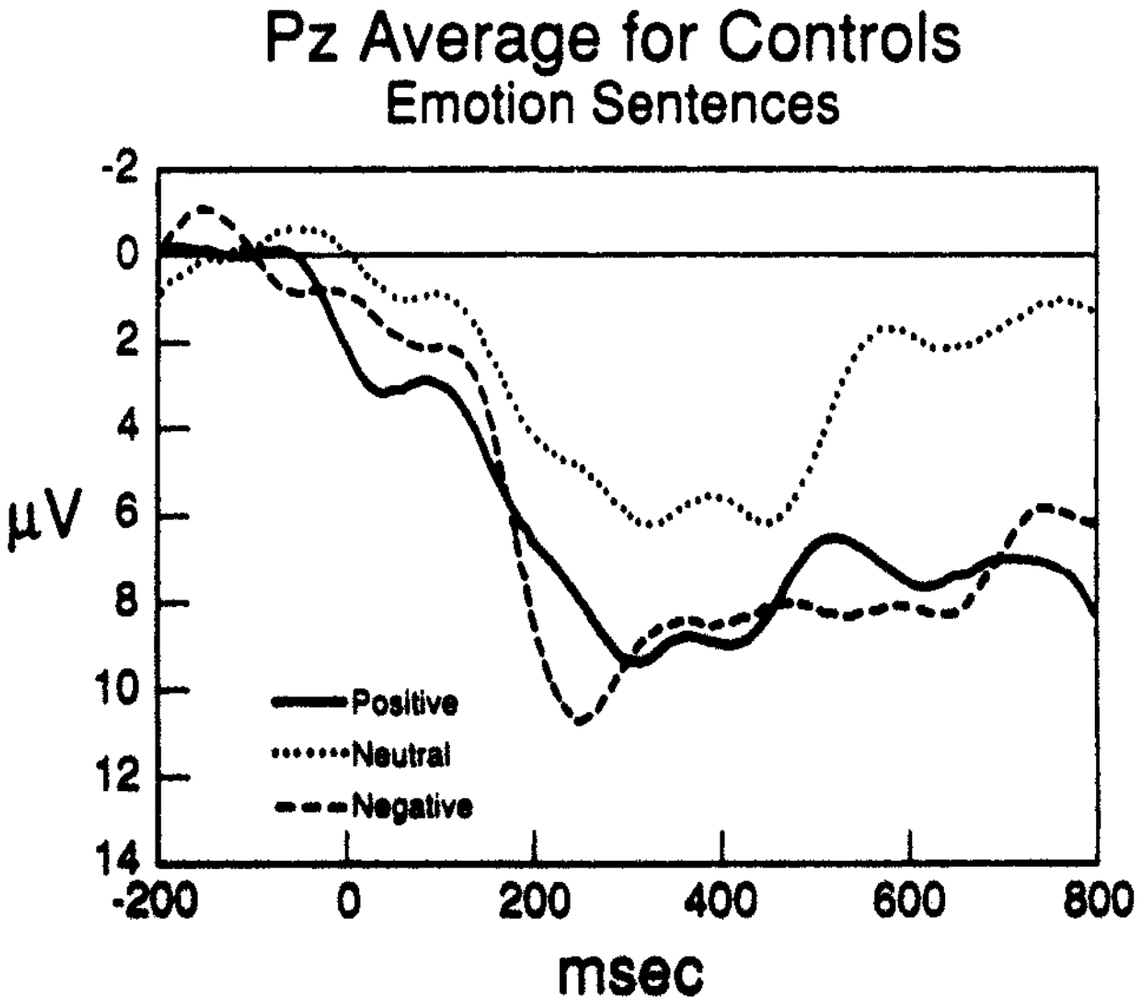
Pz Average for Controls
Emotion Sentences
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Figure 3.

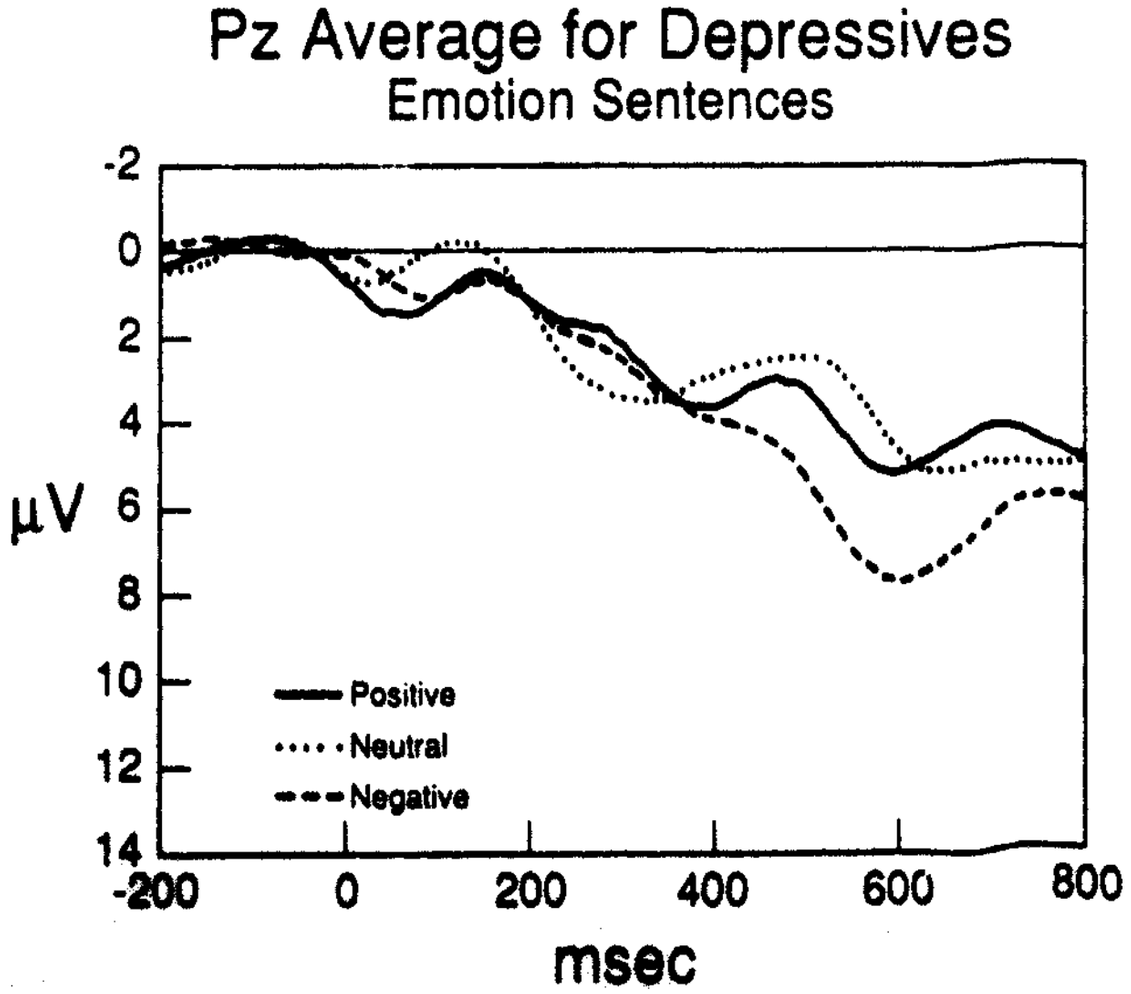
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Figure 4.